11 th INTERNATIONAL BLACK SEA COASTLINE COUNTRIES SCIENTIFIC RESEARCH CONFERENCE

March, 9-10, 2025 / Samsun, Türkiye

EDITOR

Dr. Alan Reed LIBERT

ISBN: 979-8-89695-050-9

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March, 9-10, 2025 - Samsun, Türkiye

25.03.2025

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adopted by Mariam Rasulan

PROCEEDINGS BOOK

ISBN: 979-8-89695-050-9

CONFERENCE ID

CONFERENCE TITLE

11th INTERNATIONAL BLACK SEA COASTLINE COUNTRIES SCIENTIFIC RESEARCH CONFERENCE

DATE AND PLACE

March, 9-10, 2025 - Samsun, Türkiye

ORGANIZATION

IKSAD INSTITUTE

KARASAM-BLACK SEA STRATEGIC RESEARCH AND APPLICATION CENTER

EDITOR

Dr. Alan Reed LIBERT

COORDINATOR

Samet KUŞKIRAN

PARTICIPANTS' COUNTRIES (21 countries)

TÜRKİYE, IRAQ, NORTH MACEDONIA, SERBIA, CANADA, NIGERIA, MOROCCO, CHINA, AZERBAIJAN, NIGERIA, AUSTRALIA, ALBANIA, KOSOVO, ROMANIA, INDIA, UKRAINE, PAKISTAN, VIETNAM, PHILIPPINES, POLAND, KYRGYZSTAN

Total Accepted Article: 115

Total Rejected Papers: 39

Accepted Articles (Türkiye): 52

Accepted Articles (Other Countries): 63

ISBN: 979-8-89695-050-9

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March, 9-10, 2025, Samsun, Türkiye

25.03.2025

REF: Akademik Teşvik

İlgili makama;

11. Uluslararası Karadeniz'e Kıyısı Olan Ülkeler Bilimsel Araştırmalar Kongresi, 9-10 Mart 2025 tarihleri arasında Samsun'da 21 farklı ülkenin (Türkiye 52 bildiri- Diğer ülkeler 63 bildiri) akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir

Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen "Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır." değişikliğine uygun düzenlenmiştir.

Bilgilerinize arz edilir,

Saygılarımla

Dr. Abbas KARAAĞAÇLI

Head of Black Sea Strategic Research and Application Center

T.C.
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Sungurlu Meslek Yüksekokulu

Sayı : E-36969287-903.07-2500021289 14.02.2025
Konu : Kongre Görevlendirme Talebi

Sayın Öğr. Gör. Dr. Songül DEMİREL DEĞİRMENCİ

İlgi : Yönetim ve Organizasyon Bölümü Başkanlığının 13.02.2025 tarihli ve E-91206956-622.99-2500020635 sayılı yazısı.

İlgi yazınıza istinaden 9-10 Mart 2025 tarihlerinde 11.Uluslararası Karadeniz'e Kıyısı Olan Ülkeler Bilimsel Araştırmalar Kongresi'nde Bilim Kurulu ve Düzenleme Kurulu üyesi olarak görev alma isteğiniz Müdürlüğümüz tarafından uygun görülmüştür.

Bilginizi rica ederim.

Öğr. Gör. Dr. Özlem BAL
M.Y.O. Müdürü V.

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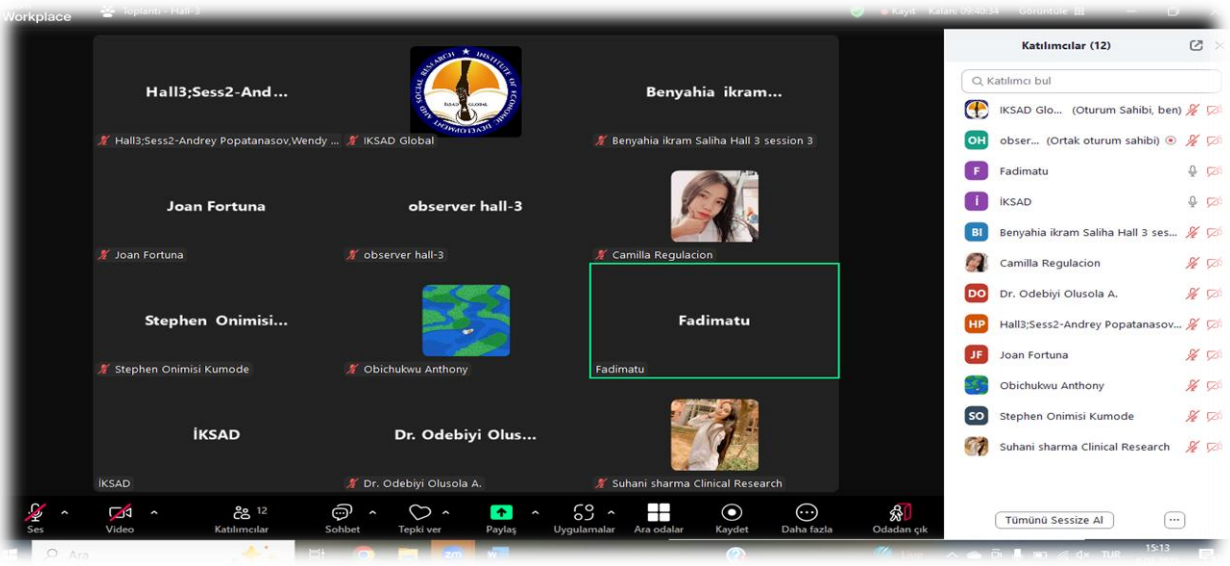

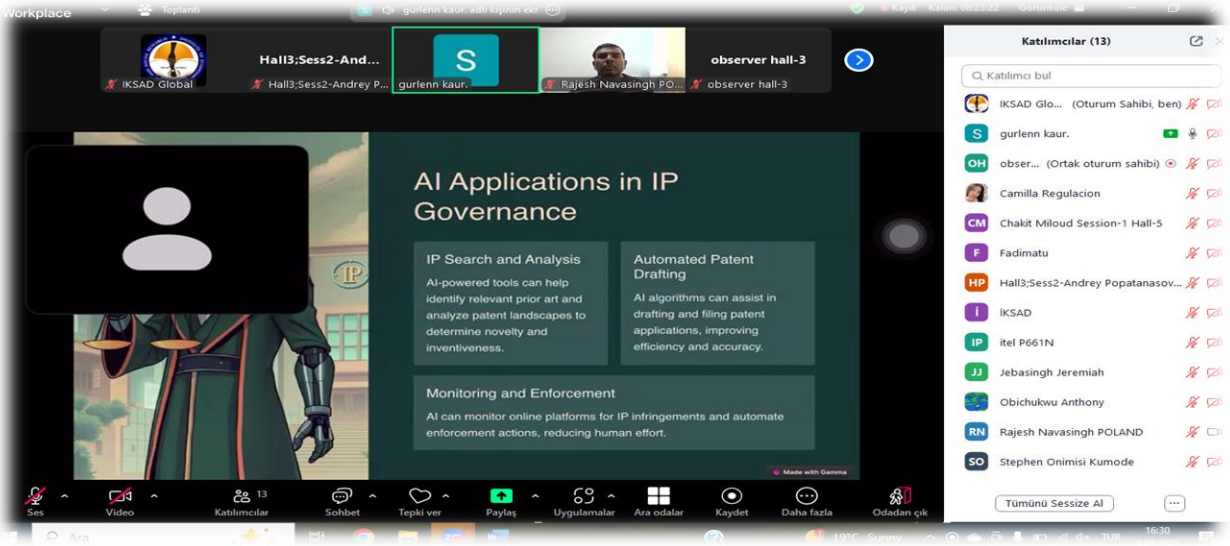

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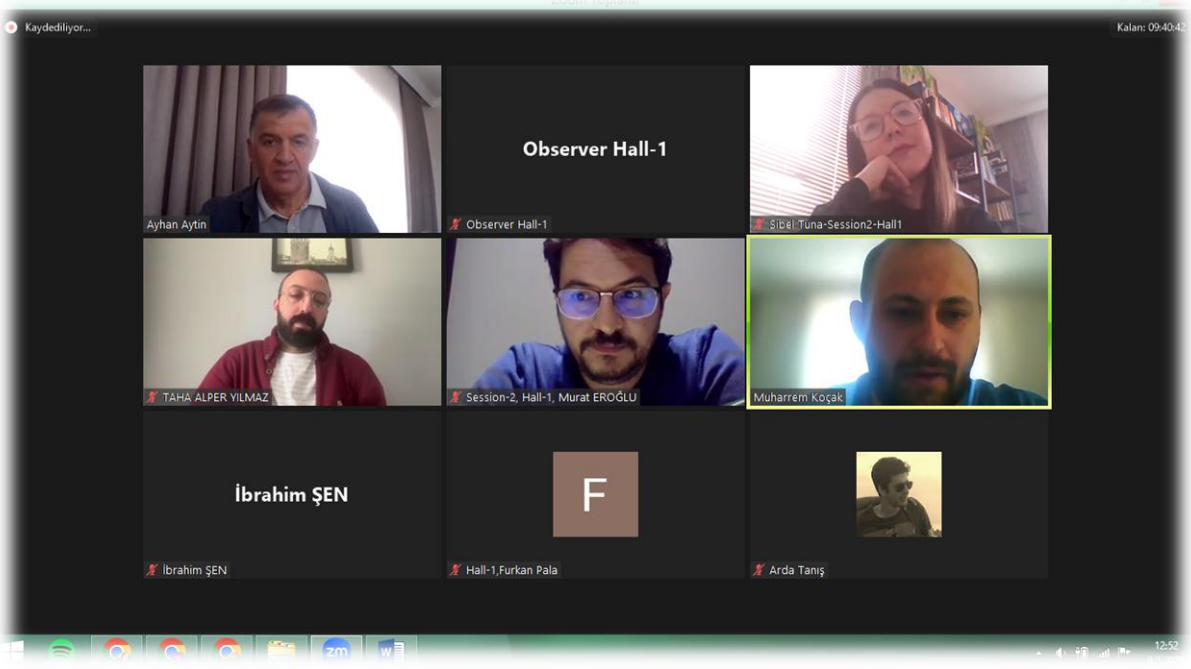

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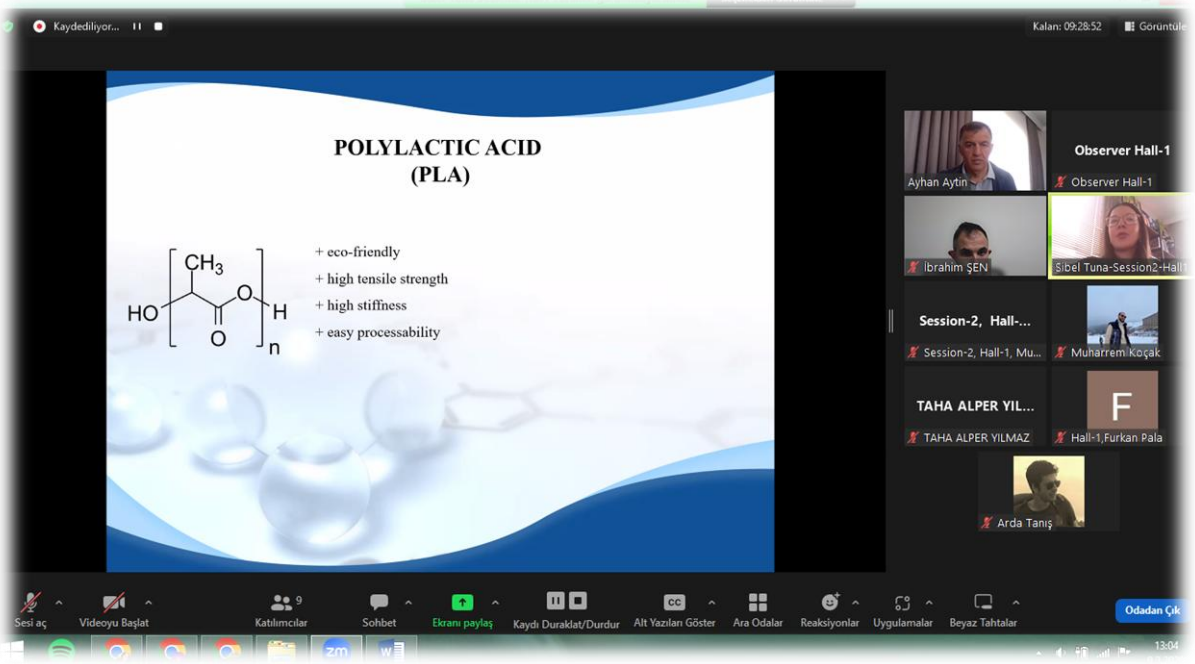

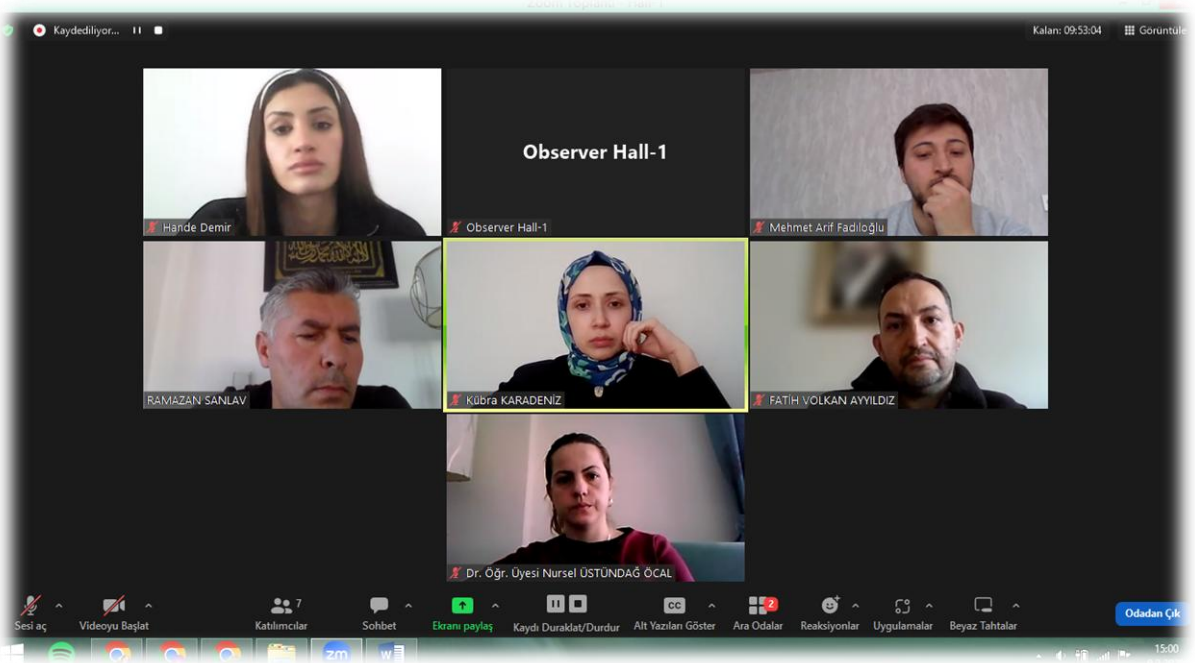

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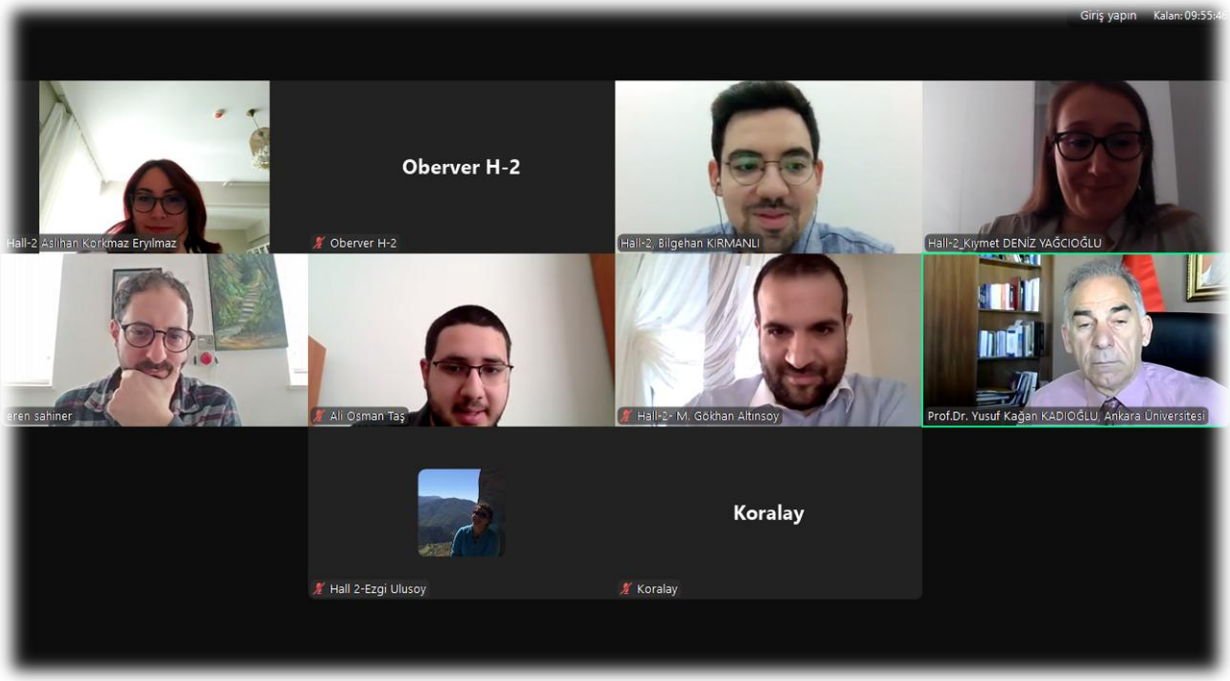

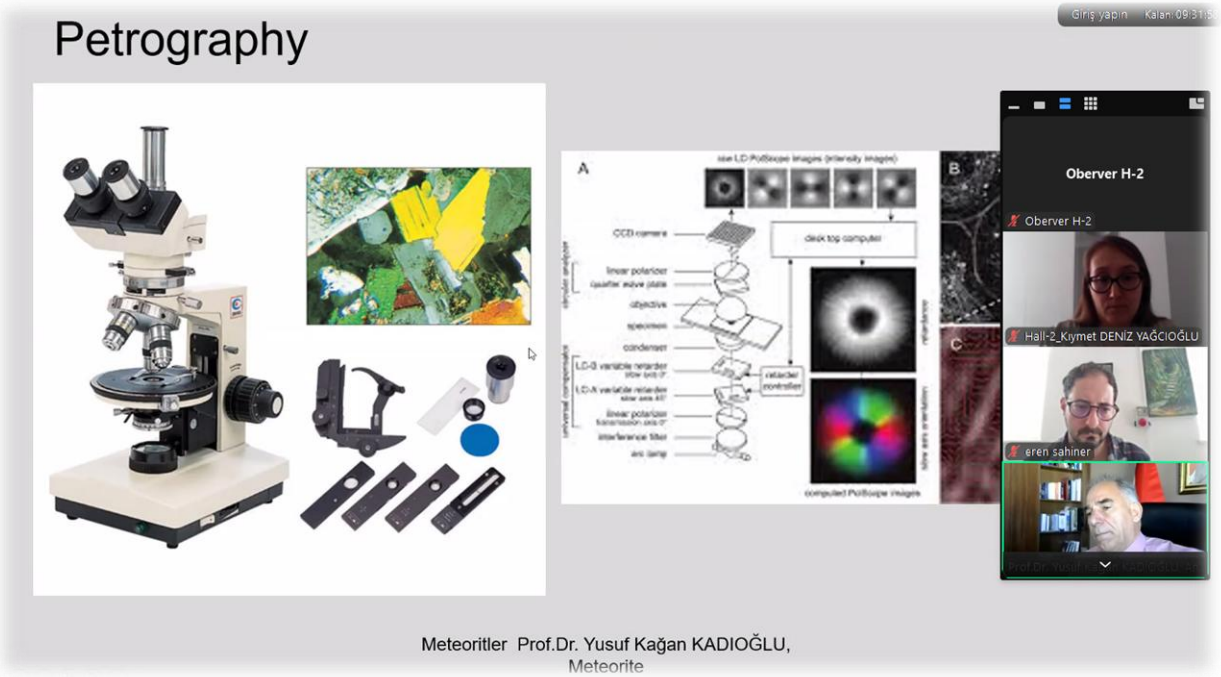

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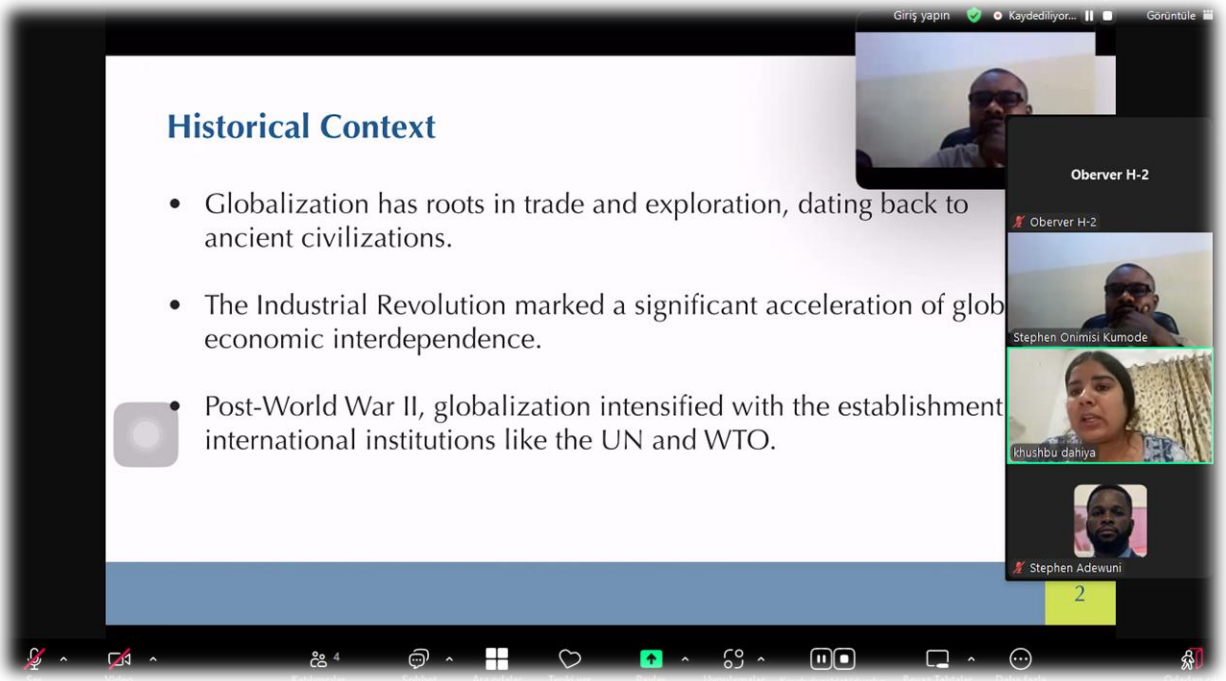

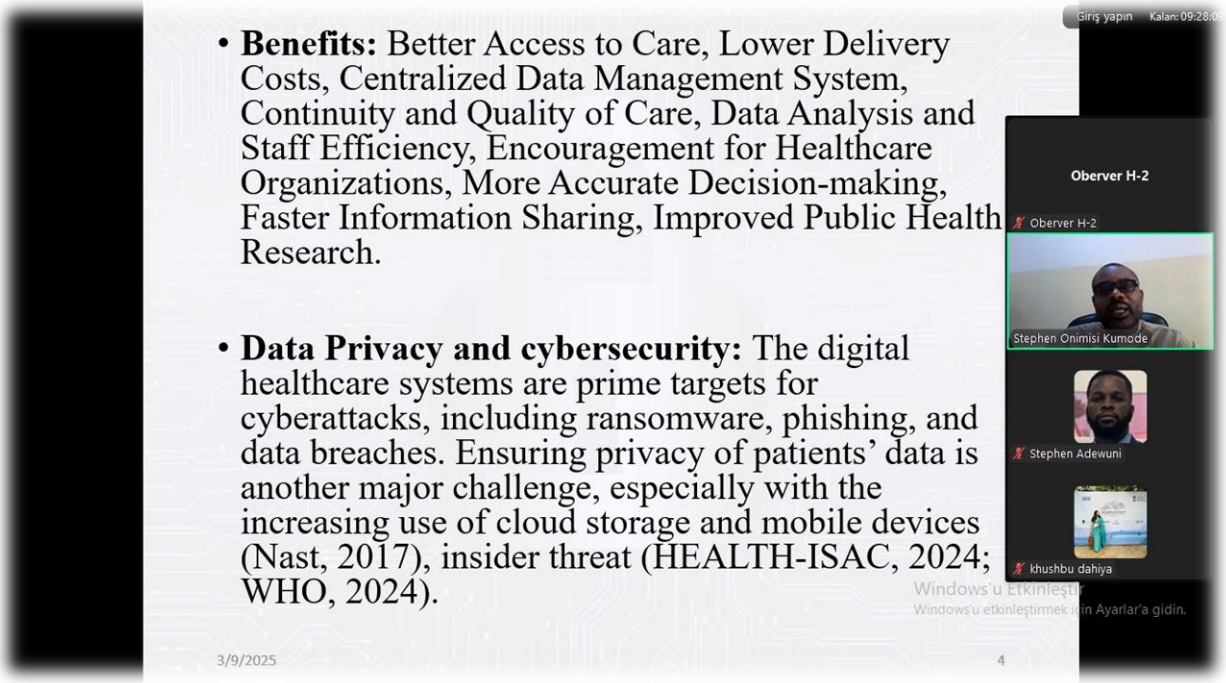

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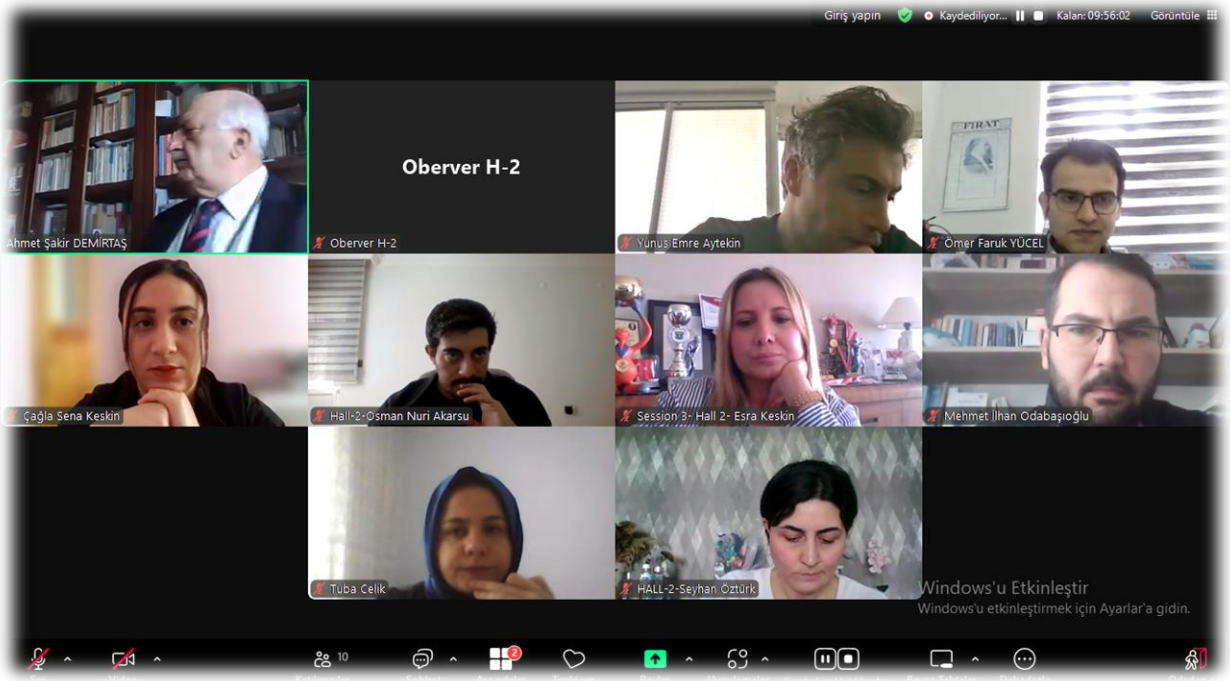

11th INTERNATIONAL BLACK SEA COASTLINE COUNTRIES SCIENTIFIC RESEARCH CONFERENCE

March 9-10, 2025/Samsun, Türkiye

CONFERENCE PROGRAM

Zoom Meeting ID: 897 0755 8402
Zoom Passcode: 111222

https://us02web.zoom.us/j/89707558402?pwd=saIvb726WnbwB4ytFJEwFAXzn2yMhd.1

PARTICIPANTS' COUNTRIES (21):

TÜRKİYE, IRAQ, NORTH MACEDONIA, SERBIA, CANADA, NIGERIA, MOROCCO, CHINA, AZERBAIJAN, NIGERIA, AUSTRALIA, ALBANIA, KOSOVO, ROMANIA, INDIA, UKRAINE, PAKISTAN, VIETNAM, PHILIPPINES, POLAND, KYRGYZSTAN

ÖNEMLİ, DİKKATLE OKUYUNUZ LÜTFEN / IMPORTANT, PLEASE READ CAREFULLY

Önemli, Dikkatle Okuyunuz Lütfen

- ✓ Kongremizde Yazım Kurallarına uygun gönderilmiş ve bilim kurulundan geçen bildiriler için online (video konferans sistemi üzerinden) sunum imkanı sağlanmıştır.
- ✓ Online sunum yapabilmek için **https://zoom.us/join** sitesi üzerinden giriş yaparak "Meeting ID or Personal Link Name" yerine ID numarasını girerek oturuma katılabilirsiniz.
- ✓ Zoom uygulaması ücretsizdir ve hesap oluşturmaya gerek yoktur.
- ✓ Zoom uygulaması kaydolmadan kullanılabilir.
- ✓ Uygulama tablet, telefon ve PC'lerde çalışıyor.
- ✓ Her oturumdaki sunucular, sunum saatinden 15 dk öncesinde oturuma bağlanmış olmaları gerekmektedir.
- ✓ Tüm kongre katılımcıları canlı bağlanarak tüm oturumları dinleyebilir.
- ✓ Moderatör – oturumdaki sunum ve bilimsel tartışma (soru-cevap) kısmından sorumludur.

Dikkat Edilmesi Gerekenler- TEKNİK BİLGİLER

- ✓ Bilgisayarınızda mikrofon olduğuna ve çalıştığına emin olun.
- ✓ Zoom'da ekran paylaşma özelliğine kullanabilmelisiniz.
- ✓ Kabul edilen bildiri sahiplerinin mail adreslerine Zoom uygulamasında oluşturduğumuz oturuma ait ID numarası gönderilecektir.
- ✓ **Katılım belgeleri kongre sonunda tarafınıza pdf olarak gönderilecektir**
- ✓ Kongre programında yer ve saat değişikliği gibi talepler dikkate alınmayacaktır

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- ✓ The Zoom application is free and no need to create an account.
- ✓ The Zoom application can be used without registration.
- ✓ The application works on tablets, phones and PCs.
- ✓ The participant must be connected to the session 15 minutes before the presentation time.
- ✓ All congress participants can connect live and listen to all sessions.
- ✓ Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.

Points to Take into Consideration - TECHNICAL INFORMATION

- ✓ Make sure your computer has a microphone and is working.
- ✓ You should be able to use screen sharing feature in Zoom.
- ✓ **Attendance certificates will be sent to you as pdf at the end of the congress.**
- ✓ Requests such as change of place and time will not be taken into consideration in the congress program.

Before you login to Zoom please indicate your name_surname and HALL number,
exp. Hall-1, Merve KIDIRYUZ

09.03.2025 / Session-1, Hall-1

Ankara Local Time: 10:00 – 12:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Assist. Prof. Dr. Cevahir PARLAK

Title	Author(s)	Affiliation
OPTIMIZING SPEECH KEYWORD SPOTTING TASKS UNDER NARROWBAND ENVIRONMENTS USING CONVOLUTIONAL NEURAL NETWORKS	Assist. Prof. Dr. Cevahir PARLAK	Fenerbahçe University TÜRKİYE
DESIGN AND PERFORMANCE ANALYSIS OF VIBRATION TESTER FOR AUTOMOBILE HEADLIGHTS	Yusuf AYİŞ Emre ERCAN Prof. Dr. Ali KİBAR	Gürçelik Machinery End. Automation System Singing. and Tic. Inc. Kocaeli TÜRKİYE Kocaeli University TÜRKİYE
THE IMPACT OF LOS ANGELES WILDFIRES ON NO_2 CONCENTRATIONS:TEMPORAL AND SPATIAL ANALYSIS USING SENTINEL-5P DATA	Assist. Prof. Dr. Emirhan ÖZDEMİR	Iğdır University TÜRKİYE
SEASONAL INVESTIGATION OF METHANE AND NDVI RELATIONSHIP IN IĞDIR WITH SENTINEL-5P AND MODIS DATA	Assist. Prof. Dr. Emirhan ÖZDEMİR Lect. Rüştü ÇALLI Lect.Mitat Can YILDIZ Assoc. Prof. Dr. Aliihsan ŞEKERTEKİN	Iğdır University TÜRKİYE
ASSESSING COASTAL VULNERABILITY OF THE YEŞİLIRMAK AND KIZILIRMAK DELTAS USING PRINCIPAL COMPONENT ANALYSIS	Res. Assist. Yağmur KOPUZ Assoc. Prof. Dr. Şafak Nur ERTÜRK BOZKURTOĞLU	Istanbul Technical University TÜRKİYE
THE ROLE OF SIEM AND PAM INTEGRATION IN STRENGTHENING CYBERSECURITY	Kübra Nur CANBAY Osman Kaan KARS	Gazi University TÜRKİYE Yeditepe University TÜRKİYE
EXPLORING DYEING PROCESSES FOR ENHANCED RUBBING FASTNESS IN SHOE LINING LEATHERS	Ulas KUTLU Dr. Nilay ORK EFENDIOGLU Prof. Dr. Behzat Oral BİTLİSLİ	ARBA Chemistry, Bursa TÜRKİYE Ege University TÜRKİYE

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09.03.2025 / Session-1, Hall-2

Ankara Local Time: 10:00 – 12:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Prof. Dr. Yusuf Kağan KADIOĞLU

Title	Author(s)	Affiliation
MINERAL, Sr-Nd-O ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY OF THE LAMPROPHYRES IN THE SAMSUN, CENTRAL PONTIDES (TÜRKİYE)	Assoc. Prof. Dr. Kıymet DENİZ YAĞCIOĞLU Prof. Dr. Yusuf Kağan KADIOĞLU Prof. Dr. Tamer KORALAY Assoc. Prof. Dr. Bahattin GÜLLÜ	Ankara University TÜRKİYE Pamukkale University TÜRKİYE Aksaray University TÜRKİYE
TEXTURAL PROPERTIES OF METEORITES AS AN INDICATION OF THEIR SOURCE: AN EXAMPLE FROM KIRŞEHİR, TÜRKİYE	Prof. Dr. Yusuf Kağan KADIOĞLU	Ankara University TÜRKİYE
LUMINESCENCE SIGNAL PROPERTIES OF NATURAL CALCIUM SULPHATES UPON INCREASING ANNEALING TEMPERATURES	Eren ŞAHİNER Ali Osman TAŞ Assoc. Prof. Dr. Kıymet DENİZ YAĞCIOĞLU Prof. Dr. Yusuf Kağan KADIOĞLU	Ankara University TÜRKİYE
INVESTIGATION OF EPIDOT MINERALS WITH DIFFERENT FORMATIONS USING CONFOCAL RAMAN SPECTROMETRY	Aslıhan KORKMAZ ERYILMAZ Prof. Dr. Yusuf Kağan KADIOĞLU Bilgehan KIRMANLI	Ankara University TÜRKİYE
AN APPROACH TO USING RAMAN SPECTRUM TO DISTINGUISH QUARTZ MINERALS OF DIFFERENT COLORS	Bilgehan KIRMANLI Prof. Dr. Yusuf Kağan KADIOĞLU Aslıhan KORKMAZ ERYILMAZ	Ankara University TÜRKİYE
ORIGIN AND RAMAN SPECTROSCOPIC CHARACTERISTICS OF XENOLITHS IN THE KEBAN INTRUSIVE ROCKS	Mustafa Gökhan ALTINSOY Metin BEYAZPİRİNÇ Mustafa Kemal ÖZKAN Assoc. Prof. Dr. Kıymet DENİZ YAĞCIOĞLU Prof. Dr. Yusuf Kağan KADIOĞLU	Ankara University TÜRKİYE General Directorate of Mineral Research and Exploration, Department of Geology, Ankara TÜRKİYE
INVESTIGATION OF TEMPERATURE EFFECTS (CALCINATION) ON CRYSTAL STRUCTURES OF SULPHATE MINERALS USING CONFOCAL RAMAN SPECTROSCOPY (CRS)	Ali Osman TAŞ Assoc. Prof. Dr. Kıymet DENİZ YAĞCIOĞLU Prof. Dr. Yusuf Kağan KADIOĞLU Eren ŞAHİNER	Ankara University TÜRKİYE
RAMAN CHARACTERISTICS OF GOLD-BEARING QUARTZ: AN ANALYTICAL PERSPECTIVE	Abdalbagi A. H. HUSSİEN Prof. Dr. Yusuf Kağan KADIOĞLU	Ankara University TÜRKİYE

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09.03.2025 / Session-1, Hall-3

Ankara Local Time: 10:00 – 12:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Assoc. Prof. Dr. Lütfü BEKAR

Title	Author(s)	Affiliation
QUORUM SENSING INHIBITION AND ANTIBIOFILM ACTIVITY OF LACTIC ACID BACTERIA SUPERNATANTS IN SALMONELLA TYPHIMURIUM 14028	Res. Assist. Dr. Ebru ÖZTAŞ GÜLMÜŞ	Erzurum Technical University TÜRKİYE
A RARE CAUSE OF CORONARY ISCHEMIA: CORONARY SUBCLAVIAN STEAL SYNDROME	Dr. Abdülmelik BİRGÜN Assoc. Prof. Dr. Lütfü BEKAR	Hitit University Erol Olçok Training and Research Hospital TÜRKİYE
SYNTHESIS OF 2-PHENYLFURANS BY OXIDATIVE CYCLIZATION REACTION	Furgan ASLANOĞLU	Van Yüzüncü Yıl University TÜRKİYE
THE INFLUENCE OF GUT MICROBIOTA ON NEUROGENESIS IN STROKE: IMPACT OF NEUROPOLEN	Major Gheorghe GIURGIU Prof. Dr. Med. Manole COJOCARU	Deniplant-Aide Sante Medical Center ROMANIA Titu Maiorescu University ROMANIA
OMEGA 3 - OMEGA 6 FATTY ACID RATIO – MORE THAN JUST THE INFLAMMATORY / ANTI-INFLAMMATORY EQUATION	Emanuela GLANDA Felicia ANDREI Anca DRAGOMIRESCU	University of Medicine and Pharmacy ROMANIA
PROTEIN-LIGAND DOCKING USING CB-DOCK: A COMPUTATIONAL APPROACH FOR DRUG DISCOVERY	Mahnoor Khalid Sikander Ali	University of the Punjab PAKISTAN Government College University PAKISTAN
GLOBAL AGING IN CRISIS: ADDRESSING ELDERLY VULNERABILITIES IN THE POST-PANDEMIC WORLD	Ph. Oana Pârvulescu Prof. Mihaela Gavrila-Ardelean, PhD	University “Aurel Vlaicu” of Arad ROMANIA
THE FACTORS THAT AFFECT NURSES’ ABILITY TO MAINTAIN THE HIGHEST STANDART OF HEALTHCARE QUALITY	Msc.Majlinda Rakipaj Dr.Denada Selfo Msc Neada Cakërri Msc.Deona Taraj	University Ismail Qemali of Vlore ALBANIA
EFFECT OF CORTICOSTEROIDS ON THE EFFICACY OF IMMUNE CHECKPOINT INHIBITORS IN PATIENTS WITH NON-SMALL CELL LUNG	PhD, Yuliia MOSKALENKO	Sumy State University UKRANIE

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09.03.2025 / Session-1, Hall-4

Ankara Local Time: 10:00 – 12:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Dr. Alan LIBERT

Title	Author(s)	Affiliation
CLASSICAL SOURCES: THEIR ROLE AND IMPORTANCE IN CONTRIBUTING TO THE STUDY OF HISTORY	Dr. Khadija Hassan Ali Al-Qusayr	Kufa University IRAQ
THE PROSPECTS AND CHALLENGES OF THE PEDAGOGICAL APPLICATION OF GENERATIVE AI: A SURVEY FOR EDUCATIONAL MANAGEMENT	Moses Adeolu AGOI Oluwakemi Racheal OSHINOWO Yewande Adeyosola ODUNAYO Oluwanifemi Opeyemi AGOI	Lagos State University NIGERIA Obafemi Awolowo University NIGERIA
TERMS FOR THE BLACK SEA IN ARTIFICIAL AUXILIARY LANGUAGES	Dr. Alan LIBERT	University of Newcastle AUSTRALIA
GLOBALIZATION OF MIRACLES: REIMAGINING AL-ISRA' WAL- MI&'RĀJ THROUGH THE LENS OF MODERN SCIENCE AND GLOBAL INTERCONNECTIVITY	Abubakar Abdulkadir	Umaru Musa Yar'adua University NIGERIA
FILM MEDIUM AND INTERCULTURALISM IN THE DIGITAL ERA. A STUDY OF FRANK RAJAH ARASE'S *GHANA MUST GO*	Divine Sheriff Uchenna Joe, PhD.	Federal University Otuoke NIGERIA
AWARENESS AND USAGE OF ELECTRONIC RESOURCES IN INTERACTIVE IN INTERACTIVE – ENGAGEMENT AND ANALOGY – ENHANCEMENT INSTRUCTIONAL STRATEGIES AS DETERMINANT OF THE ACHIEVEMENT OF STUDENTS IN BIOLOGY	Babagana Mohammed Shuaeeb Ibn Ahmad Abdullahi Usman Laka	Federal University of Technology NIGERIA

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09.03.2025 / Session-1, Hall-5

Ankara Local Time: 10:00 – 12:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Dr. Monika Stojanova

Title	Author(s)	Affiliation
OPTIMIZING AGRICULTURAL PRACTICES: THE POTENTIAL OF NANO FERTILIZATION FOR SUSTAINABLE PLANTH GROWTH	Marina T. STOJANOVA Dragutin A. DJUKIC Monika STOJANOVA Blazo LALEVIC	Ss. Cyril and Methodius University NORTH MACEDONIA Kragujevac University SERBIA Association for Scientific-research, Educational and Cultural Activities “Open Science” NORTH MACEDONIA Belgrade University SERBIA
WATER QUALITY ASSESSMENT FOR IRRIGATION USING THE IRRIGATION WATER QUALITY INDEX	Imane Bedoui Miloud Chakit Mohamed Fadli	Ibn Tofail University MOROCCO
MICROBIOLOGICAL QUALITY ASSESSMENT OF URBAN AND RURAL IRRIGATION WATER FROM FEZ CITY, MOROCCO	Imane Bedoui Miloud Chakit Mohamed Fadli	Ibn Tofail University MOROCCO
ETHNOBOTANICAL PLANT USE IN PEDIATRIC DERMATITIS IN OSARA, ADAVI LOCAL GOVERNMENT, KOGI STATE, NIGERIA	OLUDARE, T. T ATTAH, F. OWOLEKE, V. A. YAHAYA, R. A. AKOR, H. I.	Confluence University of Science and Technology NIGERIA
EFFECT OF KITCHEN WASTE SUPPLEMENTATION ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF WEANER RABBITS IN KANO STATE- NIGERIA	Mubarak Ahmad Hasssan Faruq Usman Yakubu Umar Ibrahim Kabiru Hamisu Abdullahi Mas’ud Shehu	Saadatu Rimi College of Education Kumbotso NIGERIA Aliko Dangote University of Science and Technology Wudil NIGERIA SR University Warangal Telangana INDIA
COST-EFFECTIVE FISHMEAL REPLACERS: COMPARATIVE EVALUATİON OF ANIMAL BY-PRODUCTS IN CIRRHINUS MRIGALA DIET	Esha Razzaq Syed Makhdoom Hussain Ajwa nazar Ulfat Batool	Government College University PAKISTAN
ANTHRAX	Fadimatu Dauda Muhammad	Usman Dan Fodio University NIGERIA
PHYSICOCHEMICAL QUALITY OF GROUNDWATER SAMPLES AROUND FEDERAL COLLEGE OF ANIMAL HEALTH AND PRODUCTION TECHNOLOGY, IBADAN, NIGERIA STUDENTS’ RESIDENTIAL AREAS	Alade, Adetomiwa Adebayo Igwe, Okereke Chigbo Olawuwo, Oluwafemi Joseph Enin, Lucky	Federal College of Animal Health and Production Technology NIGERIA

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09.03.2025 / Session-2, Hall-1

Ankara Local Time: 12:30 – 14:30

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Assoc. Prof. Dr. Ayhan AYTİN

Title	Author(s)	Affiliation
CHARACTERIZATION AND THERMAL ANALYSIS OF SCOTCH PINE FLOUR FILLED EPOXY-BASED COMPOSITES	Lect. Murat EROĞLU	Bursa Technical University TÜRKİYE
INVESTIGATION OF DENSITY, THERMAL, AND CHEMICAL PROPERTIES OF HAZELNUT SHELL FLOUR-FILLED EPOXY COMPOSITES	Lect. Dr. İbrahim ŞEN	Bursa Technical University TÜRKİYE
PRODUCTION OF WE43 MG MATRIX B 4 C ADDED FUNCTIONAL GRADED MATERIALS VIA POWDER METALLURGY METHOD AND INVESTIGATION OF THEIR MECHANICAL PROPERTIES	Muharrem KOÇAK Lect. Dr. Ufuk TAŞCI Assist. Prof. Dr. Naci Arda TANIŞ Prof. Dr. Recep ÇALIN	Kırıkkale University TÜRKİYE Gazi University TÜRKİYE
PREPARATION AND CHARACTERISATION OF PLASTICISED POLYLACTIC ACID BASED COMPOSITE FILMS WITH INCORPORATED LEONARDITE MINERAL	Lect. Sibel TUNA	Bursa Technical University TÜRKİYE
EFFECT OF CRYOGENIC TREATMENT ON COMPRESSIVE RESISTANCE AND DENSITY CHANGE IN THERMOWOODPOPULUS TREMULA	Assoc. Prof. Dr. Ayhan AYTİN	Düzce University TÜRKİYE
EFFECT OF FILLER STRUCTURE ON TENSILE PERFORMANCE OF NYLON6 COMPOSITES PRODUCED BY ADDITIVE MANUFACTURING	Assist. Prof. Dr. Taha Alper YILMAZ	Gazi University TÜRKİYE
NUMERICAL ANALYSIS OF LOW-VELOCITY IMPACT ON GLASS FABRIC-ALUMINUM SANDWICH COMPOSITE PLATES	Furkan PALA Assist. Prof. Dr. Zeynal Abidin OĞUZ Assoc. Prof. Dr. Nurettin Furkan DOĞAN	Gaziantep University TÜRKİYE Adıyaman University TÜRKİYE
INVESTIGATION OF THE MECHANICAL PROPERTIES OF ADDITIVELY MANUFACTURED POLYMER COMPOSITE MATERIALS WITH DIFFERENT INFILL GEOMETRIES	Lect. Dr. Ufuk TAŞCI	Gazi University TÜRKİYE

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09.03.2025 / Session-2, Hall-2

Ankara Local Time: 12:30 – 14:30

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Ananda Majumdar

Title	Author(s)	Affiliation
SOCIAL BOUNDARIES AS BORDERS: ADDRESSING POVERTY AND INEQUALITY	Ananda Majumdar	Alberta University CANADA
NAVIGATING ECONOMIC TURBULENCE: THE IMPACT OF ECONOMIC SHOCKS ON HEALTH FINANCING AND HEALTH OUTCOMES IN NIGERIA	Abayomi Stephen ADEWUNI Khadijat Toyin MUSAH	University of Abuja NIGERIA
CYBERSECURITY IN HEALTHCARE: PROTECTING PATIENT DATA AND NURSING INFORMATION SYSTEMS IN NIGERIA	Stephen Onimisi KUMODE Khadijat Toyin MUSAH	University of Abuja NIGERIA
CATALYZING ECONOMIC CONVERGENCE: THE ROLE OF ALBANIA'S NATIONAL PROMOTIONAL BANK IN BRIDGING FINANCIAL GAPS AND ADVANCING EU INTEGRATION	Delina Ibrahimaj	Tirana University ALBANIA
GLOBALIZATION AND GEOPOLITICS: THE EVOLVING WORLD ORDER	Khushbu Dahiya	Maharshi Dayanand University INDIA
HAITI - ITS CHRONIC POVERTY, ENVIRONMENTAL AND ECONOMIC DISASTER, CRISIS MANAGEMENT AND FOREIGN AID-TAKING A FRESH PERSPECTIVE RESIDING AT THE BACKYARD OF USA - THE BIGGEST AND RICHEST WESTERN NATION	Wendy De SHONG-NEUHALFEN Andrey POPATANASOV	Institute of Neurobiology BULGARIA
IMPACT OF MIGRATION ON SOCIAL AND ECONOMIC DEVELOPMENT	Full-Professor PhD. Habil. Cristina Raluca Gh. Popescu	University of Bucharest ROMANIA

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09.03.2025 / Session-2, Hall-3
Ankara Local Time: 12:30 – 14:30
Meeting ID: 897 0755 8402 / Passcode: 111222
Moderator: Assit. Prof. Babita Gupta

Title	Author(s)	Affiliation
DEVELOPMENT OF A NOVEL LOW-COST ADSORBENT CHITOSAN@EDTA@CELLULOSE COMPOSITE TO EFFECTIVELY REMOVE METHYL ORANGE DYE FROM WASTEWATER: EXPERIMENTAL AND THEORETICAL INVESTIGATION	Soukaina El Bourachdi Abdelhay El Amri Ali Raza Ayub Fatima Moussaoui Amal Lahkimi	Sidi Mohamed Ben Abdellah University MOROCCO Ibn Tofail University MOROCCO Beijing Institute of Technology CHINA
ENHANCING THE MECHANICAL PROPERTIES OF SUSTAINABLE CONCRETE USING BRICK POWDER AS A PARTIAL SAND REPLACEMENT	FILALI, Saloua NASSER, Abdelkader AZOUGAY, Abdellah	Mohammed Premier University MOROCCO
HIGH-PERFORMANCE OF TREATED CLAY FOR THE CONGO RED REMOVAL: ADSORPTION ISOTHERM AND KINETIC STUDY	Yahia Saghir Ayoub Chaoui Noureddine El Alem Mohamed Ezzahery	Ibn Zohr University MOROCCO
MATERIALS SCIENCE INNOVATIONS: GRAPHENE, SMART MATERIALS, AND BEYOND	Saloni Sharma Suhani Sharma	Deemed to be University INDIA
COMPARISON OF CATALYTIC APPLICATIONS OF CAO-AG BIMETALLIC NANOPARTICLES AND ITS COMPOSITE: CAO-AG/NA-ALG/PANI	Asima Saif Muhammad Ali	University of Agriculture Faisalabad PAKISTAN
NANOMATERIAL-BASED TRANSDERMAL DRUG DELIVERY FOR SKIN-RELATED DISORDER	Assit. Prof. Babita Gupta	Institute of Technology and Management INDIA

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09.03.2025 / Session-2, Hall-4

Ankara Local Time: 12:30 – 14:30

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Bahijjah Abdallah

Title	Author(s)	Affiliation
ALBANIAN TRANSMISSION SYSTEM IN THE CONTEXT OF THE RES DEVELOPMENT IN SEE	Viktor RROTANI Rajmonda BUALOTI Marialis ÇELO Arben GJUKAJ Elio VOSHTINA	Polytechnic University of Tirana ALBANIA University of Prishtina KOSOVO Albanian Transmission System Operator ALBANIA
INVESTIGATION OF CAPACITIVE AND NON-CAPACITIVE BEHAVIOUR IN A COMPOST-BASED SYMMETRIC ENERGY STORAGE DEVICE	Poonam Vijay Kumar Sunil Kumar	Indira Gandhi University INDIA
SMART WASTE MANAGEMENT SYSTEM USING IoT AND MACHINE LEARNING	Bahijjah Abdallah	Federal Polytechnic NIGERIA
NETWORK UTILIZATION WITH PROXY ROUTERS TO IMPROVE INTERNET PERFORMANCE EFFECTIVENESS	Muhammad Naafi'an ANUGERAH Muhammad Rikzam Kamal	Abdurrahman Wahid Pekalongan INDONESIA
ANALYSIS OF A REFORMULATED BLOCK HYBRID LINEAR MULTISTEP METHOD INTO RUNGE –KUTTA TYPE METHOD FOR FIRST ORDER INITIAL VALUE PROBLEM (IVP)	ALIYU Abubakar MUHAMMAD Raihanatu ABDULHAKEEM Yusuf	Federal University of Technology NIGERIA
A SPECTRAL CONJUGATE GRADIENT METHOD VIA HYBRIDIZATION APPROACH FOR SYSTEM OF NONLINEAR EQUATIONS	Abdullahi Adamu. Kiri Zainab Ishaq Zaharaddini Haruna Musa Abubakar Isah Abubakar Sadiq Gambo	Jigawa State Polytechnic for Information and Communication Technology NIGERIIA
SIN, SACRIFICE, SALVATION, AND THE HIDDEN CHRIST IN THE RIG VEDA: A COMPARATIVE EXPLORATION	Rajesh Jesudoss Hynes Navasingh Jebasingh Jeremiah Rajesh	Opole University of Technology POLAND

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09.03.2025 / Session-3, Hall-1

Ankara Local Time: 15:00 – 17:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: A Dr. Lect. Ramazan SANLAV

Title	Author(s)	Affiliation
AN INVESTIGATION ON THE EFFECT OF ERGOGENIC AIDS IN SPORT	Hande DEMİR	Amasya University TÜRKİYE
WHAT IS THE IMPACT OF ORTHOREXIA NERVOSA AND EATING ATTITUDES ON SOCIAL APPEARANCE ANXIETY IN YOUTH	Nursel ÜSTÜNDAĞ ÖCAL Bekir Barış CİHAN	Yozgat Bozok University TÜRKİYE
COMPARISON OF DIGITAL GAME ADDICTION LEVELS OF STUDENTS STUDYING AT THE FACULTY OF SPORTS SCIENCES	Assoc. Prof. Dr. Ünsal TAZEGÜL Dr. Lect. Ramazan SANLAV	Iğdır University TÜRKİYE
COMPARISON OF CAREER AWARENESS LEVELS OF STUDENTS STUDYING AT THE FACULTY OF SPORTS SCIENCES	Dr. Lect. Ramazan SANLAV Assoc. Prof. Dr. Ünsal TAZEGÜL	Iğdır University TÜRKİYE
EFFICIENCY MEASUREMENT OF KÜTAHYA HEALTH SCIENCES UNIVERSITY: DEA METHODOLOGY	Assoc. Prof. Dr. Güller ŞAHİN Assist. Prof. Dr. Fatih Volkan AYYILDIZ	Kütahya Health Sciences University TÜRKİYE Ordu University TÜRKİYE
BIBLIOMETRIC ANALYSIS OF THESIS ON 'RESVERATROL' IN THE FIELD OF NUTRITION AND DIETETICS	Kübra KARADENİZ Assist. Prof. Dr. Nezihe OTAY LÜLE	Hasan Kalyoncu University TÜRKİYE Gaziantep University TÜRKİYE
BIBLIOMETRIC ANALYSIS OF THESIS INVESTIGATION OF THE EFFECTS OF OMEGA 3 SUPPLEMENTATION ON BLOOD LIPID LEVELS IN THE FIELD OF NUTRITION AND DIETETICS	Mehmet Arif FADILOĞLU Assist. Prof. Dr. Nezihe OTAY LÜLE	Gaziantep University TÜRKİYE
THE MULTIDISCIPLINARY IMPACT OF ERAS PROTOCOLS ON LAPAROSCOPIC CHOLECYSTECTOMY OUTCOMES: A RETROSPECTIVE COHORT STUDY	Suat EVİRGEN Şirin ÇETİN	Amasya University TÜRKİYE

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09.03.2025 / Session-3, Hall-2

Ankara Local Time: 15:00 – 17:00

Meeting ID: 897 0755 8402 / Passcode: 111222

Moderator: Assist. Prof. Dr. Ahmet Şakir DEMİRTAŞ

Title	Author(s)	Affiliation
BIBLIOMETRIC ANALYSIS OF ACCOUNTING LAW-THEMED STUDIES	Prof. Dr. Seyhan ÖZTÜRK Dr. Osman Nuri AKARSU Res. Assist. Muhammet KARALI	Kafkas University TÜRKİYE
PRODUCTION AND MANAGEMENT OF RENTAL HOUSING: AN ASSESSMENT OF THE APPLICABILITY OF THE BUILT-TO-RENT MODEL IN TURKEY	Assist. Prof. Dr. Esra KESKİN Res. Assist. Emine BAYDAN	Ankara University TÜRKİYE
SHOULD THE TURKISH CONSTITUTIONAL COURT HAVE THE AUTHORITY TO SUSPEND THE ENFORCEMENT?	Assist. Prof. Dr. Ahmet Şakir DEMİRTAŞ	KTO Karatay University TÜRKİYE
THE DEFICIENCY IN THE PRINCIPLE OF FAIR TRIAL AND LEGAL SECURITY DUE TO THE COURTS' DIFFERENT DECISIONS ON LEGAL DISPUTES OF THE SAME NATURE	Assist. Prof. Dr. Ahmet Şakir DEMİRTAŞ	KTO Karatay University TÜRKİYE
SAMSUN TOURISM: THE PEARL OF THE BLACK SEA WITH ITS STRENGTHS AND WEAKNESSES	Çağla Sena KESKİN Assoc. Prof. Dr. Ayşe ATAR YILMAZ	Ondokuz Mayıs University TÜRKİYE
DIGITAL TRANSFORMATION AND SUSTAINABILITY IN PARTICIPATION BANKING: A COMPREHENSIVE COMPARATIVE ANALYSIS FOR THE PERIOD 2015-2024	Lect. Yunus Emre AYTEKİN	Sinop University TÜRKİYE
AN EVALUATION OF THE CONTENTS OF VAKIT NEWSPAPER REGARDING THE LANGUAGE REVOLUTION	Assist. Prof. Dr. Ömer Faruk YÜCEL	İnönü University TÜRKİYE
OPINIONS OF TEACHER CANDIDATES ON THEIR TEACHING PRACTICE EXPERIENCES	Assoc. Prof. Dr. Aliye ERDEM Res. Assist. Kübra BABACAN	Ankara University TÜRKİYE
LEARNING ENVIRONMENTS IN TURKISH TEACHING COURSE	Assoc. Prof. Dr. Aliye ERDEM	Ankara University TÜRKİYE

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09.03.2025 / Session-3, Hall-3
Ankara Local Time: 15:00 – 17:00
Meeting ID: 897 0755 8402 / Passcode: 111222
Moderator: Assoc.Prof. J.Salai Thillai Thilagam

Title	Author(s)	Affiliation
ADVANTAGES AND RISKS OF USING AI IN THE PROTECTION OF THE ELDERLY	Sorina Corman, Ph.D.	Lucian Blaga University of Sibiu ROMANIA
AI IN HEALTHCARE: TRANSFORMING DIAGNOSIS AND TREATMENT	Assoc.Prof. J.Salai Thillai Thilagam N. Lalitha	G.Pulla Reddy Engineering College INDIA
GLOBAL HEALTH INTELLIGENCE SHARING: A VITAL TOOL FOR ACHIEVING SUSTAINABLE DEVELOPMENT GOAL 3 (SDG 3)	Ugwunnadi Anthony OBINNA Khadijat Toyin MUSAH Saheed Ayodeji ADEKOLA	University of Abuja NIGERIA
AVIAN INFLUENZA VIRUS (AIV)	Fadimatu Dauda Muhammad	Usman Dan Fodio University NIGERIA
ADVANCEMENTS IN NEUROLOGICAL DISORDERS: ALZHEIMER'S, PARKINSON'S, AND BEYOND	Saloni Sharma Suhani Sharma	Deemed to be University INDIA
EFFECTIVENESS OF PHYSIOTHERAPY IN REHABILITATION OF FROZEN SHOULDER	Paula Gjoshi Angjela Caveli	University of Medicine ALBANIA
CHAYOTE (Sechium edule): INNOVATING HEALTHY CARBONATION THROUGH NATURAL EXTRACT	Regulacion, Camilla R. Magtibay Ma. Fatima Piedad Riza Mae G. Dr. Fortuna Joan J.	Cavite State University PHILIPPINE
ANALYZING THE STABILITY OF HEPATITIS B MODEL: A MATHEMATICAL APPROACH TO UNDERSTANDING DISEASE TRANSMISSION	O. A. Odebiyi J. K. Oladejo Oladapo, O.A Agemo D.N Ayanrinola, O.W Elijah, E.O	Ladoke Akintola University of Technology NIGERIA Federal University of Technology NIGERIA
EVALUATION OF TAXANE-INDUCED SIDE EFFECTS IN PATIENTS WITH BRONCHIAL CANCER: A RETROSPECTIVE ANALYSIS	Ikram Saliha BENYAHIA Wefa BOUGHRARA Amina LAKMECHE Fatma BELHOUCINE Amel ALIOUA BERREBBAH	University of science and technology ALGERIA

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09.03.2025 / Session-3, Hall-4
Ankara Local Time: 15:00 – 17:00
Meeting ID: 897 0755 8402 / Passcode: 111222
Moderator: Assist. Prof. Dr. Akhtarul Islam Amjad

Title	Author(s)	Affiliation
GLOBALIZATION AND INTERNATIONAL RELATIONS IN CONNECTION WITH BIOTECHNOLOGIES IN THE FOOD INDUSTRY	Madalina Alexandra DAVIDESCU Ioana POROSNICU Claudia PANZARU Bianca Maria MADESCU Ioana BOLOHAN Alexandru USTUROI	Ion Ionescu de la Brad ROMANIA
STRATEGIES FOR THE SUSTAINABLE DEVELOPMENT OF THE LIVESTOCK SECTOR IN THE CONTEXT OF GLOBALIZATION: A SYSTEMATIC LITERATURE REVIEW	Ioana BOLOHAN (ACORNICESEI) Roxana LAZAR Bianca Maria MADESCU Madalina Alexandra DAVIDESCU Paul-Corneliu BOISTEANU	Ion Ionescu de la Brad ROMANIA
THE GLOBAL BATTLE AGAINST DISINFORMATION: A DEEP DIVE INTO ELECTIONS AND DIGITAL MANIPULATION	Gurleen Kaur	IILM Law Unıversıty Gurgaon INDIA
HANDICRAFTS AND HANDLOOM: A TOOL USED FOR THE DIPLOMATIC RELATION BY INDIA	Assist. Prof. Dr. Akhtarul Islam Amjad	National Institute of Fashion Technology Panchkula INDIA
FOREIGN INVESTMENTS AND THEIR INFLUENCE ON ALBANIA'S TOURISM AND REAL ESTATE MARKET	Msc. Enea Stavre Msc. Migen Duka	Arkvizion ES ALBANIA Metropolitan Tirana University ALBANIA
DECODING CONSUMER PURCHASE INTENTIONS: EXPLORING KEY DRIVERS OF MASSTIGE MARKETING SUCCESS	Res. Assist. Dr.Seema Rathee Res. Assist. Nishu Goyal Res. Assist. Sonali	Maharshi Dayanand University INDIA
CROSS-BORDER MERGERS AND ACQUISITIONS IN NIGERIA AND OTHER JURISDICTIONS: LEGAL COMPLEXITIES AND REGULATORY CHALLENGES	Iberedem Udofia Obot Afia-ama Udofia Obot	Akwa Ibom State Polytechnic NIGERIA
CHALLENGES AND OPPORTUNITIES IN MULTINATIONAL HIGH- SPEED RAIL DEVELOPMENT: A EUROPEAN PERSPECTIVE	Khanh Giang Le	University of Transport and Communications VIETNAM

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09.03.2025 / Session-3, Hall-5
Ankara Local Time: 15:00 – 17:00
Meeting ID: 897 0755 8402 / Passcode: 111222
Moderator: Gurleen Kaur

Title	Author(s)	Affiliation
AI-DRIVEN INTELLECTUAL PROPERTY GOVERNANCE IN BRICS+ NATIONS: CHALLENGES, STRATEGIES, AND GLOBAL IMPACT	Gurleen Kaur	IILM Law Unıversıty INDIA
AFCTA AND AFRICAN INTEGRATION: WHERE IS THE PEOPLES' INTEGRATION?	Emmanuel Zwanbin, PhD.	El-Amin University NIGERIA
LEVERAGING ARTIFICIAL INTELLIGENCE FOR EFFECTIVE CRISIS MANAGEMENT: ENHANCING PREDICTION, RESPONSE, AND COMMUNICATION	Jebasingh Jeremiah Rajesh Rajesh Jesudoss Hynes Navasingh	Opole University of Technology POLAND
ENSURING ETHICAL AI PRACTICES: CORPORATE ACCOUNTABILITY IN A DIGITAL WORLD	Tavneet Kaur	Punjab Unıversıty INDIA
FOREIGN DIRECT INVESTMENT, MIGRATION AND INTERNATIONAL RELATIONS: CATALYSTS FOR ECONOMIC DEVELOPMENT IN CENTRAL ASIAN COUNTRIES	Asel Pazylova	Osh Technological University KYRGYZSTAN
MECHANISMS FOR JOB CREATION IN THE REGIONS OF KYRGYZSTAN THROUGH FOREIGN INVESTMENTS AMID MIGRATION PROCESSES	Asel Pazylova	Osh Technological University KYRGYZSTAN

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09.03.2025 / Session-2, Hall-6
Ankara Local Time: 15:00 – 17:00
Meeting ID: 897 0755 8402 / Passcode: 111222
Moderator: Prof. Dr. İlkay KOCA

Title	Author(s)	Affiliation
PRODUCTION OF SWEET POTATO CHIPS AND DETERMINATION OF DRYING CHARACTERISTICS AND SOME PHYSICAL PROPERTIES USING CONVECTIVE AND MICROWAVE DRYING METHODS	Assoc. Prof. Dr. Fadime Begüm TEPE Tülay AKAN Lect. Dr. Tolga Kağan TEPE	Giresun University TÜRKİYE
DETERMINATION OF THE QUALITY PROPERTIES OF PRODUCED RAW MILK	Hakan ÇAĞLAYAN Prof. Dr. Fehmi YAZICI	Ondokuz Mayıs University TÜRKİYE
DEVELOPMENT OF THERAPEUTIC DEEP EUTECTIC SOLVENTS (THEDES), THEIR APPLICATION FIELDS AND FUTURE PERSPECTIVES	Beyza KABA Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
AS A FOOD SOURCE: CAMELLIA OLEIFERA	Kübra ABANOZ Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
GLYCOALKALOID IN THE SOLANACEAE FAMILY: SOLANINE	Kübra ABANOZ Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
USING NATURAL DEEP EUTECTIC SOLVENTS IN FOOD APPLICATIONS	Sara ELORABİ Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
EPIGALLOCATECHIN GALLATE IN ALL ITS ASPECTS	Mahdı FARSHADFAR Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
SOURCES, PROPERTIES, EXTRACTION, AND HEALTH EFFECTS OF CURCUMIN	Mahdı FARSHADFAR Prof. Dr. İlkay KOCA	Ondokuz Mayıs University TÜRKİYE
A STUDY ON THE PROPAGATION OF SINGLE-BUD CUTTINGS OF SOME LOCAL GRAPE VARIETIES CULTIVATED UNDER ŞANLIURFA CONDITIONS	Tuba ÇELİK Assist. Prof. Dr. Mehmet İlhan ODABAŞIOĞLU	Kilis 7 Aralık University TÜRKİYE Adıyaman University TÜRKİYE

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TERMS FOR THE BLACK SEA IN ARTIFICIAL AUXILIARY LANGUAGES

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ABSTRACT

The Black Sea is a well-known body of water. One would therefore expect a fair proportion of artificial auxiliary languages (that is, languages created to help with international communication) to have a term for it. In this paper I will investigate and discuss these terms, and look at which artificial languages have and do not have such a term. Esperanto is the most successful and best-known artificial auxiliary language, and it has a term for 'Black Sea', *Nigra Maro*. Not surprisingly, because it is a modified version of Esperanto, Ido has the same term. Interlingua IALA has a similar term, but the components are in a different order: *Mar Nigre*. The same is true of Idiom Neutral, whose term is *mar Negr*. All of the languages just mentioned are of the *a posteriori* type of artificial language, that is, they have taken their vocabulary from natural languages such as English and Spanish. Another type of artificial language is the *a priori* languages, attempts to build a language from scratch, without taking material from natural languages. There appear to be very few languages of this type which have a term for the Black Sea. The mixed artificial languages are between the *a priori* and the *a posteriori* languages, in that some of their material was drawn from natural languages, but some was not. One of the most successful artificial languages, Volapük, is of this type, and it has a word for 'Black Sea', *Blägamel*. Note that it is only a single word, while the terms previously cited consisted of two words. This research may give us insights into vocabulary formation in artificial languages.

Key Words: Black Sea, Artificial Languages, Auxiliary Languages, International Languages

INTRODUCTION

A very large number of languages have created to allow people speaking different natural languages to communicate with each other more easily. These languages are called *artificial auxiliary languages*.[1] While most of these languages were not fully worked out, e.g. their vocabularies are small, there are a few which have extensive vocabularies, including some or many place names. Since the Black Sea is rather well known, it would not be surprising if some of these languages have a term for it. In this paper I will discuss such terms.

DATA AND DISCUSSION

By far the most successful artificial auxiliary language is Esperanto, which has by far the largest number of speakers of the languages of this type, and in which there are many books and

[1] For information on languages of this type, one can consult Couturat and Leau (1903), Clark (1907), Pei (1958), Monnerot-Dumaine (1960), and Duličenko (1990). There are artificial languages designed for other purposes, but I will not deal with such languages here.

journals. The Esperanto term for 'Black Sea' is *Nigra Maro* (Waringhien 2002:624).[2] If one knows one or more Romance languages, the components of this term may be familiar, as the first one comes from Latin (*niger*) (Rajki 2006:63) and the second from various languages, including French (*mer*) and Italian (*mare*), but also some non-Romance languages, e.g. German (*Meer*) (ibid.:56).

This shows the nature of **Esperanto**, it is an *a posteriori* artificial language, i.e. an artificial language drawing on one or more natural languages. The most used artificial auxiliary languages are of this type, and they have taken their vocabulary mainly from major European languages, as Esperanto has. **Ido** is a modification of Esperanto, and, not surprisingly, its term for 'Black Sea' is identical to that of Esperanto (Feder 1919:810).

Several other modifications of Esperanto were created by René de Saussure. The terms for 'Black Sea' in two of them **Esperantido** and **Esperantida**, are *Nigra-Maro* (de Saussure 1919a:53 and de Saussure 1919b:65). However, a later work on Esperantida, de Saussure (1922), gives a slightly different form of the word, lacking a hyphen between the two components, i.e., *Nigra Maro* (p. 154).

Occidental/Interlingue draws on major languages of Western Europe; in this language 'Black Sea' is *Nigri Mare* (Schmidt 2013:70). Another major *a posteriori* language is **Interlingua** (IALA); its term for 'Black Sea' is *Mar Nigre* (Gode 1951:232). Note that the components are similar to those of the Esperanto/Ido term, but they are in the reverse order. The same is true of **Idiom Neutral**'s term, *mar Negr* (Holmes 1903:151). A more recent *a posteriori* language is **Lingua Franca Nova**; it took its vocabulary from various Romance languages. Its term for the Black Sea is *Mar Negra*.[3] Another fairly recent *a posteriori* language is **Sambahsa**; its term for 'Black Sea' is *Kyehrsen Mar*.[4]

The **Neo** term is somewhat different from those mentioned above, and it is a single word, *Nermar* (Alfandari no date:179). The first part of it might appear to come from French. **Uropi** "is a really international language, in so far as it has been created from the roots which are common to Indo-European languages".[5] The term for 'Black Sea' in this language is *Nar Mar*.[6] **Sintezo** "has the intention to be a compromise language of Esperanto, Ido and Interlingua".[7] Its term for the Black Sea is *Maro Nigra*;[8] it contains the same components as the Esperanto/Ido term, but in the reverse order.

NOXILO is also an *a posteriori* language, but it uses a wider range of languages, including some from Asia, as sources for its vocabulary than the *a posteriori* languages mentioned above. Nevertheless, its term for 'Black Sea', *EIBLA SII*,[9] appears to have come from English. (*EI* is a "radical" for color adjectives.[10])

Interslavic is an *a posteriori* language designed "for communication between Slavs of different nationalities",[11] and hence draws upon Slavic languages for its vocabulary.The Interslavic word for 'Black Sea' is *Črno morje*,[12] from *črny* 'black' and *morje* 'sea'.

[2] However, see Benson (1995:72), who gives *Maro Nigra* as the term for "Black Sea'.
[3] <https://elefen.org/disionario/>
[4] https://www.geocities.ws/sambahsa/dict/JS-dictionar%20-%20Englisch-Sambahsa.html?>; *kyehrsen* means '(jet) black' (ibid.)
[5] <http://uropi.free.fr/>
[6] <https://uropi.fandom.com/wiki/Vortaro_Uropi-Esperanto>
[7] <https://www.reddit.com/r/auxlangs/comments/gg8chh/sintezo/>
[8] <https://ial.fandom.com/wiki/Sintezo/Vortaro#M>
[9] <http://www2s.biglobe.ne.jp/~noxilo/EN10k.htm>
[10] <http://www2s.biglobe.ne.jp/~noxilo/sub1d.htm>
[11] <http://steen.free.fr/interslavic/introduction.html>
[12] <http://steen.free.fr/interslavic/en-ms.html#B>

The opposite of the *a posteriori* languages are the *a priori* languages, attempts to build an artificial language without using anything from natural languages. These languages were not successful and are obscure. Very few of them have a term for the Black Sea, but a recent one, **Kah**, does, *Finso Sol*, from *finso* 'sea' and *sol* 'black'. One will see the difference between this term and the ones previous mentioned; presumably its parts will be unfamiliar to everyone, whatever natural languages they might know.

The vocabulary of many or most *a priori* languages was designed in such a way that words which are close in meaning are also close in form. This holds true for C.-L.-A. Letellier's **Langue universelle**, whose word for the Black Sea is *ydɑlɑg* (Letellier 1854:300). One can compare the words for other seas near it: *ydɑlɑb* 'Sea of Azov', *ydɑlɑd* 'Adriatic Sea', and *ydɑlɑv* 'Sea of Marmara' (ibid.). The first two sounds/letters of these words, *ydɑ*, have the meaning 'sea' (ibid.:301).

The distinction between *a posteriori* and *a priori* languages is a spectrum, as some *a priori* languages have a small amount of *a posteriori* material, and some *a posteriori* languages may have a few *a priori* items. Artificial languages which have a substantial amount of both *a priori* and *a posteriori* material are known as mixed artificial languages. **Volapük**, a relatively successful artificial language, belongs to this group. Its term for 'Black Sea' is *Blägamel* (Wood 1889:387), from *bläg* 'black' and *mel* 'sea'; one might see a relation between these components and their English and French equivalents respectively. Another mixed artificial language is **Bolak** (or the **Blue Language**); its word for 'Black Sea' is *Nermar* (Bollack 1900:294). Note that it is identical to Neo's word.

The term for the Black Sea in the **Langue internationale néo-latine** is *iqollagoro* (Courtonne 1875: "Grammaire internationale":79).[13] It is an *a posteriori* language, and uses French, Spanish, Italian, Portuguese, and English as vocabulary sources. However, the part of this term which means black, *iqol*, seems to be partly *a priori*, constructed following the same principle as in Letellier's Langue universelle. *Qol* seems to be borrowed from English (*color*), but consider the following terms for colors: *eqola* 'white', *iqola* 'black', *oqola* 'yellow', *uqola* 'red', *əqola* 'blue' (ibid.:72).

Many artificial auxiliary languages, in fact the vast majority of them, do not have a term for 'Black Sea', at least to my knowledge. These include Algilez, American, Atlango, Atlas, aUI, Euriziano, Eurolang, Eurolengo, Konya, Lingualumina, Mondlango, Neo Patwa, Novbasa, Romanova, Sasxsek, Unish, Veltparl, and Wede. Note that many of these were not completed (and many cannot be considered fully serious attempts at an international auxiliary language, given the number of such languages which already exist), and their vocabularies were relatively small, so this is not a surprise.

CONCLUSION

Terms for the Black Sea appear in most of the major artificial auxiliary languages, and are generally similar to each other, which is a consequence of the fact that they are a posteriori languages which took their vocabulary from some of the same natural languages. In addition, most of the terms have the same components as terms for the Black Sea in many, if not all, natural languages: a component meaning 'black' and one meaning 'sea' (e.g. Hungarian Fekete-tenger, Turkish Karadeniz). It might be interesting to look at word for other seas in artificial languages to see whether there is a similar degree of uniformity.

[13] It is given as *i qol lag oro*, i.e. with most of its components as separate words, but this may be for the sake of clarity, and I believe that it may be a single word.

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IMPACT OF MIGRATION ON SOCIAL AND ECONOMIC DEVELOPMENT

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ABSTRACT

According to the Organization for Economic Cooperation and Development and the International Labor Organization, immigrants represent, these days, a large share of the workforce in major economic sectors, which results in assessing the social and economic importance of labor immigration. The current research is vital in offering a reliable and evidence-based understanding on how the immigration phenomenon influences developing countries, focusing on building social connections, contribution to growth, and impact on the labor market as well as public finances and social services. The originality of the study is represented by a comparative data analysis, done both quantitatively and qualitatively, which emphasizes: how immigrants contribute to economies; how experts and policy makers can gain a better understanding of the migration phenomenon, its advantages and disadvantages; and, ultimately, how countries need to have long-term immigration strategies. Additionally, pivotal connections are made with the Sustainable Development Goals, particularly in the areas of education, health, labor market, economic growth, and equality.

Key Words: Managing Migration; Social and Economic Analysis; Long-Term Immigration Strategy; Migrant Labor; Integration Policies; International Relations; Sustainable Development.

INTRODUCTION AND PURPOSE

This section is dedicated to offering a better understanding of the motivation behind the theme of the study, with a keen interest in showing this is a hot topic today especially since there are so many changes in all domains. In addition, this section creates vital connections between the initial motivations of the study – namely, to address migration due to the novel trends and to tackle the reasons why people choose to move from their places of origin in order to seek new beginnings, and the desire to integrate the topic in other discourses which address the globalization, cultural changes, and economic growth.

Nowadays, based on the most recent reports published by the Organization for Economic Cooperation and Development (OECD) and the International Labor Organization (ILO), immigrants represent a large share of the workforce in major economic sectors, having major influences at all levels, which results in assessing the social and economic importance of labor immigration. The current research is vital in offering a reliable and evidence-based understanding on how the immigration phenomenon influences developing countries, by focusing on a several elements, namely: building social connections, contribution to growth, and impact on the labor market as well as public finances and social services. The originality of the study is represented by a comparative data analysis, done both quantitatively and qualitatively, which sheds a new light on the following issues: how immigrants contribute to economies; how experts and policy makers can gain a better understanding of the migration phenomenon, its advantages and disadvantages; and, ultimately, how countries need to have long-term immigration strategies. Additionally, the study is very important due to the pivotal

connections that are made with the Sustainable Development Goals (SDGs), particularly in the areas of education, health, labor market, economic growth, and equality.

There are several key concepts that create strong and vital connections between migration and sustainable development, such as: managing migration; social and economic analysis; long-term immigration strategy; migrant labor; integration policies; international relations; and, sustainable development.

Besides the aforementioned pivotal concepts there are several questions that come to facilitate and support a better understanding of the migration phenomenon and the implications at the social and economic level (Popescu & Popescu, 2024). One of these questions is: What are the influences of happiness management on migrants? An interesting approach to answering this question would be to create some vital connections between work and life balance, so that migrants would be able to benefit from knowing how to adjust their lifestyles so that they could reach the optimum levels in terms of both professional and personal lives. Another thought-provoking question is: What are the factors that determined a person to leave the country/region of origin and go in a different place? Interestingly, the approach taken in order to offer significant answers to this question could different based on the cases taken under analysis. For example, the case of an individual that leaves the country of origin in order to study aboard could be taken, with major arguments brought to support such a decision, as follows: that person is willing to perfect much more in a different country and put much more emphasis on the education received, especially when willing to learn a language better or be part of an elite community; and, additionally, that person might find a job much easier after graduation, in those circumstances in which the competences and skills acquired are seen as more significant when received from certain education providers while compared to others (González *et. al.*, 2024).

These days, according to the OECD and the ILO, migration represents a highly topical issue in all countries, with a particular emphasis placed on migration to the OECD countries (Organization for Economic Cooperation and Development (OECD), 2024).

When analyzing the complex and vast international literature in the field, it can be noticed that the concepts “migrant” and “immigrant” have numerous definitions provided in a different manner by countries.

For example, according to the European Commission (EC) – the Migration and Home Affairs, the word “migrant” is attributed to a person, who moves from place to place, and who has not yet reached the final destination. In contrast, an “immigrant” is a person who leaves one place of residence for another place, having the objective to reside there permanently (European Union (EU) and European Commission (EC), 2024).

While, for instance, the United Nations (UN) Migration Agency, the International Organization for Migration (IOM), offers as definition for the concept “migrant” any person who is moving or has moved across an international border or within a State away from the usual place of residence, regardless of that person’s legal status (United Nations (UN) Migration Agency, the International Organization for Migration (IOM). (2024).

Although countries offer so many definitions regarding who is considered an immigrant, the OECD standardizes international migration data by specific categories in order to enhance comparability, as follows: (a) the migration related to family represents the main category of permanent migration across the OECD; (b) the free mobility migration, in free movement zones, such as the European Union (EU) and the European Free Trade Association (EFTA); and (c) labor and humanitarian migration (European Free Trade Association (EFTA), 2025; European Free Trade Association (EFTA), 2024).

What is more, the purpose of standardizing international migration data by specific categories, in the manner the OECD did, is to be able to create a distinction between different types of

migration in order to be able to focus on the drivers of migrations, the policy implications, and, also, the creation and planning of effective integration policies.

In particular, according to the International Migration Outlook 2024, migration to the OECD countries is at high levels (Organization for Economic Cooperation and Development (OECD), 2025).

There are numerous reasons to these trends, especially when being able to acknowledge the fact that migration is a social phenomenon caused by a vast variety of reasons among which could be mentioned: better economic and education opportunities; climate change and disasters; the desire for family reunification, among others (International Labor Organization (ILO), 2025).

This section not only puts the topic of migration into perspective and reaches out to those questioning the real benefits, but also tries to close the gap that exists between the reasons why people choose to migrate and the advantages that migration brings in different contexts and fields. The next section is materials and methods and brings to light the main research questions (RQs) for the current research paper, with the objective of showing that: firstly, there are numerous trends in international migration; additionally, there are many benefits of international migration that ought to be considered particularly by developing countries; and, in the end, migration should be addressed in correlation with the SDGs, since living no one behind is an imperative for happiness, peace, and ensuring that all individuals and communities will find the balance between development and growth.

MATERIALS AND METHODS

This section is focused on the materials and methods, bringing as novelty the 3 (three) main research questions (RQs) that come to support the idea of a better future for all – with a keen interest in the future generations and their perspective to develop and grow. The current research paper focuses on analyzing the international migration trends, with a particular accent placed on pivotal documents published mainly by the OECD, the ILO, the UN, and the IOM.

The study centers on creating a comparative data analysis, done both quantitatively and qualitatively, which emphasizes: how immigrants contribute to economies; how experts and policy makers can gain a better understanding of the migration phenomenon, its advantages and disadvantages; and, ultimately, how countries need to have long-term immigration strategies.

In addition, pivotal connections are made with the SDGs, particularly in the areas of education, health, labor market, economic growth, and equality.

The 3 (three) main research questions (RQs) for the current research paper are, as follows: (a) the first research question, namely (RQ1), is what are the major recent international migration trends; (b) the second research question, namely (RQ2), is how the immigration phenomenon influences developing countries; and, (c) the third research question, namely (RQ3), what are the major connections between migration and the SDGs, particularly in the areas of education, health, labor market, economic growth, and equality.

This section is followed by the findings and discussion, hence embracing the most important ideas that have been drawn from the international documents analyzed.

FINDINGS AND DISCUSSION

This section on findings and discussion centers on three main areas of interest that are derived from the analysis of the documents on migration, as flows: firstly, the international migration trends; secondly, the ways in which the migration phenomenon influences high-income

destination countries and developing destination countries; and, thirdly, the major connections between migration and the SDGs, particularly in the areas of education, health, labor market, economic growth, and equality (Sustainable Development Goals (SDGs) & United Nations (UN) Department of Economic and Social Affairs Sustainable Development, 2025):

To begin with, the main ideas derived from the documents analyzed on the international migration trends are the ones stated below:

- According to the World Migration Report 2024: "The vast majority of people continue to live in the countries where they were born —only one in 30 are migrants" (Organization for Economic Cooperation and Development (OECD), 2024). "The current global estimate is that there were around 281 million international migrants in the world in 2020, which equates to 3.6 percent of the global population" (Organization for Economic Cooperation and Development (OECD), 2024).
- Overall, based on the most recent published statistics, the estimated number of estimated migrants has significantly increased over the past five decades (Organization for Economic Cooperation and Development (OECD), 2024).
- What is more, based on the most recent published statistics, there is a larger number of male than female international migrants worldwide and, additionally, the growing gender gap has increased over the past twenty years (Organization for Economic Cooperation and Development (OECD), 2024).

In continuation, there are many ways in which the migration phenomenon influences high-income destination countries and developing destination countries, and specialists have pointed out that the most important ones are:

- Researchers have shown that there are powerful links between migration and development.
- Migration has the potential of influencing the development of countries in terms of trade, foreign investments, communication, transport, and aid, among others.
- High-income destination countries have numerous benefits from migration which come from increased supplies of labor, entrepreneurship, skills, innovation. Great advantages are acknowledged due to the fact that migrants pay taxes and make contributions to the social security system.
- Developing destination countries are lately putting a particular emphasis on the international relations, in order to be able to promote the relationships between development and migration. Hence, at both micro and macro levels, migration is envisioned as a catalyst for development and social change.
- Based on statistics, in developing countries the net outward migration boosts growth in the long run.

When willing to shed a new light on migration, there are major connections due to be remarked between migration and the Sustainable Development Goals (SDGs), particularly in the areas of education, health, labor market, economic growth, and equality, as follows (Sustainable Development Goals (SDGs) & United Nations (UN) Department of Economic and Social Affairs Sustainable Development, 2025):

- Migration can work for sustainable development.
- The SDGs promote harnessing the development benefits of migration, while reducing the negative effects of migration for host and home communities, migrants, and family members.
- It is considered more beneficial for the countries' development when the accent is positioned on helping migrants as well as home and host communities into the following directions: equitable access to better education, health, social services, and labor market integration.

- Goal 8: Decent work and economic growth: This is a highly representative Global Goal for the migration phenomenon, since it promotes the benefits implicated by happiness management and achieving full and productive employment and decent work for all individuals by 2030 (United Nations (UN), 2025).

All in all, there are so many reasons to support migration according to the recent documents that have come to analyze this phenomenon, but there are also aspects that could worry nations. Furthermore, these reasons are even more complex when considering the impact of Artificial Intelligence (AI) in our lives and in the context of the work and personal life balance (Popescu & Šebestová, 2024; Rylková *et al.*, 2025).

CONCLUSION AND RECOMMENDATIONS

All the international documents that were analyzed have the purpose of bringing a substantial contribution in offering a better and more complex understanding the migration phenomenon throughout the world.

All the international documents that constituted the subject of research for this current paper were published by reputed international scientists and renowned international organizations, being mainly chosen due to the fact that they offer, on the one hand, pivotal data and information on migration, and, on the other hand, in-depth most recent perspectives on highly topical migration issues.

Highlighting migration issues and the links with the SDGs is very important for this current research and the details are presented in the table below (see, in this matter, Table no. 1: Highlighting Migration Issues and the Links with the SDGs).

Table no. 1: Highlighting Migration Issues and the Links with the SDGs

World Record Levels in Terms of Displacement:	
Countries should put an emphasis on their humanitarian protection regimes, so that migrants will be able to receive help and support.	Example: The crisis in Ukraine, which forced people to other countries, in particular, the ones in the EU, but also in North America and Japan.
Conflict, coup violence, and food insecurity represent reasons why people were pushed outside their country's borders over the last decades.	Examples: Burkina Faso and Myanmar, from where people had to flee in order to avoid violence.
In the Americas, Migration Becomes Hemispheric, while East Africa is Hit by Draught and Hunger	
Long-term interaction challenges, since some migrants contemplate a longer stay abroad, might determine the host's attitudes towards newcomers to harden.	Examples: the bilateral migration-related agreements signed by the United States with Costa Rica and Panama and others; the bilateral migration-related agreements signed by Colombia and Mexico.
Draught and hunger have affected East Africa, imperiling millions and scientists have created connections with climate change.	Examples: East Africa suffered in 2022 the worst draught in 40 years, which led to crops withering, animals starving, and sharp uptick in food prices.
Countries Yearn for Foreign Workers, Mainly due to Facing Persistent Labor Shortages and Demographics that are Less and Less Favorable	
Governments have enacted long-term strategies intended to support recruiting immigrants to fill labor gaps.	Examples: countries in the EU, Australia, and North America, many countries of the Global North
The countries' efforts to recruit foreign-born workers are centered in-demand domains, such as, health care and manufacturing, in order to focus on enhancing competitiveness.	Examples: mobility restrictions versus easing access to citizenship, facilitating legal changes intended to incentivize migration and plug labor shortages.

Source: The Author' Own Elaboration, Based on the References Highlighted in the Table and in the Bibliography Section

A better understanding of migration implicates being able to seek the explanations for the changes in scale, the emerging trends, and the shifting demographics centered on the social and economic transformations that took place in the last decades.

Being able to acknowledge all the implications of migrations profoundly helps the individuals, communities, business environment, organizational' leaders, managers, and policy-makers to make sense of the changing world we live in and make relevant plans for the future.

There are very strong connections between migration and the SDGs which are mainly referenced in the Agenda 2030 in target 10.7. The commitment of leaving no one behind may not be truly achieved without thoroughly taking into consideration migration.

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The Author has declared that no competing interests exist.

STATEMENT OF CONFLICT OF INTEREST

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AUTHORS CONTRIBUTIONS

Conceptualization, Cristina Raluca Gh. Popescu (C.R.G.P.); methodology, C.R.G.P.; software, C.R.G.P.; validation, C.R.G.P.; formal analysis, C.R.G.P.; investigation, C.R.G.P.; resources, C.R.G.P.; data curation, C.R.G.P.; writing—original draft preparation, C.R.G.P.; writing—review and editing, C.R.G.P. The Author has fully contributed to this manuscript. The Author has read and agreed to the published version of the manuscript.

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ALBANIAN TRANSMISSION SYSTEM IN THE CONTEXT OF THE RES DEVELOPMENT IN SEE

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ABSTRACT

Albania has a key location in the Balkan region with reference to the topology of the electricity system and future plans for the integration of energy markets. The transmission network is not an isolated network but regionally connected through interconnection lines. The Albanian transmission network plays an important role for the transfer of energy from Greece and North Macedonia/Bulgaria to Kosovo and Montenegro and furthermore in the future to Italy. This impacted in the parameters of transmission network (voltage, loading, etc.).

Due to the variability of RES production and the very large impact of metrological conditions, the power transfer through the Albanian transmission network deviates considerably from the scheduled values, which submits this network in almost the same regime as that of contingencies.

With the large-scale renewable connected to the neighbouring countries power grid, the analysis and evaluation of the safe and sustainable operation of the interconnected system is

very important to address the problems and challenges of the future electrical power system development. The long-term Albanian TSO development plans must consider not only the studies of RES development in the country, but also the studies carried out at the regional and wider European level.

This paper addresses the challenges of the development of Albanian transmission network from the point of view of the security of the electric power system in the conditions of increased penetration of renewable sources in generation and hydrological conditions for an efficient and safe operation of the electric power system

Key Words: Transmission system, Interconnection lines, Renewable sources, Hydrological conditions

INTRODUCTION

The global shift from fossil fuels to sustainable energy sources, such as wind and solar, as well as lithium-ion batteries, known as the energy transition, is one of the most pressing challenges of the last years. The increasing penetration of renewable energy in the energy supply, electrification and improvements in energy storage are all key drivers of the energy transition. Driven by the need to mitigate climate change, reduce energy dependency, and ensure long-term economic stability, this transition involves the gradual replacement of carbon-intensive energy systems with renewable alternatives such as solar, wind, and hydroelectric power. While technological advancements and policy frameworks have accelerated the adoption of renewable energy, significant barriers, including infrastructure limitations, financial constraints, and socio-political resistance, continue to shape the pace and effectiveness of this transition.

The increasing integration of renewable energy sources (RES) is reshaping electricity markets and transmission systems across Southeast Europe (SEE). As countries strive to meet sustainability goals and align with European Union (EU) energy policies, the need for a flexible, efficient, and interconnected electricity grid has become more pressing. Albania, with its energy sector historically dominated by hydropower, stands at a critical juncture in this transition. The diversification of its energy mix, driven by the growing deployment of solar and wind power, presents both opportunities and challenges for the national transmission system.

The Albanian Transmission System Operator (TSO) plays a vital role in ensuring grid stability, facilitating cross-border electricity exchange, and integrating new RES capacities. However, several technical and structural barriers must be addressed to accommodate the increasing share of intermittent renewable energy. These include grid congestion, the need for advanced forecasting and balancing mechanisms, and the enhancement of interconnection capacities with neighbouring SEE countries. Additionally, regulatory and market reforms are essential to enable efficient energy trading, attract private investments, and align Albania's energy policies with EU standards.

The transition towards RES has placed significant emphasis on the modernization of transmission systems to ensure grid stability and reliability. According to (Shahzad, 2024), the integration of variable renewables, such as wind and solar, necessitates investments in grid flexibility, storage solutions, and cross-border interconnections. The research (Pérez, Punda, 2017) highlights that grid congestion and the lack of real-time balancing mechanisms remain key barriers to efficient RES integration, particularly in developing electricity markets like those in SEE. The study (Rrotani, 2024) emphasizes that Albania's heavy reliance on hydropower makes its electricity system highly vulnerable to seasonal fluctuations, necessitating greater regional integration and storage solutions. Several studies examine the state of transmission infrastructure in SEE and its role in enabling regional energy cooperation

(Cartaxo, 2023; Besselink, 2015). Weak interconnections between SEE countries impede efficient electricity trade and limit the potential for cross-border RES integration (Bahar, 2013). Literature (Voshtina, 2023) emphasizes the need for improved balancing market mechanisms and suggests a cooperative model between Albania and Kosovo, which aligns with broader SEE regional energy market integration goals and is a step toward a more interconnected balancing market. Moreover, (Voshtina, Hida, 2023) conducted an analysis of the RES integration in the Albanian landscape and stated that without development of new cross border transmission lines, this RES integration will lead to congestion in the transmission network, either internal or cross border.

This paper is organized into four sections. In the second section, there are described the used methodology and the selected case studies. Furthermore, in the third section are presented the main results of the study. In addition, fourth section specifies the conclusion on the main points of the paper.

MATERIALS AND METHODS

An overview of Albanian Power System and TSO is presented in this section. Furthermore, it is presented also the case study taken into consideration for analysis.

Albanian Power System

The Albanian power system operates as a meshed network with vertical profile, and the country's current installed capacity stands at approximately 2.675 MW. The primary challenge facing Albania's electric power system is its heavy reliance on hydropower, coupled with the rapidly increasing demand for electricity. Fig. 1 shows the country energy balance for period 2012-2023 (ERE, 2023). We can see that the production of electric energy is strongly influenced by the hydrologic year. In Albania, the annual demand for electricity is estimated to be higher than energy production. To improve this disadvantage, Albania turns to importing energy. The Albanian state's strategy to adopt instruments for the promotion of RES fits well into this energy scenario.

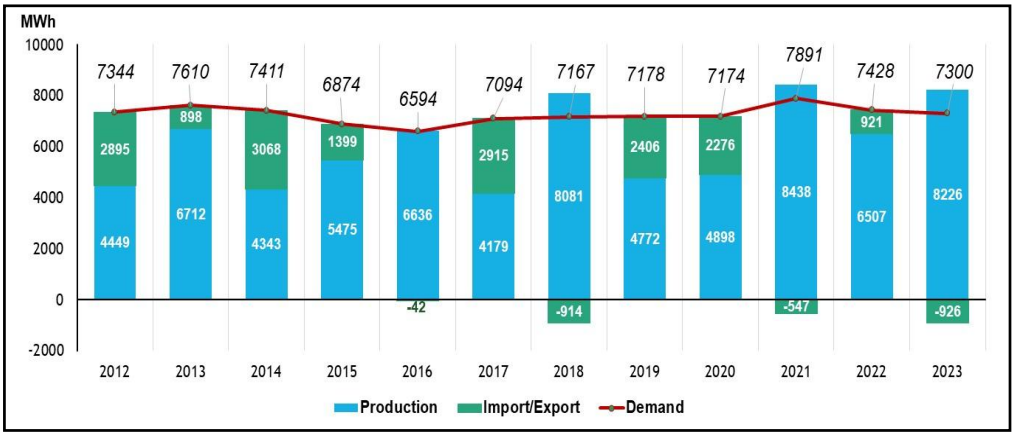
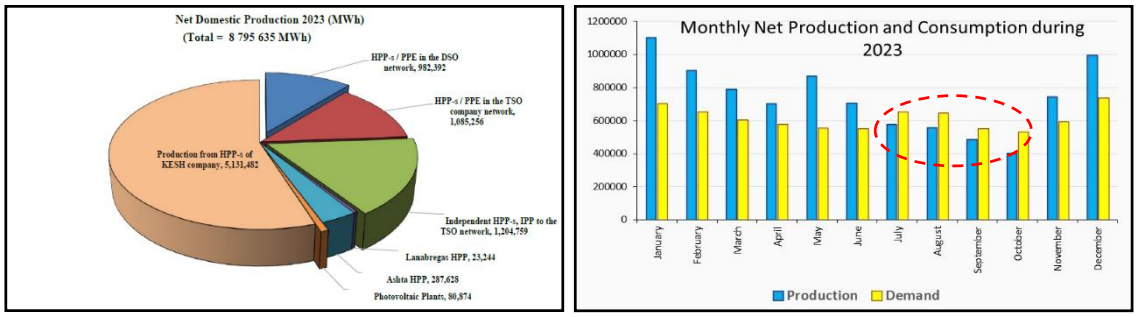


Figure 1. The Albanian energy balance for period 2012-2023

In Fig. 2a, is illustrated the net domestic production during 2023, while Fig. 2b shows the monthly net production and consumption in Albania during 2023 (ERE, 2023). We observe that load surpasses the production during summer, because of droughts. The main source of electricity for Albania is hydropower, contributing around 95% of the total electricity supply. The system is increasingly vulnerable to changes in hydrological conditions.



a) b)

Figure 2. Net domestic production during 2023 a) Monthly net production and consumption in Albania during 2023 b)

Transmission System Operator (TSO)

Albania holds a strategic position within the Balkan region in terms of power system topology and future energy market integration plans. The transmission network operated by OST plays a crucial role in facilitating energy transfer from Greece and Macedonia/Bulgaria toward Kosovo, Montenegro, and Italy (Voshtina, 2024). In addition to the existing submarine cable connection between Greece and Italy, a new cable connection between Montenegro and Italy has recently become operational, further enhancing regional energy interconnectivity.

The TSO power system operates at voltage levels of 400 kV, 220 kV, and 110 kV. Its network topology follows a vertical profile, with the majority of power generation sources concentrated in the northern region of Albania, while the main consumption is located in the central and southern parts of the country. It has 16 substations with a total installed capacity of 4621 MVA and 6 interconnected lines (OST, 2023).

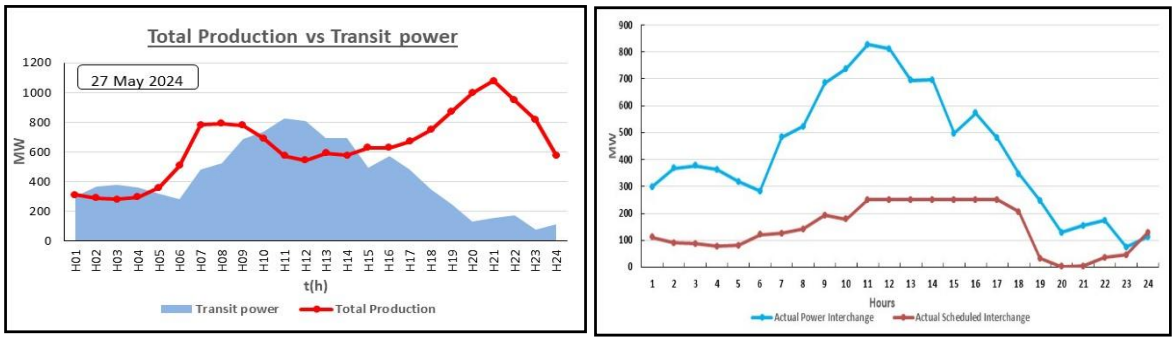
In recent years, there has been a significant increase in applications for photovoltaic and wind renewable sources. Table 1 shows the installed capacity of generators in TSO and the projected growth of Albania's installed generation capacity in the transmission system from 2023 to 2033. It shows a significant increase from 2441 MW in 2023 to 4970 MW in 2033, with a strong focus on renewable energy sources (OST, 2023). The projections highlight Albania’s transition toward a more diversified and sustainable energy mix, reducing dependence on hydropower and increasing the role of solar and wind energy.

TABLE 1. INSTALLED CAPACITY OF GENERATION SOURCES IN TSO

YEAR	**2023**	**2028**	**2033**
TOTAL INSTALLED CAPACITY IN TSO (MW)	2441	3650(+49%)	4970(+36%)
HPP	2230	2600	3000
THERMAL	97	300	470
PV	115	500	1000
WIND	0	250	500

Electricity Transit

In recent years, as a result of the development of renewable sources, an increase in electricity transits has been observed, mainly in the South-North direction. The electricity transit flows are then oriented towards Montenegro DC cable-Italy. Transit flows of electricity vary greatly from predicted values, especially during sunny periods due to photovoltaic installations in neighbouring South-Eastern countries. Fig. 3a represents the power flow in transmission system, which includes the country production and transit power from the neighbour countries, during 27 May 2024, while in Fig. 3b is illustrated the comparison between the total actual and scheduled transit power from Southern neighbor country of Albanian power system during 27 May 2024. The data was taken from the database of Albanian TSO (OST, 2023). The Albanian transmission system experiences significant stress, not only due to new developments in domestic power generation but also as a result of increased generation in neighbouring countries. These countries utilize Albania's TSO as a transit corridor for energy transfers to other regions, further intensifying the load on the network.



a) b)

Figure 3. The production and transit power from Southern neighbor country of Albanian power system in a daily basis a) Total Actual and Schedule Transit Power from Southern neighbor country of Albanian power system in a daily basis b)

Case Study

The consequences of energy transit over the scheduled values will be analysed in this paper. The Transmission Albanian power system has been taken in consideration for analysis. Neplan software is used for analysis. Albanian power system is modelled with 150 nodes and with its 6 interconnected lines, in the high nominal voltages that are 400 kV, 220 kV, and 110 kV. Until now, the Albanian power system has relied exclusively on synchronous generators from hydropower plants. This heavy dependence on water flows from snowfall and rainfall poses challenges in ensuring a stable energy supply, particularly during the summer months when water availability may be reduced. To diversify the energy mix and enhance system reliability, new wind and PV plants are planned for construction in the coming years in SEE, complementing the existing plants. In this paper, two case studies has been analysed:

- Total Actual Power Interchange
- Total Actual Scheduled Interchange

Fig. 4 shows a schematic representation of the electricity system of Albania, but the system under consideration with several voltage levels consists of many layers built in Neplan software.

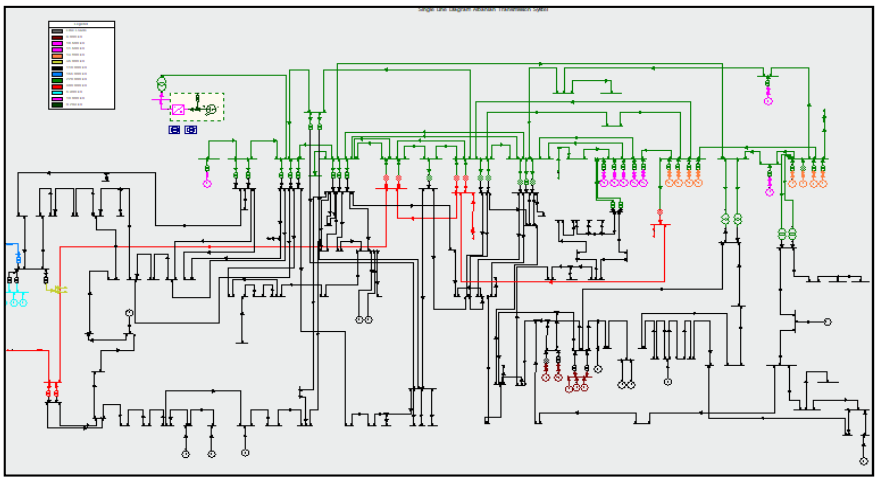


Figure 4. Schematic design of the Albanian Power System

RESULTS AND DISCUSSION

In following, the two scenarios have been analysed. For each of them there are calculated the loadings of lines and node voltages, calculating, also, the changes between two scenarios.

Line Loadings

Fig. 5 shows the loading percentage of the transmission lines under two different conditions. Throughout the graph, the red (scheduled) and blue (actual) lines show noticeable deviations, due to power transfers over the scheduled values. Notably, L220-1 has extreme peaks, indicating severe congestion and possible risks of overload.

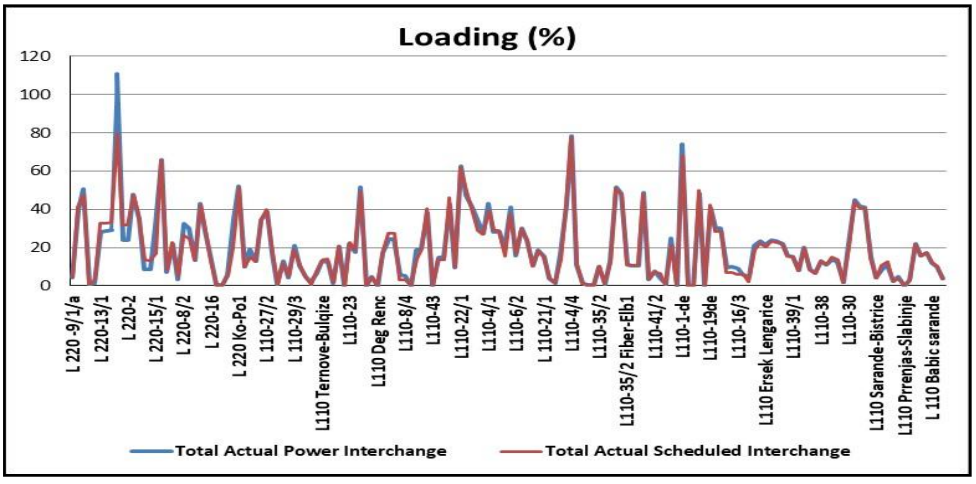


Figure 5. Loading (in %) of the transmission lines for the two scenarios

Change of Loadings

Fig. 6 shows the change of loadings of the transmission lines during the scenarios analysed. According to, Commission Regulation (EU) 2017/1485 (Article 84), which defines how to determine if a network element (transmission line, transformer, etc.) is significantly influenced by power flows in the system. A network element is considered "influenced" if the change in active power flow on that element exceeds a predefined threshold due to variations in other parts of the grid. This threshold is crucial for determining which elements should be monitored

in n-1 security analysis and helps TSOs identify critical network elements that require special attention. We can see that L220-1 exceeds the 15% threshold.

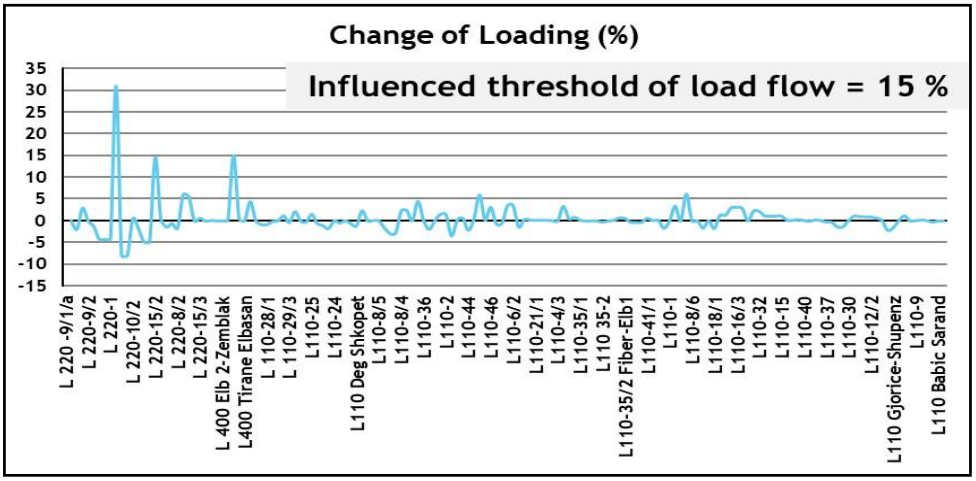


Figure 6. Change of Loading (in %) of the transmission lines for the two scenarios

Change of Voltages

Fig. 7 shows the change of voltages of the nodes during the scenarios analysed. The voltage impact threshold is 0.03 pu. Voltage changes in one country can propagate across interconnections, making regional coordination essential.

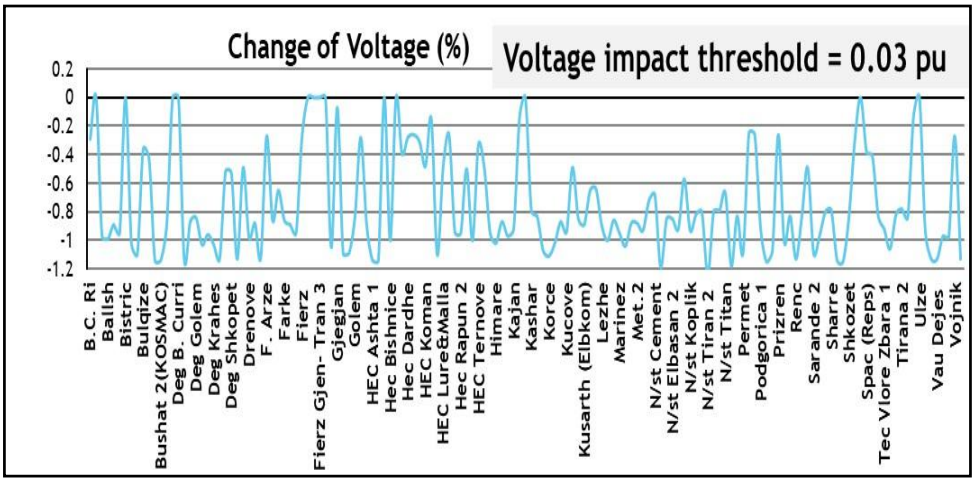


Figure 7. Change of Voltage (in pu) of the nodes for the two scenarios

CONCLUSIONS

The study analyzes the challenges and future development of the Albanian transmission system within the broader context of renewable energy integration in SEE. The integration of renewable energy sources (RES) in Albania's transmission system presents both opportunities and challenges for grid stability and regional energy exchange. The transit load flows from Greece & North Macedonia towards Montenegro DC cable – Italy, changes much from the schedule value due to the integration of renewable sources in the region. This has a great impact in the parameters of transmission network (voltage, loading, ect). The findings indicate that increased energy transit, particularly from neighboring countries, places additional stress on

the Albanian grid, often over scheduled power transfer values, indicated by surpassed threshold limits.

To address these challenges, it is necessary to invest in networks, strengthen regional interconnection, ensure the connection of electricity markets - both within the region and with neighboring countries - attract investments in flexibility solutions to manage balancing and establish frameworks to ensure investments in reserves. Meanwhile, the Albanian Transmission System Operator, through new investments, aims to strengthen interconnection links with the regional electricity network, creating conditions for unrestricted trade and transit of electricity in the region and is under construction the 400 kV interconnection lines: Albania-North Macedonia and Albania-Greece, as well as the expansion of the Elbasan-2 and Fier substations.

The definition of a final transmission system plan must necessarily analyze the penetration of renewable energy, the assessment of renewable sources, their impact on transmission networks from the point of view of system reliability, voltage levels, contingencies, relay protection system, as well as cost analyses of auxiliary services.

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OMEGA 3 - OMEGA 6 FATTY ACID RATIO – MORE THAN JUST THE INFLAMMATORY / ANTI-INFLAMMATORY EQUATION

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ABSTRACT

The balance between omega-3 and omega-6 fatty acids plays a crucial role in human health, extending beyond their well-known effects on inflammation. In the fields of nutraceuticals and nutricosmetics, these fatty acids influence skin physiology, metabolic regulation, and gut microbiota composition. This study explores the impact of the omega-3/omega-6 ratio on dermatological and metabolic health, highlighting its relevance for functional foods and cosmetic applications. A systematic review and meta-analysis were conducted to assess dietary intake, supplementation, and biomarker responses. Findings indicate that a high omega-6/omega-3 ratio, characteristic of Western diets, contributes to oxidative stress, impaired skin barrier function, and accelerated aging, while a balanced intake improves dermal hydration, elasticity, and metabolic parameters. These results support the integration of omega-3-rich formulations into nutraceutical and nutricosmetic interventions for both systemic and topical benefits.

Keywords: omega-3, omega-6, nutraceuticals, nutricosmetics, skin health, lipid metabolism, inflammation

Introduction and Purpose

The omega-3/omega-6 fatty acid ratio has been extensively studied for its role in inflammation; however, its broader implications in dermatology, metabolism, and gut health are increasingly recognized. Omega-3 fatty acids, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), exhibit anti-inflammatory, antioxidant, and dermoprotective properties, whereas omega-6 fatty acids, particularly linoleic acid (LA) and arachidonic acid (AA), are often associated with pro-inflammatory pathways.

The imbalance between these fatty acids, prevalent in Western diets, has been linked to a range of health issues, including chronic skin conditions (e.g., acne, eczema, psoriasis), premature aging, metabolic syndrome, and gut dysbiosis. Nutraceutical and nutricosmetic formulations incorporating omega-3 fatty acids offer promising strategies to counteract these effects by enhancing skin hydration, barrier function, and overall metabolic health.

This study aims to evaluate the role of the omega-3/omega-6 ratio in dermatological and metabolic health, with a focus on its potential applications in nutraceuticals and nutricosmetics.

Materials and Methods

A systematic literature review and meta-analysis were conducted using data from PubMed, Scopus, and Web of Science databases. The inclusion criteria were:

- Clinical trials, cohort studies, and meta-analyses published between 2000 and 2024.
- Studies assessing the impact of dietary omega-3 and omega-6 fatty acids on skin health, sebum production, dermal hydration, and metabolic outcomes.
- Research evaluating the effect of omega-3 supplementation in nutraceuticals and nutricosmetic formulations.

Data extraction focused on omega-3/omega-6 dietary intake, biomarker levels (e.g., inflammatory cytokines, lipid profiles), and clinical outcomes. Meta-regression models were applied to identify correlations between fatty acid intake and dermatological/metabolic health indicators.

Results

The analysis revealed significant associations between the omega-3/omega-6 ratio and skin, metabolic, and gut health:

Skin Health

- A **balanced omega-3/omega-6 ratio (2:1 to 5:1)** was correlated with **improved skin hydration, elasticity, and reduced transepidermal water loss (TEWL)**.
- Omega-3-rich diets stimulated **collagen synthesis** and protected against **UV-induced oxidative damage**.
- High omega-6 intake (>15:1) was associated with **pro-inflammatory conditions** such as acne, atopic dermatitis, and psoriasis.

Sebum Regulation

- EPA supplementation **reduced sebum production**, beneficial for individuals with acne-prone skin.
- Excessive omega-6 intake contributed to **hyperkeratinization and increased sebaceous gland activity**.

Metabolic and Gut Health

- A high omega-6/omega-3 ratio (>15:1) correlated with **increased insulin resistance, dyslipidemia, and systemic inflammation**.
- Omega-3 supplementation promoted **beneficial gut microbiota profiles**, increasing *Bifidobacterium* and *Lactobacillus*, which are linked to **anti-inflammatory effects and improved skin health**.

Discussion

The findings reinforce the significance of the omega-3/omega-6 ratio in nutraceutical and nutricosmetic science, supporting its role beyond inflammation regulation. Key considerations include:

- **Nutricosmetic Applications**: Omega-3 fatty acids enhance **skin hydration, elasticity, and repair mechanisms**, making them valuable in dietary and topical formulations for anti-aging and dermal protection.
- **Nutraceutical Benefits**: Optimizing the omega-3/omega-6 ratio improves **metabolic homeostasis**, reduces systemic inflammation, and supports gut microbiota diversity, which has indirect benefits for skin health.
- **Dietary Interventions**: The Western diet, characterized by a high omega-6/omega-3 ratio, contributes to **chronic skin and metabolic disorders**, highlighting the need for **targeted supplementation and dietary modifications**.
- **Future Research Directions**: Personalized nutrigenomic approaches should be explored to optimize fatty acid intake based on **genetic predisposition, skin conditions, and metabolic profiles**.

Conclusion

The omega-3/omega-6 ratio plays a pivotal role in skin and metabolic health, making it a critical factor in nutraceutical and nutricosmetic formulations. A high omega-6 intake contributes to oxidative stress, inflammatory skin conditions, and metabolic imbalances, whereas an optimized omega-3 intake enhances dermal hydration, collagen synthesis, and overall homeostasis. Integrating omega-3-rich functional foods and topical formulations into dermatocosmetic strategies offers a promising avenue for promoting long-term skin health and metabolic balance. Future dietary guidelines should emphasize **reducing excessive omega-6 intake while increasing omega-3 consumption** to optimize skin and metabolic health.

PROTEIN-LIGAND DOCKING USING CB-DOCK: A COMPUTATIONAL APPROACH FOR DRUG DISCOVERY

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ABSTRACT

Protein-ligand docking is a key methodology of computational drug design, where the prediction of protein-small molecule interactions at the molecular level is done. CB-Dock, as a blind docking method, presents a computerized and effective technique in docking where prospective binding sites are identified automatically and ligand positions are optimized. Conventional approaches like AutoDock and Dock6 need known binding sites for protein studies to work, constraining their uses for new protein studies. CB-Dock overcomes this limitation by automatically recognizing possible binding pockets, and thus it is a useful tool for computational chemists and biotechnologists. The complexity of the disease and the necessity for new drug candidates have motivated the use of computational docking algorithms. The process in CB-Dock involves the detection of the pocket, docking simulation, and scoring, which predicts ligand binding interactions with accuracy. In contrast to traditional docking software, CB-Dock maximizes efficiency by lowering computational cost and offering more than one binding site prediction. Furthermore, CB-Dock's automated process is accessible to scientists who lack considerable computational skills, thus making it possible for high-throughput virtual screening campaigns. Future developments for CB-Dock may involve refinements in the scoring functions, more extensive coupling with molecular dynamics simulations, and AI-based prediction for improved docking accuracy. With advancing computational tools, CB-Dock is also poised to have a more crucial position in current drug discovery processes.

Key Words: Protein-ligand docking, CB-Dock, blind docking, drug discovery, molecular modeling.

ENHANCING THE MECHANICAL PROPERTIES OF SUSTAINABLE CONCRETE USING BRICK POWDER AS A PARTIAL SAND REPLACEMENT

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ABSTRACT

The increasing demand for concrete, driven by urbanization and infrastructure development, significantly strains natural resources and threatens ecological balance. Incorporating recycled materials in concrete presents a viable solution to meeting this demand while maintaining performance standards. This study examines the mechanical properties of environmentally sustainable concrete incorporating brick powder (BP) as a partial sand replacement in fine aggregates. A combination of destructive and non-destructive testing methods was employed to evaluate the concrete's characteristics. Concrete mixtures were prepared with sand replacements ranging from 5% to 25% by brick powder and assessed for workability, compressive strength, and split tensile strength in comparison to conventional concrete. The findings indicate that replacing 10% of sand with brick powder increases compressive strength by 29.94%, reduces workability by 42.66%, and enhances split tensile strength by 8.74%. Regression analysis confirmed a strong correlation between compressive strength, ultrasonic pulse velocity (UPV), and rebound number. The results highlight that a 10% substitution of sand with brick powder enhances mechanical properties and supports sustainable construction practices.

Keywords: Brick powder; Schmidt hammer; strength; ultrasonic velocity; workability.

EVALUATION OF TAXANE-INDUCED SIDE EFFECTS IN PATIENTS WITH BRONCHIAL CANCER: A RETROSPECTIVE ANALYSIS

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Abstract

Introduction: This work focuses on evaluating the side effects induced by chemotherapy with taxanes in patients with bronchial cancer. Taxanes, such as paclitaxel and docetaxel, are key antineoplastic agents used in the treatment of various cancers, including bronchial cancer. However, their use is associated with significant side effects that can impair patients' quality of life and limit treatment efficacy.

Material and methods: Our work is based on a retrospective epidemiological analysis that used patient data from multiple oncology facilities' cancer registries at the Oran city level. Lung cancer patients were questioned and database information on the most common side effects, such as peripheral neuropathy, hypersensitivity reactions, and gastrointestinal disorders, while considering their frequency and severity based on administered doses, patient age, and the number of treatment cycles received.

Results: In this study, we included 142 patients with broncho-pulmonary carcinoma receiving taxanes. We discovered a considerable imbalance in treatment responses, with nonresponders outnumbering responders. Peripheral neuropathy was identified as the most serious side effect, and categorization by treatment tolerance revealed heterogeneity in individual responses and unfavorable impact profiles.

Conclusion: The research aims to establish correlations between these adverse effects and patient clinical characteristics by focusing on a specific population of bronchial cancers patients. The ultimate goal is to enhance understanding of taxane-induced toxicity, identify risk factors, and propose tailored strategies to optimize their use while minimizing negative patient impacts.

ADVANTAGES AND RISKS OF USING AI IN THE PROTECTION OF THE ELDERLY

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Abstract

This paper was carried out within the project "Increasing excellence in research on the relationship between state, religion, and body", Contract no. PN-IV-P8-8.1-PRE-HE-ORG-2024-0233, Funded by UEFISCDI, European and International Cooperation Programme, Horizon Europe Sub-programme. The paper presents the main aspects regarding the role of AI in the protection of the elderly, as highlighted in the specialized literature. On the one hand, the advantages of AI are inventoried and on the other hand, the risks produced by AI and digitalization regarding the quality of life of the elderly are signaled.

In direct relation to elder protection, AI is applied in fields such as medicine, economics, agriculture, law, education, finance, transportation, and media. Diagnosis and therapy of the elderly can be improved, artificial intelligence (AI) can be used to develop personalized treatment plans based on medical history and other factors. Elderly care and health status can also be improved through AI, robots can support caregivers in providing personalized and effective care, improving patient outcomes, and optimizing health resources for the increasingly aging population. In difficult times, older adults can feel more confident when AI technologies provide them with protection and safety.

From a risk perspective, digital technologies can cause social inequities and negative effects on the elderly population, digitalization being a source of exclusion and loss of autonomy for this population category. Also, the limitations of AI in geriatric care also refer to the lack of emotional intelligence and the inability to provide personalized care that takes into account individual preferences and values.

Keywords: artificial intelligence (AI), elderly protection, risks, advantages

STRATEGIES FOR THE SUSTAINABLE DEVELOPMENT OF THE LIVESTOCK SECTOR IN THE CONTEXT OF GLOBALIZATION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Globalization has profoundly transformed the livestock sector, influencing trade flows, resource allocation, and labor market dynamics. As global demand for animal-based products continues to increase, livestock farms encounter both economic opportunities - such as enhanced market access and technological advancements - and significant challenges, including price volatility, competitive pressures, and efficient workforce management. A crucial aspect of this transformation is ensuring a stable and adaptable workforce, which is essential for sustaining farm productivity and operational continuity. In a globalized economy, the availability of human resources is shaped by economic conditions, social factors, and labor market fluctuations. Thus, the livestock sector must implement strategic workforce management approaches, optimizing recruitment, employee retention, and the adoption of innovative technologies that enhance farm efficiency.

This study presents a systematic literature review on the impact of globalization on the livestock sector, with a particular emphasis on the role of labor in maintaining productivity and competitiveness. The analysis explores key economic trends, emerging challenges, and strategic adaptation measures, underscoring the interconnection between livestock sector development and labor market evolution. The findings contribute to a deeper understanding of the adaptive mechanisms required to foster a resilient and sustainable agricultural sector in an increasingly globalized economy.

Key words: agricultural economy, globalization, labor force, livestock sector, sustainability.

CHALLENGES AND OPPORTUNITIES IN MULTINATIONAL HIGH-SPEED RAIL DEVELOPMENT: A EUROPEAN PERSPECTIVE

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ABSTRACT

The development of multinational high-speed rail (HSR) networks plays a crucial role in enhancing regional connectivity, promoting economic integration, and advancing sustainable transportation. Europe has successfully implemented several cross-border HSR projects, such as Eurostar, Thalys, and Rail Baltica, providing valuable lessons for other regions. This paper examines the key challenges and opportunities in multinational HSR development from a European perspective, with implications for future projects in Asia and beyond.

Key challenges include infrastructure standardization, interoperability of signaling and operational systems, regulatory harmonization, and financing mechanisms for large-scale investments. Additionally, geopolitical considerations, environmental concerns, and the need for public-private partnerships (PPP) present significant hurdles. However, the European experience also highlights opportunities, such as the use of GIS and BIM for efficient planning, the application of Transit-Oriented Development (TOD) for sustainable station areas, and advancements in smart mobility solutions to enhance passenger experience.

By analyzing European best practices, this study provides insights into how other regions, particularly Vietnam and China, can optimize their transnational HSR planning. The findings emphasize the importance of technological integration, policy coordination, and strategic investment to create a seamless and efficient international railway network.

Keywords: High-Speed Rail, Multinational Rail Planning, GIS, TOD, BIM, Europe, Vietnam-China Connectivity.

EFFECT OF CORTICOSTEROIDS ON THE EFFICACY OF IMMUNE CHECKPOINT INHIBITORS IN PATIENTS WITH NON-SMALL CELL LUNG

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ABSTRACT

Corticosteroids (CS) are widely used in the treatment of lung cancer patients. Patients receiving immune checkpoint inhibitors (ICIs) may use CS therapy for the management of immune-related adverse effects, comorbided conditions (such as chronic obstructive pulmonary disease and allergies), and palliative care for cancer-related symptoms (including cachexia, pain syndrome, and intracranial hypertension syndrome). The aim of this study was to assess the impact of systemic corticosteroids (SCS) and inhaled corticosteroids (ICS) on the efficacy of immune checkpoint inhibitors in patients with non-small cell lung cancer (NSCLC). A total of 105 NSCLC patients receiving immune checkpoint inhibitors were included in the study. Progression-free survival (PFS) and overall survival (OS) were assessed in patients who did not receive CS therapy and in those who received either systemic or inhaled corticosteroids. The Kaplan-Meier method was used to estimate survival rates. Independent survival predictors were identified using Cox regression analysis. Statistical analysis was performed using Stata v.18.0. The median PFS was 8.6 months, 4.1 months, and 16.8 months for patients who did not receive CS, received SCS, and received ICS, respectively (Log-rank p=0.0001). The median OS was 20.1 months, 6.9 months, and 35.1 months for patients who did not receive CS, received SCS, and received ICS, respectively (Log-rank p=0.0001). SCS therapy was identified as an independent predictor of survival. Patients receiving SCS during immune checkpoint inhibitor therapy had worse survival outcomes compared to those receiving ICS or no CS (HR 3.94, 95% CI 2.29–6.79, p=0.0001). In conclusion, SCS negatively impact PFS and OS in NSCLC patients undergoing immune checkpoint inhibitor therapy. These findings suggest that SCS reduce the effectiveness of immunotherapy, whereas ICS do not demonstrate a similar effect.

Keywords: immune checkpoint inhibitors, corticosteroids, non-small cell lung cancer, efficacy, survival.

DEVELOPMENT OF A NOVEL LOW-COST ADSORBENT CHITOSAN@EDTA@CELLULOSE COMPOSITE TO EFFECTIVELY REMOVE METHYL ORANGE DYE FROM WASTEWATER: EXPERIMENTAL AND THEORETICAL INVESTIGATION

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Abstract

Methyl Orange, a toxic and persistent azo dye, poses significant environmental challenges in aquatic ecosystems. This study investigates the efficiency of a novel Chitosan@EDTA@Cellulose composite, synthesized by linking shrimp-derived chitosan and cactus-derived cellulose using EDTA as a linking agent. Comprehensive characterization techniques, including Fourier-transform infrared spectroscopy, scanning electron microscopy, X-ray diffraction, and Brunauer-Emmett-Teller surface area analysis, were employed. Under optimal conditions (pH 5, 50 mg/L dye concentration, 55 min, 0.1 g adsorbent), the composite achieved a maximum adsorption capacity of 55.87 mg/g, significantly outperforming chitosan (7.29 mg/g) and cellulose (5.69 mg/g). Adsorption followed the pseudo-second-order kinetic model and the Langmuir isotherm model, with thermodynamic analysis confirming a spontaneous and endothermic process. Competitive adsorption tests demonstrated more than 90% removal efficiency despite the presence of interfering ions, attributed to the chelating properties of EDTA and the synergistic effect of the composite structure. Reusability tests showed a slight efficiency decline from 97.8% to 81.86% after four cycles. Box-Behnken Design optimization identified adsorbent mass, pH, and dye concentration as key factors in removal efficiency. Density functional theory analysis clarified the functional group interactions driving adsorption. These findings underscore the composite's potential as an effective and eco-friendly adsorbent for Methyl Orange removal.

Keywords: Adsorption, Box-Behnken Design, Cellulose, Chitosan, Density Functional Theory, Response Surface Methodology.

FOREIGN INVESTMENTS AND THEIR INFLUENCE ON ALBANIA'S TOURISM AND REAL ESTATE MARKET

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Abstract

Foreign investments play an important role in the economic development of countries like Albania. They have significantly contributed to the growth of the economy, job creation, and the improvement of infrastructure and innovations. The real estate and construction sector has greatly benefited from foreign investments, bringing about a noticeable change, especially in tourist areas. Foreign investors have primarily invested their capital in building hotels, apartments, bars, and restaurants, contributing to the growth of the tourism sector.

The tourism industry in Albania has seen significant development in recent years. This success is the result of a successful campaign to promote Albania as an attractive international destination. This phenomenon has led to an increase in real estate prices, making them unaffordable for a significant portion of the population. This study aims to analyze the factors that have influenced the rise in real estate prices and examine the reasons that have led foreign investors to increase their investments in this sector. Real estate, especially those related to tourism and construction, has become a very attractive field for investors, offering numerous opportunities for profit and development. The government should design favorable policies for the development of tourism and encourage investments in this sector.

Keywords*:* Foreign investments, construction, real estate, tourism

AFCTA AND AFRICAN INTEGRATION: WHERE IS THE PEOPLES' INTEGRATION?

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Abstract

The Africa Continental Free Trade Area (AfCFTA) holds a lot of potentials for intra-African Trade to galvanise the continent into sustainable development, industrialisation and economic growth. However, while the benefits are enormous, African integration suffers several challenges: proliferation of regional economic communities (RECs) disjointed infrastructure, political rivalry, democratic deficit, colonial affiliation, immigration bottlenecks, terrorism, populism and economic nationalism. The paper underscores the African regionalism, regional economic communities and the successes and challenges. The paper emphasis the importance of the AfCFTA but argue that deliberate effort to create a socially integrated Africa is intrinsic for the framework to succeed. Furthermore, it analyses AfCFTA's socioeconomic challenges while emphasising the role of labour and mobility as crucial to trade and continental economic growth. African has one of the most complex ethno-religious makeups. Therefore, it is very herculean to define Africa and who is an African. Therefore, Africa is theorised in terms of geography, people and ideology. The paper raise questions such as, can the AU structure and AfCFTA guarantee a peaceful and socially integrated Africa? What is the collective identity of African people in the tide of economic nationalism and Afrophobia? The paper is hinged on qualitative review published materials and social media sources. The paper anticipates to contribute to the urgent discourse on AfCFTA and people-to-people relations in the rising tides of Afrophobia in the continent.

Keywords: Regional Integration, AfCFTA, RECs, Social Integration, African Union, Afrophobia, Economic Nationalism

AI IN HEALTHCARE: TRANSFORMING DIAGNOSIS AND TREATMENT

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Abstract

Artificial Intelligence (AI) is transforming healthcare and biomedicine, enabling more accurate diagnostics, personalized treatments, and efficient patient care. AI-powered tools such as deep learning, natural language processing, and computer vision enhance medical imaging, predictive analytics, and drug discovery. This paper explores AI's role in early disease detection, robotic-assisted surgery, and precision medicine, along with its impact on hospital management and electronic health records.

Despite its benefits, challenges like data privacy, ethical concerns, and model transparency remain. Through real-world applications, this study highlights AI’s potential to revolutionize healthcare while emphasizing the need for responsible implementation to ensure equitable and effective medical solutions.

Keywords: AI in Healthcare, Medical Imaging, Predictive Analytics, Precision Medicine, AI Ethics.

PHYSICOCHEMICAL QUALITY OF GROUNDWATER SAMPLES AROUND FEDERAL COLLEGE OF ANIMAL HEALTH AND PRODUCTION TECHNOLOGY, IBADAN, NIGERIA STUDENTS' RESIDENTIAL AREAS

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Abstract

Groundwater resources provide an alternative way to tackle the shortage of water supply in many areas. It is a major source of water in Federal College of Animal Health and Production Technology, Ibadan, Nigeira. Hence, the study was conducted to investigate the physicochemical profile of groundwater samples by standard analytical procedure. A total of ten water samples from five sampling points within the study area were collected. Elevation and coordinates of the locations were taken using a global positioning system. Results of the physical parameters showed: pH (7.08 -7.29), Temperature (25 - 45.90)℃, Total dissolved solid (82.00 - 484.50) mg/L, Electrical conductivity (154.50 - 949.00) µ/cm, Turbidity (12.81 - 82.65) NTU, Total alkalinity (2.91- 38.16) mg/L and Total hardness (2.20 - 202.85) mg/L; values were lower than WHO safe limit except for turbidity. Results of the chemical parameters showed (mg/L): cations - Ca^{2+} (0.71 -190.96), K^{+}(1.52 - 10.01), Mg^{2+}(1.49 - 15.87) and Na^{+} (7.37 - 88.30); anions -PO^{-}_{4} (BDL - 1.77), SO^{2-}_{4} (1.34 - 32.95), NO^{-}_{3} (30.36 - 722.07), NO^{-}_{2} (12.72 - 354.05), Cl^{-} (16.08 - 127.79) and Fl^{-} (0.14 - 0.88); heavy metal - Fe (BDL - 9.85), Cu (0.35 - 6.40), Zn (2.50 - 6.10), Mn (0.38 - 2.95), Cr (BDL - 20.43), Ni (1.25 - 7.80), Pb (BDL - 0.65) and Cd (0.18 - 0.88); values obtained were within the safe limits set by WHO except for NO_3^{-} and NO_2^{-}. High nitrate and nitrite levels indicate sewage pollution. Thus, the groundwater samples may not be safe for consumption and domestic use unless it is treated. The potential health risk due to heavy metal contamination in the groundwater samples should be evaluated in order to reveal health implications of the water when ingested. However, this study could serve as a baseline for further research in the future.

Keywords: Groundwater, physicochemical, heavy metal, health risk.

ANTHRAX

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Abstract

Bacillus anthracis, the zoonotic pathogen that causes anthrax, is a serious threat to biosecurity, agriculture, and human health. Strong virulence factors produced by the bacterium, such as the anthrax toxin complex (protective antigen, deadly factor, and edema factor), impair immune function and cause serious illness. The three primary kinds of anthrax are gastrointestinal, cutaneous, and inhalational; the last is the most lethal. In addition to discussing the growing threat of anthrax as a biological weapon, this paper looks at the genetic mechanisms of B. anthracis, including plasmids involved in toxin production, its environmental persistence as spores, and transmission through animal contact. Although detection has increased because to advancements in diagnostic procedures like PCR and immunohistochemistry, early diagnosis is still difficult, particularly in settings with limited resources. Antibiotics like ciprofloxacin and doxycycline are used in treatment, although antimicrobial resistance is a growing issue. Vaccination is essential for prevention; there are few human vaccine choices, but there are veterinary vaccines accessible. In order to prevent and contain epidemics, particularly in areas with insufficient healthcare infrastructure, the review also emphasizes the significance of global surveillance, biosecurity protocols, and the One Health concept.

Keywords: Anthrax, *Bacillus anthracis*, Virulence Factors, Inhalational Anthrax, Bioterrorism, Diagnosis, Vaccine Development, Antimicrobial Resistance, Global Surveillance, One Health.

Introduction

Bacillus anthracis, a Gram-positive, spore-forming bacteria that is mostly found in soil, is the cause of the zoonotic infectious disease anthrax (Turnbull, 2008). This virus is distinct because it can generate spores that are extremely resilient to environmental stressors including heat, desiccation, and UV light, enabling them to last for long periods of time in the environment (Boyer et al., 2009). Humans can contract B. anthracis by direct contact with infected animals or their products, consuming contaminated food, or inhaling spores, even though the disease typically affects herbivorous animals such as cattle, sheep, and goats (Junqueira & Carneiro, 2005).

The ability of B. anthracis to create strong toxins that impair cellular function is what makes it pathogenic. Among these toxins are the edema toxin (ET) and lethal toxin (LT), which both aid in tissue destruction, immune evasion, and the spread of infection throughout the body (Klee et al., 2006). Depending on the mode of transmission, the disease can present in four main ways: cutaneous, inhalational, gastrointestinal, and injectional.

• The most prevalent type of anthrax is cutaneous, which is contracted by coming into touch with contaminated animal products or infected animals. Usually, it starts as an itchy, painless sore that turns into a black-centered ulcer (Tucker, 2000).

• Although infrequent, inhalational anthrax is the most deadly type; it frequently manifests as flu-like symptoms before developing into severe respiratory distress, shock, and, in the event that treatment is not received, death (Dixon et al., 2000).
• After eating tainted meat, gastrointestinal anthrax can cause vomiting, severe abdominal discomfort, and bleeding in the gastrointestinal tract (Junqueira & Carneiro, 2005).
• Recent years have seen reports of injectional anthrax, a newly discovered type linked to illegal drug use that is marked by a high fatality rate and quick progression (Boyer et al., 2009).

Controlling the disease is made more difficult by B. anthracis spores' resistance to environmental stressors and their capacity to lie latent for years or even decades, especially in places with poor veterinary care or restricted access to medical facilities (Moss, 2012).

Furthermore, because of the significant fatality rates linked to inhaling anthrax and the relative ease with which its spores can spread, B. anthracis is considered a possible biological warfare agent (Guillemin, 2005).

Early treatment is the most effective way to treat anthrax. First-line therapies for inhalational anthrax include antibiotics such ciprofloxacin and doxycycline; however, because mortality is still high even with early antibiotic delivery, a combination of antibiotics and supportive therapy is necessary (Glickman et al., 2004). Vaccination is an important preventive measure for people who are at high risk of exposure, such as laboratory workers and military personnel (Moss, 2012).
Improved veterinary control strategies, such as cattle immunization programs, have reduced the global anthrax burden in recent decades. However, anthrax outbreaks continue to happen, especially in regions of Asia, Eastern Europe, and Africa where control measures are laxer and animal immunization is not common (Turnbull, 2008). Anthrax is still a major public health concern because of its potential for bioterrorism and the ongoing risk of outbreaks in some areas (Tucker, 2000).

Literature Review on Anthrax

Bacillus anthracis, a spore-forming, Gram-positive bacteria that grows well in soil, is the cause of the zoonotic infectious disease anthrax, which can seriously harm both people and animals. Because it can produce extremely resistant spores that can endure for decades in hostile environments, Bacillus anthracis is a powerful pathogen (Turnbull, 2008). The effects of anthrax on agriculture, public health, and its potential as a bioterrorism agent have all been the subject of much research. Drawing from a range of scientific fields and recent research developments, this review summarizes the existing body of information regarding the epidemiology, etiology, clinical symptoms, diagnostic techniques, treatment choices, and prevention measures for anthrax.

Epidemiology and Transmission of Anthrax

The environment in which Bacillus anthracis lives has a direct impact on the epidemiology of anthrax. Spores of Bacillus anthracis are mostly found in soil, where they can survive for extended periods of time. The health of both wild and domesticated animal populations as well as agricultural economy are significantly impacted by this. With sporadic outbreaks in the US and other industrialized countries, the illness is endemic throughout most of the world, especially in sub-Saharan Africa, South Asia, and portions of Europe and the Middle East (Moss, 2012). According to Boyer et al. (2009), sporadic outbreaks in animal populations persist, particularly in areas with inadequate veterinary control efforts.

Aerosolized spores can potentially cause infection, particularly in bioterrorism situations, but direct contact with infected animals or contaminated animal products is usually how the disease is spread to humans (Tucker, 2000). According to Junqueira and Carneiro (2005), occupational groups that are more likely to be exposed to B. anthracis by cutaneous, inhalational, or gastrointestinal pathways include farmers, veterinarians, butchers, and laboratory workers. Despite being less frequent, inhalational anthrax has historically been the most deadly kind, leading to significant death rates (Dixon et al., 2000).

The epidemiology of Bacillus anthracis is further complicated by the possibility that it could be used as a biological weapon. The potential for the virus to create widespread fear and injury in urban environments was shown by the 2001 anthrax assaults in the United States, where spores were purposefully dispersed through the postal system (Guillemin, 2005). In order to reduce the hazards associated with purposeful anthrax exposure, these attacks highlighted the necessity of strong detection, containment, and response strategies (Glickman et al., 2004).

Pathogenesis of *Bacillus anthracis*

Bacillus anthracis's capacity to produce a wide range of virulence factors, chief among them its toxins, lethal toxin (LT) and edema toxin (ET), is the primary cause of anthrax pathogenesis. The majority of anthrax's clinical symptoms are caused by these toxins, which are encoded on the pXO1 plasmid. Protective antigen (PA) and lethal factor (LF) make up the fatal toxin, whereas PA and edema factor (EF) make up the edema toxin. Tissue damage and cellular dysfunction result from PA's binding to cell surface receptors, which allows LF and EF to enter the host cell (Klee et al., 2006).

While the edema toxin (ET) damages endothelial cell integrity and results in fluid accumulation, which contributes to the development of edema and weakened immune response, the lethal toxin (LT) induces a strong inflammatory response and systemic vascular collapse, resulting in organ failure (Hernandez et al., 2005). Early diagnosis and care are essential to preventing fatal consequences, particularly in cases of inhalational anthrax, due to Bacillus anthracis's capacity to inflict quick and extensive tissue damage (Dixon et al., 2000).

Furthermore, a key component of B. anthracis' pathogenicity and environmental survival is its capacity to produce extremely durable spores. Even in the absence of an appropriate host, spores can lie dormant for long periods of time. The spores can reactivate, germinate, and develop the vegetative form of the bacteria, which releases toxins and causes disease, when exposed to suitable environmental circumstances (Boyer et al., 2009). Because of its ability to generate spores and infiltrate many bodily systems, B. anthracis is a hazardous and adaptable pathogen.

Clinical Manifestations of Anthrax

The clinical manifestations of anthrax vary widely depending on the route of infection, with cutaneous, inhalational, gastrointestinal, and injectional forms representing the primary clinical presentations.

- **Cutaneous Anthrax :**

Over 95% of human cases of anthrax are of the most frequent and mildest type, cutaneous anthrax. Direct contact with tainted animal products or diseased animals is usually the cause. The condition starts as a painful papule and develops into an ulcer with an eschar, a distinctive black necrotic core. Although mortality is minimal in the absence of complications, it can result in bacteremia and systemic infection if left untreated (Tucker, 2000).

- **Inhalational Anthrax:**

Inhaled The deliberate release of spores as a biological weapon is the main association with anthrax, the most deadly type of the disease. At first, inhalational anthrax causes vague flu-like symptoms like fever, coughing, and exhaustion. However, patients may get septic shock, hemorrhagic mediastinitis, and severe respiratory distress within 24 to 48 hours. According to Dixon et al. (2000), early diagnosis and intervention are significantly hampered by the rapid progression of symptoms, and mortality rates persist despite vigorous therapy.

- **Gastrointestinal Anthrax:**

Although it happens seldom, intestinal anthrax is contracted by eating tainted meat from sick animals. Abdominal pain, nausea, vomiting, and gastrointestinal bleeding are all part of the clinical presentation. Death and systemic sepsis may result from the infection if left untreated (Junqueira & Carneiro, 2005). The mortality rate for the gastrointestinal type is substantial, especially when there is a significant gastrointestinal bleeding.

- **Injectional Anthrax:**

A more recent and developing type of anthrax connected to illegal drug usage is injectional anthrax. It has been reported that injecting tainted heroin can result in injectional anthrax. Soft tissue infections, severe sepsis, and necrotizing fasciitis are among the quickly developing symptoms of this kind of anthrax (Boyer et al., 2009). Because injectional anthrax has an especially high death rate, prompt diagnosis and treatment are essential.

Diagnostic Approaches for Anthrax

Anthrax is mainly diagnosed clinically, and laboratory confirmation is crucial for both public health response and successful treatment. Particularly in cases of inhalational anthrax, when fatality rates can reach 100% in the absence of prompt care, early detection is essential. Diagnostic techniques consist of:

- **Culture and Gram Staining:** Gram staining shows distinctive big, Gram-positive rods with no spores in the blood or tissue samples, and Bacillus anthracis is easily recognized on common laboratory growth media.

- **Polymerase Chain Reaction (PCR) :** PCR has emerged as a vital technology for the quick identification of Bacillus anthracis DNA, especially in settings where anthrax exposure is suspected, including in cases involving bioterrorism (Baillie et al., 2006). Early detection of anthrax cases is made possible by PCR assays, which may identify B. anthracis and its virulence genes.

- **Serology**: In patients exposed to the pathogen, serological assays that identify antibodies against anthrax toxins, such as the fatal factor and edema factor, can aid in diagnosis confirmation (Moss, 2012). These tests are very helpful in post-exposure evaluations and epidemiological studies.

Treatment and Prevention

Antibiotics like ciprofloxacin, doxycycline, and penicillin are the first-line treatment options for all forms of anthrax; however, inhalational anthrax requires combination therapy with intravenous antibiotics and the addition of anthrax-specific antitoxins, like obiltoxaximab, to neutralize circulating toxins (Glickman et al., 2004). In severe cases, supportive therapies, such as mechanical ventilation and intensive care, may be necessary to manage respiratory failure and shock.

Particularly for those who are at a high risk of exposure, such as military personnel, laboratory professionals, and veterinarians, vaccination is still an essential preventive step. The main ingredient of the anthrax toxin, protective antigen, is present in the cell-free filtrate that makes up the human anthrax vaccination (Moss, 2012). Despite its effectiveness, the vaccination has raised certain safety concerns and its use has been restricted to some high-risk groups. In endemic areas, vaccination campaigns have been quite effective in lowering the frequency of anthrax outbreaks in animals (Turnbull, 2008). In order to prevent human cases and stop the spread of anthrax, animal vaccination programs are essential, especially in areas with inadequate veterinary surveillance and control measures.

Bioterrorism and National Security Concerns

One of the biggest threats to national security is the intentional use of Bacillus anthracis as a biological weapon. The possibility of bioterrorism was brought into stark relief by the 2001 anthrax assaults, which involved the deliberate spread of spores via the U.S. postal system (Guillemin, 2005). This event made clear how susceptible contemporary society are to biological threats and how urgently anthrax exposure must be detected, contained, and treated medically (Tucker, 2000).

Governments and international organizations have made significant investments in improving monitoring systems, accelerating diagnostic methods, and building up national vaccine and therapeutic agent stocks to combat bioterrorism in response to these concerns. Using the knowledge gained from previous outbreaks and bioterrorism incidents, public health organizations are continuously improving their emergency response plans for biological occurrences (Boyer et al.,2009).

Conclusion

Because of its zoonotic origin, potential for broad transmission, and potential as a biological weapon, anthrax, which is caused by Bacillus anthracis, continues to pose a serious threat to public health. Anthrax continues to be a natural and deliberate hazard to human and animal populations worldwide, despite improvements in our knowledge of its epidemiology, pathophysiology, and clinical management (Moss, 2012; Boyer et al., 2009). The variety of clinical presentations of the disease, from the relatively mild cutaneous form to the quickly lethal inhalational anthrax, highlights its complexity (Dixon et al., 2000). Because of its strong toxins and unusual ability to produce extremely durable spores, B. anthracis is able to remain in the environment and inflict extensive tissue damage when infected (Klee et al., 2006; Hernandez et al., 2005).

The quick spread of anthrax, particularly in cases of inhalational infection, necessitates ongoing improvement of clinical procedures and public health readiness, even though tremendous progress has been made in the creation of efficient diagnostic techniques, treatment plans, and preventive measures (Baillie et al., 2006).
The threat of bioterrorism has made anthrax a more serious worldwide health and security issue. The deadly effects of deliberate exposure were made evident by the 2001 anthrax assaults in the United States, which led to the creation of novel detection tools, treatment alternatives, and emergency response plans (Guillemin, 2005; Tucker, 2000). Reducing the harm from possible bioterrorism incidents requires the ability to promptly identify anthrax and take the necessary countermeasures (Glickman et al., 2004).

Human and animal vaccination efforts have been successful in lowering the incidence of anthrax (Turnbull, 2008), but widespread adoption is still hampered by concerns about accessibility, safety, and public opinion (Moss, 2012). Although the inclusion of antitoxins and supportive therapy is essential for severe cases, especially in inhalational anthrax, antibiotic treatment continues to be the cornerstone of anthrax management (Glickman et al., 2004).

Recommendation

Prioritizing immunization for people at high risk of exposure, such as military personnel, laboratory workers, and those handling animal products, is crucial to reducing the hazards of anthrax. Additionally, raising public awareness of safe handling procedures is crucial. For people exposed to anthrax spores, early treatment with antibiotics like ciprofloxacin, doxycycline, or penicillin is essential. To lower the risk of infection, post-exposure prophylaxis with antibiotics should be given to those with confirmed or suspected exposure (Centers for Disease Control and Prevention, 2020). In order to prevent large-scale outbreaks, it is imperative that surveillance systems in the human and veterinary sectors be strengthened, especially in areas where animal epidemics occur often (World Health Organization, 2022).

Effective veterinary surveillance and livestock vaccination programs can also greatly lower the risk of zoonotic transmission, and thorough decontamination procedures should be followed in environments suspected of being contaminated with anthrax spores (U.S. Department of Agriculture, 2020). Lastly, to further lessen the impact of anthrax on public health, greater research into more potent vaccines—including innovative formulations for both humans and animals—as well as improvements in diagnostic and treatment techniques will be essential (National Institutes of Health, 2019).

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NAVIGATING ECONOMIC TURBULENCE: THE IMPACT OF ECONOMIC SHOCKS ON HEALTH FINANCING AND HEALTH OUTCOMES IN NIGERIA

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ABSTRACT

Introduction and Purpose: Economic shocks, including financial crises and pandemics, profoundly impact health financing and health outcomes, particularly in low- and middle-income countries like Nigeria. These disruptions exacerbate existing vulnerabilities, underscoring the need for resilient health systems. This study examines how economic downturns affect health financing and outcomes in Nigeria, drawing insights for policy and practice.

Methods: A systematic review was conducted using academic databases, government reports, and international publications, analyzing data from 2000 to 2024. Both quantitative indicators, such as government health expenditure trends, and qualitative case studies were assessed to evaluate the health sector's response to economic crises. Comparative analyses with countries like Rwanda were also undertaken to identify best practices in mitigating economic shocks.

Results: Findings indicate that economic shocks in Nigeria lead to decreased government health spending, increased out-of-pocket costs, and worsening health disparities, particularly in rural areas. Case studies, including the 2014 oil price collapse and the COVID-19 pandemic, reveal significant disruptions in healthcare access and deteriorating health indicators, such as rising maternal and child mortality rates. In contrast, countries with robust health insurance systems, such as Rwanda, demonstrate greater resilience in maintaining healthcare access during economic downturns.

Conclusions: Key challenges identified include limited health insurance coverage, inadequate social protection programs, and overreliance on donor funding. Strengthening health system resilience requires expanding health insurance coverage, diversifying funding sources, and establishing emergency health funds. This study provides a critical framework for policymakers to develop sustainable health financing strategies that safeguard health outcomes during economic crises.

Keywords: Economic shocks, health financing, health outcomes, resilience, Nigeria, health equity, policy response, health insurance, pandemics.

AVIAN INFLUENZA VIRUS (AIV)

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Abstract

The highly changeable and contagious Avian Influenza Virus (AIV) poses a serious risk to public health and the worldwide poultry business due to its potential for zoonotic transmission to humans. This review of the literature offers a thorough analysis of the molecular biology, epidemiology, and changing effects of AIV on human and bird populations. Worldwide, AIV, which is mainly divided into two main types—low pathogenic avian influenza (LPAI) and highly pathogenic avian influenza (HPAI), is the cause of frequent and destructive outbreaks, especially of the H5 and H7 subtypes, which include the infamous H5N1, H7N9, and H5N8 strains. The review explores the complex molecular mechanisms of AIV, including viral entry, replication, and the genetic factors driving antigenic variation, reassortment, and host adaptation. Additionally, the role of migratory wild birds as reservoirs and vectors of AIV transmission across continents is critically examined, along with the implications of domestic poultry movements and intensive farming practices in shaping the dynamics of AIV outbreaks. These strains have not only caused significant economic losses in poultry farming but also posed a serious risk for human infection, with cases of interspecies transmission and the possibility of viral reassortment that could result in pandemic strains. Even though global surveillance efforts are substantial, early detection is extremely difficult, especially in resource-poor places. The review emphasizes how developments in diagnostic tools, like high-throughput sequencing and molecular tests, allow for the quick detection of new strains. There is also a thorough discussion of the difficulties in managing AIV, which are made worse by the virus's quick rates of mutation and the development of antiviral resistance. Public safety and avian health are examined in relation to preventive measures, such as immunization campaigns and biosecurity protocols in chicken farms. Effective worldwide control is still hampered by the intricate relationships between virus evolution, host immunity, and environmental factors, even with continuous improvements in vaccine development and antiviral treatments. The review's conclusion highlights the need for global cooperation and integrated One Health strategies to strengthen response systems, increase surveillance, and lessen the likelihood of avian influenza-related pandemics in the future.

Keywords: Avian Influenza Virus, HPAI, LPAI, H5N1, H7N9, Zoonotic Transmission, Viral Evolution, Antigenic Variation, Reassortment, Host Adaptation, Surveillance, Diagnostic Technologies, Antiviral Resistance, Vaccine Development, Migratory Birds, Biosecurity, One Health, Pandemic Preparedness.

Introduction to Avian Influenza Virus (AIV)

The highly contagious viral infection known as "avian influenza," or "bird flu," mainly affects birds, especially livestock. It is caused by the Avian Influenza Virus (AIV), a subtype of the influenza A virus belonging to the Orthomyxoviridae family (Webster et al., 1992). Based on the two surface proteins, hemagglutinin (HA) and neuraminidase (NA), which define the strain's virulence and host range, AIV is divided into several subgroups. Because they are

linked to serious illness in both people and birds, the H5 and H7 subtypes are most concerning among them (Liu et al., 2016).

In the early 2000s, the most notorious strain of these, H5N1, became a serious public health concern and is now the focus of global surveillance efforts (Peiris et al., 2007). The majority of AIV's victims are birds, and the virus naturally spreads through wild birds, particularly waterfowl (Alexander, 2007). However, poultry are especially vulnerable, and epidemics can cause devastating financial losses because of widespread bird slaughter, trade restrictions, and public anxiety about the disease spreading to people. Direct contact with contaminated feed, water, or equipment, as well as the droppings and nasal secretions of sick birds, can spread the virus (Swayne, 2008).

Controlling the virus is especially difficult in chicken farming situations with a high population density since it can also spread indirectly through contaminated surfaces (Bahl et al., 2009). AIV primarily infects birds, although some strains, especially the H5N1 and H7N9 subtypes, have shown the capacity to infect humans across species boundaries. Although AIV infections in humans are uncommon, they can cause serious respiratory conditions and a high death rate when they do happen (Chen et al., 2014). A serious public health worry is the possibility that AIV will experience genetic mutation and recombination, creating new strains that are more contagious to people.

The 2009 H1N1 influenza pandemic, for instance, demonstrated how quickly influenza viruses may change, highlighting the significance of continuous monitoring and readiness for zoonotic spillover events (WHO, 2009).

The potential for human pandemics is a major driving force behind the considerable study of avian influenza's epidemiology, modes of transmission, and mutation patterns. Given how easily AIV may spread in bird populations, there is concern worldwide about the possibility that an AIV strain could develop into a pandemic strain that can transfer from person to person. The establishment of biosecurity standards in chicken production, mobility limitations, and the culling of affected animals are the usual control strategies (Gilbert et al., 2006).

Monitoring AIV's genetic development in wild birds and its ability to spread between species is essential for averting future human outbreaks in addition to managing animal health (Smith et al., 2009).

Because AIV has the potential to inflict serious public health catastrophes as well as economic destruction in the chicken industry, the scientific community is closely monitoring its development. To reduce the hazards posed by this virus, more developments in vaccine research, antiviral treatments, and international surveillance systems are necessary.

Literature Review on Avian Influenza Virus (AIV)

Overview of Avian Influenza Virus (AIV)

The Avian Influenza Virus (AIV), a member of the Orthomyxoviridae family of RNA viruses that are divided into types A, B, C, and D, is the cause of Avian Influenza (AI). AIV is a member of type A, which is the primary cause of outbreaks in birds and sporadically in people and has the highest zoonotic potential. Hemagglutinin (HA) and neuraminidase (NA), two surface proteins that define the influenza A virus, are also used to further classify the virus (Webster et al., 1992).

There are 11 NA and 18 HA subtypes; H5 and H7 are among the most significant for human health. These strains provide serious threats to public health and have been connected to multiple zoonotic epidemics (Peiris et al., 2007; Liu et al., 2016). The 1997-detected H5N1 strain is especially well-known for its high human fatality rate, while the 2013 Chinese-

detected H7N9 virus also showed notable virulence and high human mortality rates (Gao et al., 2013).

Transmission Dynamics of Avian Influenza

Since ducks are the virus's natural reservoirs, birds are the primary victims of avian influenza. Ducks, swans, and geese are examples of migratory waterfowl that carry both low-pathogenic (LPAI) and high-pathogenic (HPAI) strains of avian influenza, often without showing any symptoms (Webster et al., 1992). The virus can spread to other birds and habitats because these birds excrete it in their saliva, feces, and nasal secretions. Poultry farms are at significant risk from avian influenza viruses, which can be transmitted by direct contact with diseased birds, contaminated water, feed, equipment, and aerosols (Swayne, 2008).

The intricate dynamics of AIV transmission are highlighted by studies by Bahl et al. (2009) and Gilbert et al. (2006), including the possibility of indirect transmission through contaminated surfaces or fomites. The virus can spread quickly in highly populated poultry production environments, particularly when biosecurity controls are inadequate. The migration patterns of wild birds, which have the ability to spread the virus over great distances and frequently introduce it into new geographic areas, increase this risk (Bahl et al., 2009). Additionally, the transfer of infected animals, equipment, or even human carriers can transmit AIV into chicken farms (Swayne, 2008).

Even though avian influenza is a disease that mainly affects birds, it can occasionally infect humans, which makes public health extremely concerned. AIV infections in humans are uncommon but extremely dangerous, especially those caused by strains like H5N1 and H7N9, which have shown little human-to-human transmission but high virulence once spread (Chen et al., 2014). Although airborne transmission has also been proposed in some circumstances, human infections usually result from close contact with infected birds or their secretions (Liu et al., 2005).

Pathogenesis and Clinical Manifestations in Avian Species

From moderate, asymptomatic infections with low pathogenic strains to severe, frequently deadly diseases with high pathogenic strains, avian influenza can produce a wide range of illness severity in birds. According to Liu et al. (2016), HPAI strains, including H5N1, are well known for rapidly producing systemic sickness in poultry, which frequently leads to sudden death, high mortality, and organ failure. On the other hand, among wild waterfowl, LPAI strains might not even be detected or just produce minor respiratory symptoms. Rapid replication in a variety of organs, such as the respiratory, gastrointestinal, and neurological systems, is a pathogenesis of HPAI strains that leads to acute sickness and mortality (Swayne, 2008).

The cleavage location of the hemagglutinin (HA) protein is thought to be responsible for the virulence of HPAI strains, as it facilitates the virus's more effective dissemination inside host tissues (Swayne et al., 2007). Birds with the infection may exhibit symptoms like cyanosis, head and neck edema, depression, and respiratory distress (Liu et al., 2016). AIV is one of the most dangerous diseases in commercial poultry because of its high mortality rate in vulnerable avian populations.

Genetic Evolution and Antigenic Drift/Reassortment

A vital component of AIVs' capacity to adapt to novel hosts and environmental circumstances is their exceptional genomic flexibility. Eight RNA segments make up the virus's genome, and

when two distinct strains infect the same host cell, they can reassort and create new viral strains (Webster et al., 1992). Its capacity to experience antigenic shift and drift is especially important since it can result in viruses with changed pathogenicity, transmissibility, and antigenicity, making disease control more difficult.

Pandemic strains have emerged as a result of antigenic shift, which is caused by the reassortment of viral genes across avian, human, and swine influenza viruses. This process was seen during the 2009 H1N1 influenza pandemic, which resulted from the reassortment of human and avian influenza strains with a swine-origin H1N1 virus (Smith et al., 2009). A zoonotic spillover event is more likely to occur as a result of this change in the viral genome, which can also help the virus adapt to new species, like humans. Conversely, point mutations in the virus's genome cause antigenic drift, which can lead to minute alterations in the viral proteins that enable the virus to elude the host immune response and make vaccine development more difficult (Liu et al., 2016).

The constant appearance of new, more virulent strains of AIV has been largely attributed to its evolution through reassortment and drift. This has made it difficult to produce effective antiviral treatments and broad-spectrum vaccinations, highlighting the necessity of continuous AIV surveillance in avian populations.

Economic and Trade Impacts of Avian Influenza

AIV outbreaks have a huge economic impact, especially in nations where raising chickens is a major business. The elimination of contaminated products, the culling of diseased birds, and the use of control measures including quarantines, travel restrictions, and improved biosecurity procedures are all examples of the direct costs associated with outbreaks. These actions occasionally result in farm closures, supply chain interruptions for chicken, and significant financial losses (Gilbert et al., 2006). Moreover, constraints on international trade, including prohibitions on the import of chicken from impacted nations, may cause a decline in export earnings and market access (Bao et al., 2009).

For example, the 2003 H5N1 outbreak caused significant disruptions to international trade, with numerous nations prohibiting the import of chicken from impacted areas, costing the global poultry sector billions of dollars in losses (Pantin-Jackwood et al., 2017). Similar to this, millions of birds were culled as a result of the 2014–2015 HPAI outbreaks in the United States; the projected losses, including indirect costs associated with trade restrictions, depopulation, and consumer confidence, exceeded $3 billion (Pantin-Jackwood et al., 2017). These outbreaks highlight the serious economic and trade-related effects of avian influenza as well as the interdependence of chicken markets around the world.

Prevention, Control, and Surveillance Strategies

Strict biosecurity protocols, early detection, and surveillance are the mainstays of AIV control and prevention. Early detection of AIV outbreaks depends on monitoring both domestic and wild bird populations, especially in areas where migratory waterfowl populations are highly concentrated. While quarantine and disinfection procedures are used to control transmission, infected birds are frequently killed to stop the virus from spreading (Swayne, 2008). Particularly in nations where AIV poses a serious danger to chicken industry, vaccination is a contentious but popular control method. However, the effectiveness of immunization varies depending on the strain, as antigenic change may cause some vaccines to not offer sufficient protection against newly emerging, circulating strains (Liu et al., 2016).

The creation of universal vaccinations that offer more comprehensive defense against several AIV subtypes is urgently needed. Although the effectiveness of current antiviral medications

against avian influenza is limited, antivirals that target viral replication and propagation are also being investigated (Swayne, 2008).

To lessen the effects of AIV outbreaks, it is essential to set up international surveillance networks and cooperate with governmental agencies, academic institutions, and global health organizations such as the World Health Organization (WHO) and the World Organization for Animal Health (OIE). According to Bahl et al. (2009), early interventions when new zoonotic strains develop and the containment of possible pandemics depend on improved global communication and quick response networks.

Future Directions and Research Needs

Further research in the domains of epidemiology, virology, and immunology is essential due to the dynamic character of AIV and its potential for zoonotic spillover. Focus areas include developing pan-influenza vaccines, enhancing diagnostics for early detection, and comprehending the mechanics behind viral reassortment and mutation (Gao et al., 2013). Furthermore, in order to create more effective mitigation techniques, research into antiviral medicines and the role of environmental factors in the transmission of AIV is essential. Continued research will be essential to the global effort to stop AIV-caused pandemics in the future. Gaining knowledge about the genetic evolution of the virus and the molecular factors influencing cross-species transmission can help design more efficient control strategies (Smith et al., 2009).

Conclusion

The global economy and public health are still at serious risk from the Avian Influenza Virus (AIV). As natural reservoirs and transmission vectors, the virus mostly affects bird species, especially ducks. High-pathogenic strains like H5N1 and H7N9 cause severe disease outbreaks in poultry, with significant mortality and significant economic repercussions for the poultry industry, whereas low-pathogenic strains frequently cause only mild symptoms or no symptoms at all (Swayne, 2008; Liu et al., 2016). As demonstrated by their sporadic transmission to humans, which can result in cases of severe sickness and death, such as H5N1 in 1997 and H7N9 in 2013, these strains also have zoonotic potential (Peiris et al., 2007; Gao et al., 2013).

AIV's genetic diversity, especially through antigenic shift and drift, allows the virus to evolve quickly, making attempts at effective control and vaccine development more difficult. The possibility that new, more virulent strains of AIV will emerge due to gene reassortment between avian, swine, and human species raises the possibility of a pandemic (Smith et al., 2009). This genetic adaptability emphasizes the difficulties in managing AIV outbreaks and calls for ongoing monitoring and the creation of more adaptable vaccines (Bahl et al., 2009; Liu et al., 2016).

AIV has a significant financial impact; direct expenses include the removal of diseased birds, the imposition of quarantine and travel restrictions, and the interruption of international trade.

For instance, the 2003 H5N1 outbreak caused the poultry business to lose billions of dollars, and trade restrictions that impacted international poultry markets made matters worse (Pantin-Jackwood et al., 2017). Furthermore, outbreaks of AIV compromise food security, particularly in developing nations that depend significantly on chicken raising (Gilbert et al., 2006). Integrated control techniques that include early discovery, quick reaction, stringent biosecurity protocols, and immunization are necessary to lessen the effects of AIV. However, because of the virus's antigenic diversity, vaccines could not always offer long-term protection, particularly against recently emerging strains (Swayne, 2008). In addition to improving

knowledge of the virus's evolution, dynamics of transmission, and interactions with different host species, ongoing research is crucial for improving the development of vaccines, antiviral therapies, and diagnostic tools (Gao et al. al., 2013).

Recommendation

Global surveillance systems for early identification of the Avian Influenza Virus (AIV), which mostly affects wild bird and poultry populations, must be reinforced in order to reduce the hazards associated with this virus. In order to stop the transmission of viruses, poultry farms must use stronger biosecurity measures, such as limiting animal movement, enhancing sanitation, and maintaining stringent quarantine guidelines. To combat the genetic diversity of the virus and guarantee defense against new strains with the potential to spread like a pandemic, broad-spectrum vaccinations must be created. To better plan for and respond to future outbreaks, international cooperation in vaccine research and data sharing will be essential.

In order to track and address zoonotic transmission, governments should also improve public health readiness, emphasizing prompt availability to vaccinations and antivirals in the event of an outbreak. Controlling breakouts and averting worldwide economic disruptions can be achieved by fortifying trade laws and rapid response procedures. The risk of AIV transmission to poultry must be decreased by environmental management, which includes keeping an eye on migratory bird populations and wetland regions. Lastly, funding training and capacity building for farmers, veterinarians, and healthcare professionals would strengthen biosecurity protocols worldwide and increase response capabilities.

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AWARENESS AND USAGE OF ELECTRONIC RESOURCES IN INTERACTIVE IN INTERACTIVE–ENGAGEMENT AND ANALOGY–ENHANCEMENT INSTRUCTIONAL STRATEGIES AS DETERMINANT OF THE ACHIEVEMENT OF STUDENTS IN BIOLOGY

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ABSTRACT

The study investigated the "Biology teacher's awareness and usage of electronic resources in interactive – engagement and analogy – enhancement instructional strategies as determinant of the achievement of students in Biology". The population of the study comprises of all biology teachers in Senior Secondary Schools in Minna metropolis. Five public secondary schools and private secondary schools were considered. The findings of the study also investigated the level of usage of electronic resources by biology teachers in interactive – engagement and analogy – enhancement instructional strategies. From the result of the analysis the respondents agreed upon the fact that, they neither often use electronic resources in interactive – engagement and analogy – enhancement instructional strategies, not find easy in usage of electronic resources while adopting interactive – engagement and analogy – enhancement instructional strategies. The effect of this is that there is inadequate or no use of electronic resources while adopting interactive – engagement and analogy – enhancement instructional strategies. P-value of 0.89 was obtained after the pilot test. As a result, there was no statistical significant difference between male and female biology teachers' responses on awareness of assimilation of electronic resources in interactive – engagement and analogy – enhancement instructional strategies. Based on the conclusion the following recommendations were made; more awareness program should be organized to sensitize biology teachers on the assimilation of electronic resources in interactive – engagement and analogy – enhancement instructional strategies, The teachers as well as secondary school management should be encouraged on adequate assimilation of electronic resource in interactive – engagement and analogy – enhancement instructional strategies, challenges and factors affecting adequate assimilation of electronic resources in interactive – engagement and analogy – enhancement instructional strategies cited in the study should be looked into, in order to improve teaching and learning, regular training and re-training of biology teachers should be organize to improve their knowledge on usage of electronic resources in interactive – engagement and analogy – enhancement instructional strategies.

Keywords: Interactive-Engagement, Analogy-Enhancement, e-Resources

WATER QUALITY ASSESSMENT FOR IRRIGATION USING THE IRRIGATION WATER QUALITY INDEX

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Abstract

Groundwater pollution is a major problem in most countries, including Morocco. This study was aimed at evaluating the suitability of groundwater for irrigation in Sidi Slimane, Morocco, using the irrigation water quality index (IWQI). Water samples were collected from 20 wells in 2018. Electrical conductivity (EC), sodium adsorption rate (SAR), sodium ions (Na+), chloride ions (Cl-), and bicarbonate ions (HCO3-) were measured, and the parameter values were used to compute and plot the irrigation water quality index (IWQI). The results showed that the average values for EC and SAR of the groundwater samples were 4915±3772 µS/cm and 11.22 ±5.36, respectively. Water toxicity was calculated in terms of sodium ion concentration (Na+), yielding a mean value of 32.09±22.03 meq/L. Furthermore, the average chloride and bicarbonate ion concentrations in the study area were 31.31±22.86 meq/L and 7.568±2.599 meq/L, respectively. The IWQI map revealed that more than 65% of the water samples were in the excellent category, which is dominant in the large areas in the west; 35% of the water samples were in the good category in the center of the study area, and 5% of the water samples were in the poor category in the east of the study area. The findings of this study should be taken into account for the management of groundwater for irrigation in the Sidi Slimane region of Morocco.

Key words: Groundwater quality, Irrigation, Water quality index, Sidi Slimane, Morocco.

GLOBALIZATION OF MIRACLES: REIMAGINING *AL-ISRĀ'WAL-MI'RĀJ* THROUGH THE LENS OF MODERN SCIENCE AND GLOBAL INTERCONNECTIVITY

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Abstract

This paper explores the symbolic and metaphysical dimensions of the Prophet Muhammad's night journey through the lens of contemporary scientific paradigms, with a particular focus on quantum entanglement and the interconnectedness observed in ecological systems. The research aims to bridge traditional Islamic understandings of *Al-Isrā'wal-Mi'rāj* with modern scientific perspectives on interconnectedness and non-locality. By examining the core themes of the journey, such as traversing vast distances and encountering different realms, the study draws parallels with the concept of quantum entanglement, wherein particles exhibit instantaneous connections regardless of spatial separation. This exploration utilizes quantum entanglement as a metaphorical framework to understand the Prophet's connection to different realms and levels of reality during his journey. Furthermore, the paper explores how the interconnectedness observed in ecological systems, where each element contributes to the health and balance of the whole, mirrors the spiritual connections experienced during *Al-Isrā'wal-Mi'rāj*. Ultimately, this interdisciplinary approach demonstrates the compatibility of faith and reason. The research articulates several empirical outcomes, including: the identification of specific linguistic patterns in classical texts that correlate with modern scientific concepts; and the development of a novel framework for teaching Textual Studies of Qur'an at the Tertiary Level in Nigeria which is designed to foster both scientific literacy and a deeper appreciation of Islamic intellectual heritage.

Keywords: Al- Al-Isrā' wal- Mi'rāj, Islamic theology, Modern Science, Interdisciplinary approach, Interconnectedness

Introduction

The Islamic tradition of *Isrā'* and *Mi'rāj*, recounting the Prophet Muhammad's nocturnal journey from Mecca to Jerusalem and his subsequent ascension to the heavens, presents a fascinating intersection of religious narrative and speculative scientific inquiry. This pivotal event in Islamic history has been subject to diverse interpretations across centuries, with scholars debating whether these experiences transpired as physical realities, spiritual visions, or dream states. The dichotomy between Al-Isrā', often viewed as a bodily journey facilitated by extraordinary means such as angelic assistance or supernatural transportation on Buraq, and Mi'rāj, frequently described as an out-of-body experience (OBE) transcending spatial constraints (Jawaid, 2021), underscores the complexity of reconciling religious accounts with empirical explanations. Recent scholarly endeavors have sought to bridge this divide by invoking principles from modern physics. Concepts like time dilation from Einstein's theory of relativity offer intriguing possibilities for understanding how rapid travel might occur within brief earthly timeframes. Moreover, speculative theories such as multiverse hypotheses and quantum mechanics provide frameworks for contemplating non-ordinary modes of existence and interconnectedness that could underpin experiences akin to *Mi'rāj*.

This paper delves into these intersections by exploring how quantum superposition—where particles exist in multiple states simultaneously—and quantum entanglement—where entities become connected across vast distances—might metaphorically illuminate aspects of consciousness during spiritual ascensions like *Mi'rāj*. By triangulating these concepts with traditional narratives about Al-Isrā' and *Mi'rāj*, this study aims to contribute a nuanced perspective on the interplay between scientific speculation and religious interpretation in understanding profound spiritual events. Through an interdisciplinary approach combining historical analysis with insights from theoretical physics, this research seeks not only to shed light on the nature of prophetic experiences but also to explore broader implications for our understanding of consciousness and reality itself. By way of examining how contemporary scientific theories can inform our comprehension of ancient mystical events without diminishing their spiritual significance or reducing them solely to material explanations, this work endeavors to enrich both theological discourse and philosophical discussions around human perception beyond conventional boundaries.

Ultimately, this investigation invites readers into a thought-provoking dialogue at the crossroads where faith meets science—a dialogue that challenges us both intellectually and spiritually while fostering deeper appreciation for the intricate tapestry woven from threads of belief and knowledge throughout human history (Guessom, 2022).

Scholarly Discussions on *Al-Isrā'wal-Mi'rāj*:

Foundational Islamic Texts and Classical Interpretations of *Al-Isrā'wal-Mi'rāj*

The event of *Al-Isrā'wal-Mi'rāj*, the miraculous night journey and ascension of the Prophet Muhammad (PBUH), is a cornerstone of Islamic belief, deeply rooted in foundational texts and classical interpretations. This systematic study synthesizes key sources, including the Quran, Hadith, classical commentaries, as well as modern Islamic thought cum reinterpretations to provide a comprehensive understanding of this significant event.

Quranic Foundation

The primary source for *Al-Isrā'wal-Mi'rāj* is found in the Quran, specifically in Surah Al-Isra (17:1), which states:

"Glory be to Him who took His servant by night from the Sacred Mosque to the Farthest Mosque whose surroundings We have blessed, so that We may show him some of Our signs. Indeed, He alone is the All-Hearing, All-Seeing.".

The Quran describes the first leg of the journey, from Masjid-i-Haram to the Temple in Jerusalem. The specifics of the entire journey, including the second part known as *Al-Mi'rāj* (ascension), are detailed in the Sunnah, with certain events from the Mi'rāj also being referenced in Surah *Al-Najm*. Nonetheless, this lone verse establishes the miraculous nature of the journey and highlights its significance as a divine event. According to Maududi (2001), there are divergent views concerning the nature of this Journey. Some scholars opined that this happened in a dream, while others are of the opinion that the Holy Prophet was fully awake and went on the Journey with his own physical body; yet, some others say that it was merely a mystic vision which was shown to him. The opening words of this verse: "Glory be to Him, who transported His Servant..." however, clearly show that it was a super-natural event which was brought about by the unlimited power of Allah, Maududi (2001) emphasized.

It is quite obvious that if the event had been merely a mystic vision, it would not have been introduced by the words which imply that the Being Who brought about this event is free from each and every kind of weakness and defect. Again, the words "transported His servant one night" also show that this was not a dream or a vision but a physical journey in which Allah

arranged that the Holy Prophet should make observation of His Signs with his physical eyes. Therefore, one is bound to admit that this was not a mere spiritual experience but a physical journey and visual observation which Allah arranged for His Prophet (Maududi, 2001:241).

Exegetes (Tabari, 1984; Ibn Kathir, 1994, Qurtubi, 1981, Al- Baghawi, 2001) emphasize that the term "servant" (*bi'abdihi*) underscores the unique bond between Allah and the Prophet, marking this journey as an honor bestowed upon him. The mention of both *al-Masjid al-Haram* (the Sacred Mosque) and *al-Masjid al-Aqsa* (the Farthest Mosque) situates the event within a sacred geographical context, further enhancing its spiritual importance.

Classical Tafsir

Classical commentators have provided extensive interpretations of these texts. For instance, Imam Ibn Kathir's *Tafsir* elaborates on the miraculous nature of the journey, asserting that it occurred while the Prophet was fully awake and conscious. He clarifies that this was not merely a dream but a physical experience that holds profound theological implications. In addition to Ibn Kathir (1994), other scholars like Al-Qurtubi (1981) and Al-Tabari (1984) have contributed interpretations that highlight various dimensions of this event. They discuss its implications for understanding divine intervention in human affairs and its role in affirming faith during times of adversity. This may be connected to tests and trials that the Sahaba went through during the event of Al-Isra as the disbelievers mock the idea. Abu Bakr's (RA) steadfastness in affirming his belief in the journey despite his absence, contributed toward silencing the enemy and their treachery.

Sufi Perspectives

Sufi interpretations often view *Al-Isrā'wal-Mi'rāj* as a metaphor for spiritual ascent and union with the Divine. Sufi literature emphasizes themes of love, longing, and divine presence during this journey. The experience is seen as an allegory for the soul's journey towards God, reflecting deeper mystical insights into human existence and spirituality (Ibn Arabi, 2004, Forman, 2014). Drawing parallels with the non-mystical Sunni *Tafasār* on the symbolic and metaphysical dimensions of the journey, major Sufi *Mufassirūn* (Qushayri, 1990; Al-Mahalli, 2019, Chittick, 2021) emphasized that the Prophet undertook the journey with his physical body. Qushayri (1990) on the other hand, introduced some emblematic meanings that set him apart from other Sufi interpreters. In his unique approach, he held that there are four levels of meaning in the Qur'an. First, the *ibāra* which is the meaning of the text meant for the mass of believers. Second, the *ishāra*, only available to the spiritual elite and lying beyond the obvious verbal meaning. Third, *laṭā'if*, subtleties in the text that were meant particularly for saints. And finally, the *ḥaqā'iq*, which he said were only comprehensible to the prophets. While interpreting the import of a segment of the first verse: "That We may show him some of Our signs...", Qushayri (1990) said "He introduced him to the signs, then to the attributes, then revealed the Self" (See also Schimmel, 1994). Thus, arguably affirming beatific vision exclusively for the prophet in the here-now. Qushayri (1990) further expounded on this matter in his interpretation of verse 13 of Surah Al-Najm: "And verily he saw Him once again". Where he opined that the ḍamīr; Him refers to Allah. He further corroborated this as follows:

There is disagreement regarding the sighting of Allah (Glorified and Exalted) on the night of Al-Mi'rāj. Aisha (may Allah be pleased with her) said: 'The Prophet (PBUH) did not see his Lord on the night of Al-Mi'rāj, and whoever claims that Muhammad saw his Lord on the night of Al-Mi'rāj has attributed a great falsehood to Allah. Ibn Abbas said: Our Prophet (PBUH) saw his Lord on the night of Al-Mi'rāj. Then the narrations from Ibn Abbas differed. In one narration, it is that he saw Him with his physical eye, and in another narration, it is that he saw Him with his heart. The scholars of verification from the People of the Sunnah said: Their disagreement in this matter is evidence of their consensus that it is permissible for the Truth (Allah) to be seen, because if they were not in agreement on the permissibility of seeing Him, their disagreement about seeing Him on that night would have no meaning. Narrations have

been reported in this regard, and Allah knows best their authenticity. If that is authentic, then it has aspects of interpretation, including what has been narrated that he said: 'I saw my Lord in the best form' - this narration has several possible meanings, including: 'I saw my Lord while I was in the best form,' meaning in the most perfect state, complete virtue, and the strongest I have ever been, without bewilderment or confusion accompanying me (Qushayri, Al-Mi'rāj p. 94).

Qushairy, in another place, compares Musa (AS), who fell unconscious merely upon hearing the call, to the Prophet Muhammad (PBUH), who remained steadfast in the place of witnessing. He adds: "Moses was in a state of *talwīn* (alternation of states), while Muhammad was in a state of *tamkīn* (establishment)." This highlights the difference in spiritual stations between the two prophets, with Muhammad possessing a higher degree of stability and divine support. In *Tafsīr Al-Jalalayn* which is yet another authoritative Sufi Tafsir, however, alluded that what the prophet saw was Jibril not Allah. Hence the purport of the verse is:

﴿ولقد رآه﴾ على صورته ﴿نزلة﴾ مرة ﴿أخرى﴾

Thus, referencing the sight of Jibril in his true physical form. The non-Sufi *Tafasīr* unanimously negated the possibility of prophet's sighting of Allah (Ibn Taymiyah, 2002). To support their aspects of interpretation, the *Mufassirūn* employed varying linguistic patterns that correlate with their theological leanings (Al-Suyuti,1999, Abdul-Raof, 2022). Consider the following interpretation in Jalalayn:

﴿مَا كَذَبَ﴾ بِالتَّخْفِيفِ وَالتَّشْدِيد أَنْكَرَ ﴿الْفُؤَاد﴾ فُؤَاد النَّبِيّ ﴿مَا رَأَى﴾ بِبَصَرِهِ مِنْ صُورَة جِبْرِيل

﴿أَفَتُمَارُونَهُ﴾ تُجَادِلُونَهُ وَتَغْلِبُونَهُ ﴿عَلَى مَا يَرَى﴾ خِطَاب لِلْمُشْرِكِينَ الْمُنْكِرِينَ رُؤْيَة النَّبِيّ صَلَّى اللَّه عَلَيْهِ وسلم لجبريل

"He did not lie" (with both the light and heavy variants of كَذَّب/كَذَبَ) refers to the heart of the Prophet. "What he saw" refers to what he witnessed with his eyes of the form of Jibril. "Do you argue with him" means do you dispute with him and overpower him "about what he sees?" This is a discourse directed at the disbelieving polytheists who deny the Prophet's (peace be upon him) vision of Jibril.

This is a striking contrast to Qushayri who resorted to *ishāra*, the demonstrable meaning lying beyond the obvious verbal connotation of the context to establish the permissibility of seeing Allah. While interpreting the first verse of Surah *Al-isrā*, Mahalli (2019) posits that

"Glory be" means to declare Allah free from any imperfection. "Who took His servant" refers to Muhammad (peace be upon him). "By night" is specified to indicate the time, and *Al-Isrā'* refers to the night journey. The mention of night implies the brevity in its duration. "From the Sacred Mosque to the Farthest Mosque" refers to Al-Aqsa, which is distant from it.

The linguistic pattern employed by Al-Mahalli (2019) particularly in his reference to Zarf Al-zaman in order to depict the brevity of the journey covering approximately 928.19 mi (1,493.77 km) which took caravans during the 7th century C.E at least 40 days to cover, aims to highlight the miraculous nature of the journey, and the uniqueness of the mode of transportation.

Hadith Literature

The details surrounding *Al-Isrā'wal-Mi'rāj* are elaborated upon in various Hadith collections.

There is consensus of Ulama' on the occurrence of *Al-Isrā'wal Mi'rāj*. Scholars have also established that the *Ahadith* of *Al-Isrā*' were narrated in different forms by more than fourty five Sahaba, thus, reinforcing its elevated status as Hadith *Mutawatir*. Some of these accounts are contained in the authentic collections such as Bukhari and Muslim. According to Ibn

Taymiyah and his disciple Ibn Al-Qayyim, the text of Al-Isra: 1 is considered definitive proof of the occurrence of Al-Isra and strengthens the position of those who say the hadith is *mutawātir* (transmitted by so many sources as to be undeniably authentic).

According to narrations in *Sahih Bukhari* and *Sahih Muslim*, the journey began with the Archangel Jibril (Gabriel) bringing a heavenly steed known as *Buraq*, which carried the Prophet from Mecca to Jerusalem. Upon arriving at *al-Masjid al-Aqsa*, he led other prophets in prayer, symbolizing unity among prophetic missions.

The second part of the journey, known as *Mi'rāj*, involves ascending through the seven heavens. Each heaven presents encounters with significant prophets such as Adam, Moses, and Jesus, culminating at *Sidrat al-Muntahā*, where Muhammad received the command for daily prayers. This aspect of the journey emphasizes not only the Prophet's elevated status but also his role as a link between various prophetic traditions.

Modern Islamic Thought and Reinterpretations

Contemporary Islamic Scholars have addressed *Al-Isrā'wal-Mi'rāj* in light of contemporary challenges and scientific advancements. They make attempts to reconcile traditional Islamic beliefs with modern scientific knowledge. While refuting the argument of the deniers of physical *Al-Isrā'*, Al Maraghi (2001) posits that the movement at this speed is possible in itself, as it is mentioned in the Quran that the winds were carrying Solomon (peace be upon him) to distant places in short periods. Allah Almighty said in describing Solomon's movement: 'Its morning [journey] was a month [long], and its evening [journey] was a month [long]' (34:12). And it is mentioned in it that the one who had knowledge from the Book brought the throne of Bilqis from the far Yemen to the far Sham in the blink of an eye, as Allah Almighty said: 'Said one who had knowledge from the Scripture, "I will bring it to you before your glance returns [to you]"' (27:40). If this is permissible for one group of people, it is permissible for all of them."

He further cleared the doubts of those who say: "Indeed, ascending with the body to the higher realm above certain layers is impossible because the air is non-existent, so the living body cannot live in it or breathe in it". Saying:

Indeed, what is innovated every day in terms of various inventions, and using them to traverse distances, with means such as airplanes, and crossing oceans in a few hours, from one continent to another, and from one region to another, makes us believe that what came in the description of these two journeys is among the facilitated matters that are not difficult to obtain or impossible things (Al Maraghi, 2001: 165).

Al-Maraghi (2001) advances the plausibility of appreciating the reality of *Al-Mi'rāj* in light of the developments of modern technology that obtained in his time. And as at the time he compiled the tafsīr probably in the first decade of 1900, NASA was not born. Stephen and Roger (N.D), while tracing the history of the National Aeronautics and Space Administration (NASA) cite a congressional act thus; "An Act to provide for research into the problems of flight within and outside the Earth's atmosphere, and for other purposes." According to them, with this simple preamble, the Congress and the President of the United States created the national Aeronautics and Space Administration (NASA) on October 1, 1958. NASA's birth was directly related to the pressures of national defense. After World War II, the United States and the Soviet Union were engaged in the Cold War, a broad contest over the ideologies and allegiances of the nonaligned nations. During this period, space exploration emerged as a major area of contest and became known as the space race. During the late 1940s, the Department of Defense pursued research and rocketry and upper atmospheric sciences as a means of assuring American leadership in technology. Hence, Al-Maraghi (2001) has contributed to the discourse based on the sophistication and depth of scientific information available to him. Decades after his response to the deniers of physical *Mi'rāj* on grounds of lack of oxygen in the outer space,

man has developed the capacity to reach other planets through manned missions and even beyond. Developments in the space-tech sphere are still unravelling. The more the advancement in science and technology, the closer we get toward appreciating and understanding the reality surrounding physical *Mi'rāj*. There will always be gaps in the realm of *Mi'rāj* vis-a-vis modern science, thus necessitating consistent research on the subject in order to fill the void in understanding *Mi'rāj* through scientific perspectives. Nonetheless, the current strides attained by Tech-titans on quantum computing may shape our understanding of this reality, as well as satisfy our curiosity pertaining how the concept of *Mi'rāj* lends itself to rational a paradigm.[14]

Progressive Islamic Thought

Current attempts at reinterpreting the concept of *Al-Isrā'* focus on two broad themes; reason and revelation, as well as emphasis on its ethical and social dimensions. Some contemporary scholars that focus on bridging the gap between reason and revelation on the concept of Al-*Isrā'* suggests that while *Al-Isrā'* was indeed a physical journey from Mecca to Jerusalem, Al-*Mi'rāj*—his ascension through the heavens—might involve elements akin to out-of-body experiences (Kastrup, 2021). This view posits that while his body remained in its place, his consciousness could have traversed realms beyond ordinary perception by means of Astral Projection (Javaid, 2022). Such interpretations reflect an ongoing effort among some scholars to bridge faith with reason, seeking explanations that resonate with both traditional beliefs and modern scientific paradigms (Dallal, 2010). The proponents of OBE rely on a narration attributed to Aisha regarding *Al-Isrā'wal-Mi'rāj*: "I never found the Prophet ﷺ absent; he was made to travel in *Al-Isrā'wal-Mi'rāj* by his soul." This narration is reported through Muhammad bin Ishaq, who mentioned it as being from some of the family of Abu Bakr.

However, this narration is considered weak and lacks a reliable chain of transmission. Scholars such as Sheikh Al-Albani have declared it not authentically proven from Aisha, and it has been categorized as a weak (*ḍaīf*) or even fabricated (*mawḍū'*) narration. It appears in works like Ibn Hisham's *As-Seerah An-Nabawiyyah* and Ibn Jareer At-Tabari's *Tafsīr*, but its authenticity remains disputed among scholars. According Al-Maraghi (2001), the hadith was criticized on the grounds that Aisha was young at that time and was not yet married to the Messenger of God, peace and blessings be upon him.

Exploration of reinterpretations of *Al-Isrā'wal-Mi'rāj* that emphasize its ethical and social dimensions foster variety in Islamic thought. Professor Syed Muhammad Naquib Al-Attas, a significant figure in the discourse surrounding Islamic metaphysics and the implications of Al-*Isrā'wal-Mi'rāj* argued for a reintroduction of metaphysics rooted in Islamic principles, emphasizing that modern secular frameworks often distort traditional understandings of Islamic history and spirituality. Al-Attas maintained that the events of *Al-Isrā'wal-Mi'rāj* should be understood within a broader metaphysical context that acknowledges both the physical and spiritual dimensions of reality (Al-Attas, 2025). Al-Attas (2025) critiqued modern science for reducing nature to mere phenomena without recognizing its deeper spiritual significance. He posited that the Islamic perspective integrates both reason and experience, leading to a comprehensive understanding of existence that transcends mere empirical observation. In his view, *Al-Isrā'wal-Mi'rāj* is not just a miraculous journey but a profound spiritual experience that affirms the Prophet Muhammad's elevated status and the divine connection between humanity and God. Al-Attas' position may be articulated in three major variables subsumed in the ethical and social dimensions of *Al-Isrā'* viz;

[14] The recent breakthrough made by Microsoft in quantum computing may accelerate future researches into phenomena which has the potential of cutting time-span of longitudinal scientific projects that may take decades to accomplish. The new quantum chip; willow unveiled by Microsoft can solve complex problems within five minutes which may take the best super computer at least Ten Septillion Years to solve.

Spiritual Web: Just as ecosystems have intricate food webs and symbiotic relationships, the spiritual realm can be seen as a web of connections. The Prophet's interactions with angels, prophets, and divine manifestations during *Al-Isrā'wal-Mi'rāj* highlight the interconnectedness of the spiritual world.

Balance and Harmony: In ecosystems, balance and harmony are essential for sustainability. The Prophet's journey to the divine presence and his return to Earth can be interpreted as a way of restoring balance and harmony, both within himself and within the world.

Microcosm and Macrocosm: Ecosystems operate within larger systems, and their health reflects the health of the whole. Similarly, the Prophet's individual spiritual experience during *Al-Isrā'wal-Mi'rāj* has implications for the entire Muslim community and humanity as a whole (Al-Gahazali, 1998). For the Muslims, *Al- Mi'rāj* opens a window for a spiritual ascension and direct communication with Allah through Salah. The prophet was reported to have said: "When you pray at its designated time, it ascends with a radiant light, and the gates of heaven are opened for it until it reaches the Throne, where it intercedes for its owner, saying, May Allah protect you as you protected me. But when you pray at a time other than its designated time, it ascends darkened, and the gates of heaven are closed against it. Then it is wrapped up like a garment, and it strikes the face of its owner, saying, May Allah forsake you as you forsook me". For the Abrahamic faiths generally, *Al-Isrā'Wal-Mi'rāj* points to their shared destiny. And for other religions built on mystical values such as Hinduism, and Buddhism, it resonates with their notion of transcendental mystical experiences. Also, the relevance of *Al-Mi'rāj* correlates with 'religious' systems or enlightenment values which do not have metaphysical foundations such as Confucianism, particularly in its articulation of self realization toward the attainment of spiritual reawakening and consciousness. Simply put, at macrocosmic level, *Al-Isra Wal-Mi'rāj* assumes a global character given the globalized nature of its miracles.

Scientific Perspectives on *Al-Isrā' wal- Mi'rāj*

Parallel to al-Attas's traditionalist approach, some contemporary scholars have sought to reconcile the events of *Al-Isrā' wal-Mi'rāj* with modern scientific concepts. For instance, discussions around the possibility of the Prophet's night journey being a physical experience have emerged. Some scholars argue that with divine assistance, such as that provided by the angel Jibril (Gabriel), it could theoretically be possible for the Prophet to travel vast distances at extraordinary speeds. This perspective attempts to frame the miraculous nature of *Al-Isrā' wal-Mi'rāj* within a context that aligns with scientific understanding, suggesting that while miraculous, these events could also be viewed through a lens compatible with contemporary physics.

Jawaid (2021) explores the Prophet Muhammad's night journey from Mecca to Jerusalem (*Al-Isrā'*) and his ascension to heaven (Mi'rāj) through a scientific lens. The author suggests that *Al-Isrā'* could have been a bodily experience, potentially facilitated by angelic assistance, allowing for rapid travel between Mecca and Jerusalem within minutes. In contrast, Mi'rāj is posited in Jawaid's submission as an out-of-body experience (OBE), given its extraordinary nature of traversing vast spaces and encountering deceased prophets. Jawaid (2021) further contends that it would take Jibraeel, who can travel at the speed of light (186,000 miles per second), about forty-two billion light years to reach the end of the universe. Thus, refuting the possibility of physical *Mi'rāj*. Astonishingly, however, he seemed to limit the 'top speed' of Jibreel to the speed of light! This is farfetched. And it is a clearly indication of his inability to explore other paradigms such as wormholes through which bodies travelling at the speed of light may reach the deepest part of space quickly. Hence acting as a barrier to his appreciation of the plausibility of a physical *Mi'rāj*.

Jawaid (2021) used the theory of wormholes to rationalize the plausibility of physical *Mi'rāj*. The narrative combines historical accounts with interpretations of Quranic verses, highlighting

different scholarly views on whether these events occurred in dreams or reality. He justifies the possibility of the Prophet Muhammad's physical journey to Jerusalem during Al-Isrā' by referencing Islamic scholarly consensus and Quranic descriptions. The majority of scholars agree that *Al-Isrā'* was a physical journey, supported by the use of terms like "*bi-'abdihi*" in Surah *Al-Isrā'*, which refers to a being with both body and soul. Jawaid (2021) further explained that Mi'rāj is akin to wormholes which are shortcut passages through space and time. Wormholes are openings in our space environments that connect with others possibly existing openings in faraway points in our universe. If one is to enter anyone of these openings they will be taken to another side of our universe. Jawaid (2021) concludes that

The Arabic term *Ma'ārij* plural of *Mi'rāj* means "ascending steps of a ladder or staircase for reaching high places". These steps or ways of ascent may be defined in the modern terminology as "wormholes" by which angels travel deeper in to space and reach on the other side of the universe closer in to Allah's presence or reach other higher levels. They would cover such distances in one heavenly (astronomical) day which equals "fifty thousand years" implying unimaginable amount of time. Despite Angels being created of an unknown *nūr* (a form of radiation or energy), and all radiation travels at the speed of light (186000 miles/second), they still must be required to enter these wormholes to cut large cosmic distances short to reach other side of the universe, without which would take them billions of light years!

Since Jawaid (2021) has alluded to the fact that the *nūr* from which angels were created is unknown, establishing a requirement for them to go through the wormholes to reach the deepest part of the universe is farfetched. More so Jibreel, an honorable righteous angel who occupies a special status with Allah. Why are some people quick at putting all angels in the same equilibrium in terms of speed, while the Qur'an has singled out others' special status: كرام برررة.

Additionally, accounts from hadiths describe the Prophet traveling on Buraq, an animal said to have extraordinary speed akin to lightning, allowing for rapid transportation between Mecca and Jerusalem. This narrative combines religious tradition with speculative interpretations that suggest such a journey could transcend ordinary limitations of space and time.

Several scientific theories have been proposed to explain the Prophet Muhammad's ascension to the heavens during *Mi'rāj*:

Relativity and Time Dilation: Said Nursi's philosophical insights suggest that time perception varies across different realms, aligning with Einstein's concepts of time dilation. This framework attempts to rationalize the Prophet's rapid ascension within a brief earthly timeframe by considering variable speeds of light, spirit, and imagination (Jawaid, 2021).

Multiverse Theory: Some interpretations propose that *Mi'rāj* involved travel through parallel universes or multiverses. This idea is linked to concepts from quantum mechanics and string theory, suggesting that such journeys could occur via wormholes or other cosmic phenomena (Shah, 2019).

Quantum Superposition: Another perspective draws on quantum superposition, where particles can exist in multiple states simultaneously. This concept is applied metaphorically to human experiences like seeing prophets in different locations during *Mi'rāj* (The Community on Friday, 2023).

The concept of quantum superposition and quantum entanglement can be metaphorically applied to the Prophet Muhammad's ascension during *Mi'rāj*. Quantum superposition refers to the ability of particles to exist in multiple states simultaneously, which could be analogously used to describe how the Prophet might have experienced multiple realms or dimensions during his ascension. Quantum entanglement involves particles becoming connected so that their properties are correlated regardless of distance, potentially allowing for instantaneous communication or influence between them. In a metaphorical sense, this could suggest that the Prophet's consciousness was "entangled" with divine knowledge or other spiritual entities

during *Mi'rāj*, enabling him to transcend spatial boundaries and communicate with prophets across different realms (Kafatos & Nadeau, 2020). However, these concepts are purely theoretical when applied to spiritual experiences like *Mi'rāj* and do not provide empirical evidence for such events. They serve more as creative interpretations rather than scientifically proven explanations (Nasr, 2015). These creative paradigms may help us articulate a framework for interpreting Qur'anic verses in light of modern science.

Triangulation

Triangulating quantum superposition and quantum entanglement in the context of spiritual experiences like *Mi'rāj* may involve exploring how these quantum phenomena can metaphorically explain or parallel certain aspects of consciousness and interconnectedness.

Quantum Superposition

- **Concept**: Quantum superposition is a state where particles exist in multiple states simultaneously until observed. This principle suggests that reality is not fixed but exists as a multitude of possibilities until measured or perceived.

- **Spiritual Parallel**: In spiritual contexts, this concept can be seen as analogous to the idea that consciousness or awareness can exist in multiple realms or dimensions simultaneously. During experiences like *Mi'rāj*, the Prophet might have been aware of different levels of existence at once, reflecting a form of "superposition" where his consciousness was not limited to one state.

Quantum Entanglement

- **Concept**: Entanglement occurs when two particles become connected so that their properties are correlated regardless of distance. This phenomenon challenges traditional notions of space and time by suggesting an instantaneous connection between entangled entities. This gives rise to concepts such as holographic matrix which suggests the idea of non-existence of time space.

- **Spiritual Parallel**: In spiritual terms, entanglement could symbolize the interconnectedness often described in religious traditions—where all beings are fundamentally linked. During *Mi'rāj*, if we consider the Prophet's ascension as an experience involving communication with other prophets across different realms, it could be metaphorically likened to entanglement: his consciousness was "entangled" with divine knowledge or other spiritual entities. The concept of *Barzakh* (the intermediate life between death and resurrection) may neatly fit into the ecosystem of holographic matrix since it implies reality in another dimension.

Triangulation Analysis

Interconnectedness vs. Multiplicity:

a. *Quantum Superposition* emphasizes multiplicity—existing in many states at once—while *Quantum Entanglement* highlights interconnectedness—being linked across distances (Capra & Steindl, 2018).

b. Spiritually, this translates into experiencing multiple dimensions (superposition) while being connected to all existence (entanglement).

Non-Locality and Timelessness:

a. Both concepts challenge classical notions of space and time: superposition implies existing beyond fixed states (potentially transcending temporal constraints), while entanglement shows instantaneous effects regardless of distance (Tart, 2012).

b. In *Mi'rāj* narratives, these concepts could explain how spatial boundaries were transcended during ascension.

Consciousness as a Quantum Phenomenon:

c. Some theories propose that consciousness itself operates on quantum principles. If so, experiences like *Mi'rāj* might involve quantum-like processes within human awareness.

d. This perspective aligns with ideas from quantum theory applied to spirituality, suggesting deep connections between physical laws and subjective experience.

A Novel Framework for Teaching Al-Isrā' wal-Mi'rāj – Bridging Faith and Science

This framework, titled "*Al-Isrā' wal-Mi'rāj: A Scientific Tafsīr*," is designed to be implemented at the tertiary level in Nigeria. It aims to foster both scientific literacy and a deeper appreciation of Islamic intellectual heritage, specifically focusing on the event of *Al-Isrā' wal-Mi'rāj*.

Core Principles

- **Interdisciplinarity:** The course will explicitly bridge traditional Islamic understanding of *Al-Isrā' wal-Mi'rāj* with contemporary scientific disciplines.
- **Critical Thinking:** Students will analyze different interpretations (traditional and scientific) of *Al-Isrā' wal-Mi'rāj*, evaluating their merits and limitations.
- **Contextual Understanding:** The course will emphasize the historical, social, and religious context of *Al-Isrā' wal-Mi'rāj*.
- **Engagement with Classical Texts:** Direct engagement with primary sources (Qur'an, Hadith, classical commentaries) is crucial.
- **Application of Scientific Concepts:** Use scientific concepts as tools for understanding and interpreting the narratives of *Al-Isrā' wal-Mi'rāj*.

Module Breakdown

The course will be structured into modules, each focusing on specific aspects of Al-Isrā'wal-*Mi'rāj* and its relationship to science.

Module 1: Foundations of *Al-Isrā' wal-Mi'rāj*

- Introduction to *Al-Isrā' wal-Mi'rāj* in the Qur'an (Surah Al-Isra 17:1).
- Detailed examination of Hadith narrations related to *Al-Isrā' wal-Mi'rāj* (Sahih Bukhari and Muslim).
- Analysis of classical Tafsir (Ibn Kathir, Qurtubi, Tabari, Jalalayn) on *Al-Isrā'wal-Mi'rāj.*
- Exploration of Sufi perspectives (Qushayri, Jalaluddin Rumi) on *Al-Isrā' wal-Mi'rāj* as a spiritual journey.

Module 2: Scientific Perspectives on Space and Time

- Introduction to Einstein's theory of relativity (special and general relativity).
- Discussion of concepts such as time dilation, length contraction, and the speed of light.
- Examination of the nature of space and time, including dimensions beyond the third dimension.
- Connecting these scientific concepts to the Prophet's journey through vast distances in a short time.

Module 3: Quantum Entanglement and Interconnectedness

- Explanation of quantum entanglement: how particles can be instantaneously connected regardless of distance.

- Discussion of non-locality and its implications for understanding the interconnectedness of all things.
- Exploration of the concept of a "quantum field" and its potential relevance to spiritual experiences.
- Using quantum entanglement as a metaphorical framework to understand the Prophet's connection to different realms and levels of reality during his journey.

Module 4: *Al-Isrā' wal-Mi'rāj* as an Out-of-Body Experience (OBE)?

- Examining the interpretations of *Al-Isrā' wal-Mi'rāj* through the lens of OBE.
- Discussion of the nature of consciousness and its potential to exist independently of the physical body.
- Analysis of the possibility of the Prophet's consciousness traversing realms beyond ordinary perception during Al-Mi'rāj.
- Evaluating the arguments for and against the OBE interpretation of *Al-Isrā' wal-Mi'rāj*.

Module 5: The *Buraq*: A Metaphor for Advanced Technology?

- Analyzing the description of Buraq, the heavenly steed that carried the Prophet.
- Discussion of whether Buraq could be interpreted as a metaphor for advanced technology or a means of transportation beyond human comprehension.
- Exploring the potential for future scientific advancements to enable rapid travel through space and time.
- Connecting the concept of Buraq to modern transportation technologies such as airplanes and spacecraft, as highlighted by Al- Maraghi.

Module 6: Encounters with Prophets in Different Heavens: Symbolic or Literal?

- Examining the Prophet's encounters with other prophets in the different heavens during *Al-Mi'rāj*.
- Discussing whether these encounters should be interpreted as literal events or symbolic representations of spiritual truths.
- Exploring the significance of the Prophet's leadership in prayer at Al-Aqsa, symbolizing the unity of prophetic missions.
- Connecting these encounters to interfaith dialogue and the common ground between different religious traditions.

Module 7: Ethical and Social Dimensions of *Al-Isrā' wal-Mi'rāj*

- Analyzing the ethical teachings and social messages conveyed through the story of *Al-Isrā' wal-Mi'rāj*.
- Discussing the importance of justice, compassion, and social responsibility in Islamic teachings.
- Exploring the lessons that can be learned from *Al-Isrā' wal-Mi'rāj* for addressing contemporary challenges facing society.
- Emphasis on reason and revelation, focusing on the ethical and social dimensions of the journey.

Assessment Methods

- **Class Participation:** Active engagement in discussions, debates, and group activities.

- **Quizzes and Exams:** To assess comprehension of key concepts and themes.
- **Research Papers:** Students will conduct in-depth research on a specific aspect of *Al-Isrā' wal-Mi'rāj*, integrating both traditional and scientific perspectives.
- **Presentations:** Students will present their research findings to the class.
- **Workshop:** Organize a workshop to engage participants and measure the increase in cross-cultural understanding and pre- and post-study surveys will be used to assess the impact of the workshop.

Expected Outcomes

- **Enhanced Scientific Literacy:** Students will develop a greater understanding of scientific concepts related to space, time, and quantum physics.
- **Deeper Appreciation of Islamic Intellectual Heritage:** Students will gain a renewed appreciation for the richness and complexity of Islamic thought on *Al-Isrā' wal-Mi'rāj*.
- **Improved Critical Thinking Skills:** Students will be able to analyze different interpretations of *Al-Isrā' wal-Mi'rāj*, evaluate their merits, and develop their own informed perspectives.
- **Greater Understanding of the Relationship Between Faith and Science:** Students will gain a nuanced understanding of the relationship between Islamic beliefs and scientific knowledge.
- **Ability to Connect *Al-Isrā' wal-Mi'rāj* to Contemporary Issues:** Students will be able to apply the lessons and insights of *Al-Isrā' wal-Mi'rāj* to address contemporary challenges.

Conclusion

This paper has sought to explore the multifaceted dimensions of *Al-Isrā' wal-Mi'rāj*, bridging traditional Islamic understandings with contemporary scientific paradigms and modern reinterpretations. Having examined foundational Islamic texts, classical commentaries, Sufi perspectives, and Hadith literature, the paper traced the historical and theological significance of this miraculous event. Furthermore, it explored modern attempts to reconcile *Al-Isrā' wal-Mi'rāj* with scientific concepts such as quantum entanglement, interconnectedness, and the possibility of advanced technologies, as well as progressive interpretations that emphasize reason, revelation, ethics, and social justice. The study reveals that *Al-Isrā' wal-Mi'rāj* serves as a powerful symbol of divine grace, the Prophet Muhammad's unique status, and the interconnectedness of the spiritual and physical realms. While traditional interpretations emphasize the miraculous nature of the journey, modern approaches seek to understand its underlying principles through the lens of scientific knowledge and philosophical inquiry.

Ultimately, this interdisciplinary exploration demonstrates the enduring relevance of *Al-Isrā' wal-Mi'rāj* as a source of inspiration, guidance, and reflection for Muslims worldwide. It encourages a deeper understanding of Islamic teachings, fosters critical thinking, and promotes dialogue between faith and reason in an increasingly interconnected world. The event continues to inspire scholarly discussions and reinterpretations, ensuring its timeless significance for generations to come.

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EFFECTIVENESS OF PHYSIOTHERAPY IN REHABILITATION OF FROZEN SHOULDER

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Abstract

Background: Frozen shoulder, or adhesive capsulitis, is a debilitating condition marked by pain and progressive loss of shoulder mobility, significantly affecting daily function. Physiotherapy is a primary treatment approach, yet the effectiveness of different rehabilitation strategies varies. Additionally, corticosteroids, either oral or injected, are commonly used as part of treatment regimens for pain relief.

Objective: This review explores the role of physiotherapy in frozen shoulder rehabilitation, evaluating its impact on pain relief, mobility restoration, and functional improvement. The review also examines studies comparing or combining corticosteroid treatments (oral or injection) with physiotherapy, as well as the inclusion of proprioceptive neuromuscular facilitation (PNF) and acupuncture in treatment protocols.

Methods: A literature review was conducted, analyzing clinical trials, systematic reviews, and relevant studies from peer-reviewed sources. Various physiotherapy interventions, including manual therapy, therapeutic exercises, proprioceptive neuromuscular facilitation (PNF), acupuncture, electrotherapy, and patient education, were examined for their effectiveness. Additionally, studies that incorporated oral or injected corticosteroids, either alone or in conjunction with physical therapy, were reviewed to assess their comparative impact on treatment outcomes.

Results: Findings indicate that physiotherapy interventions, particularly a combination of manual therapy and structured exercise programs, contribute to significant improvements in shoulder mobility and pain reduction. Joint mobilization, stretching, and strengthening exercises appear to be the most effective strategies. Proprioceptive neuromuscular facilitation (PNF) techniques also showed promise in improving shoulder range of motion and functional capacity. Acupuncture was found to provide pain relief and may help reduce muscle stiffness, enhancing overall rehabilitation. Furthermore, studies involving corticosteroid injections or oral corticosteroids showed significant pain relief, particularly in the short term. When combined with physiotherapy, corticosteroid treatments were often more effective than either intervention alone in reducing pain and improving mobility. Adjunct modalities such as ultrasound therapy and neuromuscular electrical stimulation may provide additional benefits when integrated into active rehabilitation programs.

Conclusion: Physiotherapy remains a fundamental component of frozen shoulder management, with active rehabilitation approaches yielding the best outcomes. Early intervention and adherence to treatment protocols are critical for optimal recovery. While corticosteroids may offer short-term pain relief, combining them with physiotherapy seems to enhance long-term functional recovery. Techniques such as PNF and acupuncture can also be

beneficial when incorporated into treatment plans. Further research is needed to refine treatment guidelines and explore the long-term efficacy of physiotherapy, corticosteroid use, and alternative therapies in managing adhesive capsulitis.

Keywords: Frozen shoulder, adhesive capsulitis, physiotherapy, rehabilitation, manual therapy, therapeutic exercise, proprioceptive neuromuscular facilitation, acupuncture, corticosteroids, injections.

OPTIMIZING AGRICULTURAL PRACTICES: THE POTENTIAL OF NANO FERTILIZATION FOR SUSTAINABLE PLANTH GROWTH

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ABSTRACT

Nanotechnology refers to the advanced manipulation of materials at the nanoscale, typically between 1 and 100 nm, leading to improvements in their physical, chemical, biological, mechanical, magnetic, optical, and electrical properties. It has a wide range of applications in agriculture, including in fertilization, irrigation, pest management, packaging, post-harvest processing, and food production. Nanotechnology's role in agriculture offers numerous environmental benefits, particularly in the development of nano fertilizers.

Nano fertilizers are a promising innovation for promoting sustainability in global food production. These fertilizers use nanoparticles, which have distinct physicochemical properties at the nanoscale, to enhance agricultural productivity and environmental health. They contribute to increased fruit yields, better quality crops, and longer shelf life by positively affecting various traits, such as morphological, anatomical, physicochemical, physiological, and molecular characteristics.

Nano fertilizers are created by combining essential plant nutrients with nanomaterials, coating nutrient molecules with a thin nanomaterial layer, or forming nano-sized emulsions. These fertilizers, along with nano biofertilizers that mix natural and synthetic components, improve bioavailability and soil fertility more effectively than traditional fertilizers. This review paper aims to highlight the importance of conventional fertilizers and the emerging use of nano fertilizers in agriculture, while also explaining the different types of nano fertilizers available.

Key Words: Fertilizers of the future; Nanotechnology; Nano plant nutrition; sustainable agriculture.

EFFECT OF KITCHEN WASTE SUPPLEMENTATION ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF WEANER RABBITS IN KANO STATE-NIGERIA

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ABSTRACT

A study was conducted at Teaching and Research farm Department of Animal Science Aliko Dangote University of Science and Technology Wudil to determine the effect of kitchen waste supplementation on the performance and carcass characteristics of weaner rabbits. A total of sixteen mongrel weaned rabbits (mixed breeds) were used in for this study. Four (4) Treatment designated as T1 (0%), T2 (5%), T3 (5%), and T4 (5%) to serve as control, morning, evening, morning and evening of kitchen waste respectively. The experiment lasted for 8 weeks. The final body weight values ranged between 1476.7-1016.7g there was significant different between treatment 4 and 2 but no significant compared to control group 990.0g. The daily weight gain was significantly ($P<0.05$) different higher in treatment 4 (10.633g) the least value is (8.483g) was recorded in treatment 1. Treatment 4 had the highest mean (3.51g) for feed conversion ratio. There were significant differences ($P<0.05$) in the liver 46.067g lungs (right &left) 4.4667g, 4.2333g respectively, pancreas 0.8667g and kidney weight. It can be concluded that kitchen waste can be supplemented to weaned rabbits in the morning or evening without any deleterious effect on the growth performance, carcass and organs weight.

Keywords: Rabbit, Carcass, Growth performance, Weaner rabbit, Kitchen waste, and Feed conversion ratio

INTRODUCTION

Background Information

Rabbits play an important role in the supply of animal protein to the Nigerian populace (Amaefule *et al*., 2005). They are efficient converters of feed to meat and can utilize up to 30% crude fibre as against 10% by most poultry species (Egbo *et al.*,2001). Rabbits can utilize unconventional feedstuffs (Ezekwe *et al.*, 2001) Odunsi (2003) reported that rabbit production is relatively important to the economy of some developing countries including Nigeria.

Odunsi (2003) reported that rapid growth of human and livestock population has led to increasing need for food and feed in less developed countries. Hence, rabbits which fall in to the category of underutilized livestock species in developing countries, have been seen as one way of meeting the animal protein requirement of the Nigeria populace(Iyeghe-Erakpotobor *et al.*, 2002*)*.This is because rabbits are renowned for their fecundity and prolificacy (Biobaku and Dosunmu, 2003), ability to utilize forage and crop bi products with no appreciable competition with human and can be easily utilized to produce meat giving it an advantage over other animal species like poultry (Biobaku and Dosunmu, 2003). Rabbit meat has high nutritive value of low fat and cholesterol levels, calories, hence often recommended for the obese and overweight. Furthermore, the fur is used for clothing, paws and tails for trinkets, and the manure for soil improvement and for energy source, or methane gas (Hassan and Owolobi, 2011). The small bodied size give them the ability to adapt over a wide range of ecological environments, rapid rate of reproduction and short gestation period of 28-32 days has made its production a wise choice as a means of alleviating food shortage (Odimba 2006).Many investigators have suggested ways of increasing the low animal protein intake of Nigerians. One of the cheapest producers of meat that can easily fit into the wider segment of the population but which has been neglected in Nigeria is the rabbit. The rabbit has the ability to convert feedstuff such as forages, most agricultural by-products, kitchen waste etc that human being cannot consume directly into highly nutritious meat. Rabbits are highly prolific, cheap to feed because they can utilize roughage feeds, they have rapid growth rate, high dressing percentage, short gestation period and low purchasing price. However, efficient rabbit production is largely dependent upon adequate and correct nutrition (Odimba 2006). There is no rabbit so good that poor nutrition will not ruin nor any bad one that good feeding will not improve. A rabbit which is not well fed cannot give its best, and when it is realized that the greatest cost of producing rabbits lies in the nutrition, correct feeding therefore becomes of utmost importance to the rabbit producer. The quantity of feed provided is important but the quality or type of feed is more important because poor nutrition result in slow growth rate, inefficient reproduction and predisposes the animals to diseases. Many studies have suggested ways of increasing the low animal protein intake of Nigerians.

One of the cheapest producers of meat that can easily fit into the wider segment of the population but which has been neglected in Nigeria is the rabbit. The rabbit has the ability to convert feedstuff such as forages, most agricultural by-products, kitchen waste etc that human being cannot consume directly into highly nutritious meat. Rabbits are highly prolific, cheap to feed because they can utilize roughage feeds, they have rapid growth rate, high dressing percentage, short gestation period and low purchasing price. However, efficient rabbit production is largely dependent upon adequate and correct nutrition (Odimba 2006). There is no rabbit so good that poor nutrition will not ruin nor any bad one that good feeding will not improve.A rabbit which is not well fed cannot give its best, and when it is realized that the greatest cost of producing rabbits lies in the nutrition, correct feeding therefore becomes of utmost importance to the rabbit producer. The quantity of feed provided is important but the quality or type of feed is more important because poor nutrition result in slow growth rate, inefficient reproduction and predisposes the animals to diseases.

The reduction on the reliance of importation of livestock feed in Nigeria has increased the demand and cost of conventional feed stuff (Togun *et al.*,2006). Therefore there is the need, to explore the use of non-conventional feed sources that have the capacity to yield the same output as conventional feed and perhaps at cheaper cost. The economization of feed cost using cheaper and unconventional feed resources is an important aspect commercial rabbit production (Bhatt and Sharma, 2001; Muriu *et al.,* 2002). Animal protein consumption has become almost unaffordable in many part of the developing countries including Nigeria, where by economic recession of the last decades has further the confounded problems. The use of conventional ingredient also hastened the situation due to serious competition between human and livestock (Dafwang*et al.,* 2001).

Aim And Objectives

The main aim of this Experiment is to determine the growth performance and carcass characteristics of weaner rabbits fed varying inclusion levels of kitchen waste while the specific objectives are to;

i. Determine carcass yield of weaner rabbits supplemented with kitchen waste.
ii. Determine the growth performance of weaner rabbits supplemented with kitchen waste.

MATERIALS AND METHOD

Study Area

The experiment was conducted at Aliko Dangote University of Science and Technology Research Farm, Wudil. The farm is located on latitude 11º37'N and 8º 58'E at an altitude of 403m above the sea level. . The area has an average amount of rain fall about 800 -900mm (Olofin *et al.,* 2008).

Experimental Animals and Their Management

Sixteen weaners rabbit were purchased from wudil market, and we're used for this study. The experimental animal were weighted individually, before the commencement of the experiment and randomly were allocated in to four (4) dietary treatment was replicated three (4) times with one (1) rabbit per replicate. Experimental animal were given antibiotics prophylaxis we're used keproceryl at dose rate of 18/2litres,dowormed were used with Albendazole suspension at dose rate 7.5mg/kg, and disinfectant using morigard solution ,house sanitation were done twice in a week.

Experimental Design

The experimental design used for the study was completely randomized design (CRD).The sixteen (16) rabbit was assigned to treatment and each treatment was replicated three (4) times.

Experimental Diet

The diet were commercial grower mash was used throughout the experimental period. Kitchen waste were supplemented at 3-8% of their body weight in the morning and evening, kitchen waste at level of 0, 5, 10 and 15 % designated as T1, T2, T3 and T4 respectively. Grower mash and fresh water were provided ad-libitum throughout the experiment.

Data Collection

Data collected during this study were include feed intake, weight gain, final body weight, feed conversion ratio and mortality record. The carcass characteristics were determined by removing the pur, and evisceration to remove the viscera and intestine. The weight of the carcass, head and internal organs were recorded. At the end of the experiment daily feed intake, final weight gain, and carcass characteristics was recorded

Statistical Analysis

The data obtained was coded to analysis of variance (ANOVA) using the procedure of SAS (2000). Means that are significantly different, Duncan Multiple Range Test (DMRT) was used to compare the means at 5% level of probability.

RESULT AND DISCUSSION

The growth performance of rabbit supplement with kitchen waste is shown in Table 4.1, the result indicate the significant (P<0.05) different in the feed intake, feed conversion ratio, final body weight and daily weight gain is an indication that animal can utilize kitchen waste in the morning, evening or both. The final body weight values ranged between 1476.7-1016.7g there was significant different between treatment 4 and 2 but in significant when compared to control group 990.0g. The daily weight gain was significantly (P<0.05) different higher in treatment 4 (10.633g) whereas the least value is (8.483g) was recorded in animals under treatment 1. There was no significant difference (P<0.05) in feed conversion ratio value across the treatment. Treatment 4 has higher value (3.51g) for feed conversion ratio.

Table 4.1 Growth performance of rabbit as influenced by different level of kitchen waste

	Treatments				
Parameters	T1	T2	T3	T4	SEM
Initial body weight (g)	633.3	650.0	833.3	1030.0	83.35
Final body weight (g)	990.0	1016.7	1270.0	1476.7	58.35
Daily weight gain 9g)	8.483	8.730	10.397	10.633	8.31
Daily feed intake (g)	23.81	23.93	25.61	36.74	14.25
Feed conversion ratio (g)	2.5100	2.4200	2.2300	3.5167	0.66
Mortality	0.3333	0.3333	0.3333	0.000	0.16

Sources: 2025

The result of the effect of supplementation of rabbit with kitchen waste on carcass characteristics (table 4.2) showed a significant difference (P<0.05) among the treatments. The slaughter weight of treatment T4 is similar to that of treatment T3.The liver weight of experimental rabbit show significant between treatment 4 and 2 but the least significant difference (P<0.05) is treatment 4.The result of organ measurements showed significant difference (P<0.05) effect on heart, lungs and liver with high value obtain in treatment 2 was recorded as (46.06) liver weight least value obtain in treatment 4 .(42.467) This also support the report of Hassan *et al*., (2011) in weaned rabbit fed varying levels of groundnut shell. The liver significantly difference (P<0.05) with higher value obtain in treatment 2 where the lower value are obtain in treatment 4.How ever the mean of right lungs and left lungs in treatment 3 and 2 re similar (P>0.05) with the least value in treatment 1.there were no significantly difference (P<0.05) in felt, head and legs value across the treatment. Treatment 4 had the higher value recorded (140.633) while treatment 2 had the least value recorded (28.000), small intestine weight and small intestine length with the higher value obtain in treatment 2 than the other treatment This also support the report of Hassan *et al.,*(2011) in weaned rabbits fed varying levels of groundnut shell.. However there were significantly difference (P<0.05) between the other treatment. The right kidney and left kidney of treatment 2 which had the higher value recorded (5.900). Large intestine show no significant difference (P>0.05) in all

the treatment mean. However the large intestine length was significantly difference (P<0.05) with the higher value obtain in treatment 2 was recorded as (104.00) while treatment 3 had the least value (97.33). The caecum weight and caecum length there were significantly difference (P>0.05) between treatment 1, 2, 3 and 4. However there were no significantly difference in pancreas, stomach and colon across all the treatment (P>0.05) with the higher value obtain in treatment 2 and treatment 4 had the least value across the treatments.

Table 3.2 Carcass characteristics and organ weight of weaned rabbit fed varying levels of kitchen waste

	Treatments				
Parameters	T1	T2	T3	T4	SEM
Before Slaughter	1.25	1.33	1.55	1.59	0.037
After Slaughter	1.19	1.08	1.47	1.49	0.036
Felt	108.13[b]	106.90[b]	132.40[a]	134.67[a]	25.061
Dressed	0.64	0.73	0.79	0.82	0.003
Head	130.93	121.80	138.77	140.63	44.510
Leg	32.57[b]	28.00[b]	42.53[a]	41.30 [a]	5.060

abc = means with different superscript on the same row are statistically different (p<0.05), SEM = Standard error of mean, NS = Not significant.

The animal on treatment 4 show the highest final body weight (1476.7g) daily weight gain (10.633g) and total daily feed intake (36.74g). This could be attributed to increase feed intake and it support the report of Bawa *et al., (2008) who* reported that feed intake, final body weight, and weight gain increase significantly (p<0.05) in weaner rabbits fed varying level of groundnut haulms and cowpea Shell. Also Hassan *et al.,* (2011) reported similar finding where weaner rabbits on 30% groundnut shell supplementation had significantly (p<0.05) feed intake, final body weight gain and average daily gain. The lowest value for FCR was observed in T3 (2.2300g).This indicated that T3 was the best diet per unit gain. This is similar to Doma *et al.,* (2008) who reported the lower the FCR the better the diet in rabbit. This is also in line with report of Eustace *et al.,* (2003) who reported that poor FCRs obtained were probably due to relative low growth rate and genetic differences.

Table 4.3 Organ weight of weaned rabbit fed varying levels of kitchen waste

	Treatments				
Parameters	T1	T2	T3	T4	SEM
S/ Intestine with Content	53.367	6.233	53.800	52.533	36.51
Small Intestine Weight	50.767	58.400	50.100	50.200	35.24
Small Intestine Length	246.667[b]	261.000[a]	272.667 [a]	261.667 [a]	25.38
Large Intestine with Content	26.233	27.700	27.067	27.233	10.87
Large Intestine Weight	24.633	25.000	23.700	25.833	10.50

Large Intestine Length	100.333	104.00	97.333	99.667	66.25
Liver	46.167	46.067	44.467	42.467	8.26
Heart	4.2333	3.2667	4.0000	3.8833	0.18
Right Kidney	4.333^{c}	5.900^{a}	5.533^{ba}	5.3333^{b}	0.03
Left Kidney	4.8667	5.5000	5.4667	5.5333	0.095
Right Lungs	3.4000^{b}	4.0667^{ba}	4.4667^{a}	4.0333^{ba}	0.11
Left Lungs	2.9333^{c}	4.2333^{a}	3.8667^{ba}	3.6667^{b}	0.04
Caecum with Content	37.500^{ba}	33.767^{b}	42.500^{a}	9.700^{ba}	5.46
Caecum Weight	34.467^{ba}	30.967^{b}	39.233^{a}	36.467^{ba}	4.91
Caecum Length	45.667	41.000	45.333	48.667	18.34
Pancrease	0.8667	0.4667	0.6433	0.5773	0.02
Stomach	15.200^{b}	25.967^{a}	19.233^{ba}	24.200^{a}	9.59
Colon	3.9667^{b}	6.0333^{a}	4.5000^{b}	4.9000^{a}	0.15

abc = means with different superscript on the same row are statistically different ($p<0.05$), SEM = Standard error of mean, NS = Not significant.

The dressing percentage was significantly different ($p<0.05$) in which treatment 4 had the highest value (0.8200%) and the lowest value was recorded in treatment 1 (0.643%), This is contrary to the report of Alade *et al*., (2005) who reported that there was not significant differences ($p>0.05$) in dressing percentage on the dietry treatment effect on the performance of rabbit fed the four treatment diets.

Conclusion

In conclusion, the experiment indicated that there was significant increase in weight gain with levels of kitchen waste supplementation without any adverse effect on the performance of weaned rabbits. Dietary level of kitchen waste can be supplemented in morning or evening to weaned rabbits without any depression on the growth performance, carcass characteristics and organs weight.

Recommendation

Base on the result of this study, the following recommendations were made;

i. Kitchen waste could be given to weaner rabbit up to 3-5% of their body weight without any deleterious effect on performance.
ii. For breeding rabbit should be given kitchen waste inform of morning and evening supplementation.
iii. Further studies should be carried out on blood chemistry and return to cyclical activities of waener rabbit.

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MICROBIOLOGICAL QUALITY ASSESSMENT OF URBAN AND RURAL IRRIGATION WATER FROM FEZ CITY, MOROCCO

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Abstract

In response to food needs and the growing desire to exploit local food, urban and peri-urban agriculture is meeting these needs by producing vegetables, fruits and other foods in cities and their suburbs. In addition to the increasing need for water due to droughts, this agriculture provides wastewater (WW) and treated wastewater (TWW) that is used for irrigation. This study was conducted to compare urban irrigation water: water from Oued Fez upstream and well water. As well as peri-urban irrigation water: water from Oued Fez downstream considered as WW and TWW from the treatment plant of the city of Fez. These in comparison with the rural irrigation waters: waters of Oued Bitit.

The microorganisms investigated are total and thermotolerant coliforms, helminth eggs, Salmonella and cholera vibrio. The study took into account the transfer of these pathogenic bacteria at the level of soils and cultivated plants, cardoon and eggplant.

The results showed a contamination out of national and international standards of the two types of coliforms that it is in winter or in summer in the TWW, WW, the water of Oued Fez and the water of wells located upstream of the city. This fecal contamination was found in soils and crops irrigated by urban and peri-urban water. The same was true for helminth eggs, but the number of eggs was greater in winter than in summer for soils. Cholera Vibrio was present in the different types of irrigation water in summer. But still in winter in WW and TWW. This bacterium was also present in soils, cardoons and eggplants irrigated by WW, TWW and Oued Fez waters upstream. Salmonella was present only in the TWW in summer.

Only the plot irrigated with water from Oued Bitit in the rural zone was within the norms on the three levels of irrigated water, soil and plants and in both periods.

Key words: Groundwater quality, Irrigation, Water quality index, Sidi Slimane, Morocco.

CATALYZING ECONOMIC CONVERGENCE: THE ROLE OF ALBANIA'S NATIONAL PROMOTIONAL BANK IN BRIDGING FINANCIAL GAPS AND ADVANCING EU INTEGRATION

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ABSTRACT

Introduction and Purpose: National Promotional Banks (NPBs) play a crucial role in addressing market failures, catalyzing investment, and ensuring economic stability. In Albania, the establishment of a National Promotional Bank (NPB) is envisioned as a key instrument to bridge financing gaps, enhance access to credit for SMEs and strategic sectors, and facilitate convergence with EU economies. This study explores the potential impact of Albania's NPB, drawing insights from the collaborative efforts of the Albanian government and Cassa Depositi e Prestiti (CDP), as well as World Bank assessments. By leveraging international partnerships and financial instruments, the NPB aims to mobilize resources for infrastructure, digitalization, green finance, and industrial modernization, critical for Albania's sustainable growth and EU integration.

Materials and Methods: The research employs a mixed-methods approach, integrating document analysis, case studies, and expert insights. It examines governance structures, financial models, and policy interventions shaping the operational framework of NPBs. A comparative analysis of peer institutions in the EU and Western Balkans is conducted to contextualize Albania's NPB, evaluating its alignment with the EU's economic convergence strategies.

Results: Findings indicate that Albania's financial sector exhibits a low credit-to-GDP ratio, underdeveloped capital markets, and significant financing constraints for SMEs and agriculture. The NPB is designed to address these deficiencies through credit guarantees, blended finance mechanisms. Drawing from CDP's experience, the NPB is projected to play a transformative role in channeling international funding, particularly in green and digital finance. However, institutional challenges such as regulatory alignment, governance risks, and fiscal sustainability must be addressed for optimal impact.

Discussion and Conclusion: The establishment of an NPB in Albania represents a strategic move to accelerate economic development and EU convergence. This study highlights the importance of a strong governance model, risk management frameworks, and strategic partnerships with international financial institutions. While NPBs have successfully mobilized funding in various EU countries, Albania's unique economic structure requires tailored financial instruments and robust institutional coordination. As Albania moves closer to EU accession, the NPI's effectiveness will be pivotal in bridging economic disparities and unlocking sustainable growth.

Key Words: National Promotional Banks, Economic Convergence, Financial Development, Blended Finance, Public-Private Partnerships, EU Integration, Green Finance, SMEs, Infrastructure Investment, Albania.

INTRODUCTION

National Promotional Banks (NPBs) have emerged as pivotal financial institutions designed to address market inefficiencies, mobilize resources for strategic investments, and catalyze

sustainable economic growth. Initially established to address gaps left by private financial sectors, NPBs strategically utilize public funds to attract private capital, effectively channeling investments into traditionally underserved sectors. Their unique capability to provide specialized financial instruments, including credit guarantees, concessional loans, blended finance, and equity investments, allows them to directly address critical economic barriers such as limited credit accessibility for small and medium-sized enterprises (SMEs), insufficient infrastructure development, and the slow adoption of green and digital technologies.

In the context of Albania, the establishment of a National Promotional Bank holds particular significance due to persistent challenges within its financial and economic environment. The country's financial sector is notably constrained, marked by an exceptionally low credit-to-GDP ratio, underscoring severe underutilization of financial resources for productive investments. Additionally, Albania's financial landscape suffers from structural weaknesses, including an underdeveloped capital market, insufficient competition among banks, and a substantial informal economy that impedes efficient capital allocation (World Bank, 2024). These constraints significantly impact strategic sectors such as SMEs and agriculture, sectors crucial for economic growth and yet severely underserved by traditional financial institutions.

The recent initiative to establish Albania's National Promotional Bank draws upon insights and collaboration from international financial entities such as Italy's established NPB, Cassa Depositi e Prestiti (CDP). This joint effort aims to create a specialized financial institution capable of effectively mobilizing national and international financial resources, specifically targeting sectors traditionally neglected by commercial banking, including SMEs, infrastructure development, agriculture, and the green and digital sectors. By doing so, the Albanian NPB is expected to substantially enhance economic stability and promote growth through targeted investments and financial innovation (NPB Albania Blueprint, 2024).

Moreover, this initiative aligns closely with broader European Union strategies, notably the European Fund for Strategic Investments (EFSI) and InvestEU. These frameworks emphasize the essential role that NPBs play in driving economic convergence and financial stability throughout the continent. By following best practices established by leading European institutions such as Italy's CDP, Albania's NPB seeks to incorporate proven governance models, robust risk management practices, and effective regulatory oversight.

The establishment of an Albanian NPB represents a strategic move to systematically tackle economic barriers that hinder growth and convergence with European standards. By effectively leveraging domestic and international capital, this initiative is poised to foster significant improvements in SMEs' access to finance, infrastructure development, and advancement towards green and digital economies. Ultimately, the National Promotional Bank of Albania is positioned not merely as a financial entity but as a crucial instrument for accelerating the country's sustainable economic development and enhancing its integration into the European economic landscape.

CONCEPTUAL FRAMEWORK

Governance and Institutional Structures

National Promotional Banks (NPBs) operate under governance structures designed to ensure efficient management, transparency, accountability, and alignment with policy objectives. According to the European Commission (2015), effective governance structures are crucial for mitigating political interference, safeguarding transparency, and maintaining operational independence. Essential governance features include clearly defined mandates, robust accountability mechanisms, and effective risk management strategies, all critical to aligning NPB activities with national and EU-level economic and developmental goals. Albania's proposed National Promotional Bank illustrates such governance considerations, reflecting

strategic alignment with EU economic frameworks and local economic priorities (NPB Albania Blueprint, 2024). The governance structure of this NPB incorporates oversight from governmental entities, with specific roles allocated to the Ministry of Finance and other relevant public bodies, ensuring transparency, accountability, and effectiveness in the execution of its developmental objectives (World Bank, 2025).

Financial Development and Economic Gaps

A fundamental rationale behind establishing NPBs, including Albania's NPB, is addressing persistent financial development gaps. Albania exhibits one of the lowest credit-to-GDP ratios in the Western Balkans, indicative of substantial underinvestment and a financial sector dominated by real estate and securities investment rather than productive sectors such as SMEs and agriculture (EBRD Macroeconomic Outlook, 2024). SMEs and agricultural enterprises are particularly underserved, despite their critical role in employment and economic output, representing approximately 19% of GDP yet receiving only around 6% of total lending (World Bank Presentation, 2024). The financial gap for Albanian SMEs and agricultural enterprises highlights significant market failures. SMEs represent 99.5% of businesses in Albania but remain severely underserved, with an estimated financing gap of approximately US$ 1 billion or 9.4% of GDP (World Bank Presentation, 2024). The role of Albania's NPB, informed by insights from peer institutions and the expertise of CDP, would be instrumental in mobilizing resources specifically targeted at bridging this financing gap, enhancing sectoral productivity, and boosting export capacities.

Role of Financial Instruments

To effectively tackle financial market inefficiencies, NPBs employ diverse financial instruments designed to leverage private capital and mitigate investment risks. These include credit guarantees, concessional financing, blended finance, and project-based funding mechanisms. Credit guarantees play a pivotal role in reducing risk aversion among banks, thus stimulating lending to SMEs and underserved sectors (New Financial Instruments, 2016). Concessional financing and blended finance strategies further enhance investment viability by combining public funds with private sector investments to facilitate economically impactful but financially challenging projects, especially within infrastructure and green initiatives (Investing Together, 2022). Blended finance mechanisms, integrating public capital with private investments, have been effectively utilized by institutions like Italy's CDP to fund infrastructure, renewable energy, and digital transformation projects, demonstrating significant multiplier effects on initial public investments (Impact Institutions, 2023). Similarly, Albania's NPB aims to replicate these successful models by introducing tailored financial solutions suitable for its specific economic environment and developmental priorities.

Alignment with EU Integration Objectives

Albania's economic convergence with EU standards is another strategic priority guiding the establishment of its NPB. EU integration not only necessitates adherence to rigorous regulatory frameworks but also mandates economic transformations to enhance competitiveness, sustainability, and resilience to shocks (EBRD Western Balkans Convergence, 2024). By integrating EU-compatible governance standards, financial instruments, and investment criteria, Albania's NPB will significantly contribute to meeting EU accession conditions. Enhanced EU integration through Albania's NPB is aligned explicitly with EU strategic frameworks such as InvestEU and the European Green Deal, aiming to accelerate the transition towards a more resilient, inclusive, and environmentally sustainable economy. This alignment

will enable Albania's NPB to leverage substantial EU financial resources, technical expertise, and regulatory frameworks critical for boosting national competitiveness and facilitating sustained economic convergence (European Commission, 2015).

METHODOLOGY

Data Collection

The methodology employed in this study adopts a comprehensive qualitative approach, which primarily consists of an extensive literature review, examination of policy frameworks, and critical analysis of expert reports relevant to National Promotional Banks (NPBs). This review included an array of essential sources such as detailed guidelines and role definitions provided by the European Commission concerning NPB operations (COM, 2015), comprehensive analyses by Rubio et al. (2018), and additional expert insights by Zylberberg (2023). Special emphasis was placed on evaluating the preliminary blueprint designed by Cassa Depositi e Prestiti (CDP, 2024), explicitly developed for the establishment of Albania's National Promotional Bank. Furthermore, structured consultations, stakeholder engagements, and targeted workshops organized by the World Bank in 2025 served as crucial sources of additional qualitative data (Gutierrez, 2025). These activities provided direct access to expert knowledge, facilitating a deeper understanding of potential challenges and operational considerations specific to the Albanian context.

Financial Market Analysis

This study involved a rigorous analysis of Albania's financial market conditions to clearly identify existing financing gaps, especially those affecting SMEs and the agricultural sector, which are critical for economic convergence and sustainability. The analysis was conducted by thoroughly reviewing statistical datasets and economic evaluations from authoritative sources such as the European Bank for Reconstruction and Development (EBRD, 2024) and comprehensive reports generated by the World Bank (World Bank Presentation, 2024). The analytical focus included critical financial indicators such as credit-to-GDP ratios, lending patterns by commercial banks, sector-specific financing data, and investment trends. These indicators were assessed to identify structural weaknesses within the financial ecosystem and pinpoint priority areas requiring targeted financial interventions. This stage of analysis was pivotal for highlighting the critical challenges hindering financial development, particularly in underfunded but economically significant sectors.

Governance and Risk Management Framework

The methodology also encompassed a detailed review of governance frameworks and risk management practices adopted by prominent and successful European National Promotional Banks, particularly emphasizing the Italian model established by CDP and other benchmark institutions within the EU. This comparative analysis aimed to identify governance standards and risk management strategies that effectively ensure institutional independence, operational transparency, and robust accountability mechanisms suitable for adaptation in Albania (Rubio, 2018; Zylberberg, 2023). Key aspects of governance that were thoroughly examined included board composition, decision-making processes, institutional checks and balances, and measures to prevent undue political influence. Simultaneously, risk management practices explored included risk identification, evaluation processes, and mechanisms for risk mitigation, crucial for ensuring financial sustainability and institutional resilience.

Alignment with EU Objectives

Another critical dimension of this methodological approach involved iterative validation procedures carried out through structured dialogues and consultations with key stakeholders. These stakeholders included experts from CDP, specialists from the World Bank, and prominent local policymakers and financial institutions. This collaborative validation process ensured the proposed model for Albania's NPB was strategically aligned with broader EU objectives and integration policies such as the European Green Deal and the InvestEU initiatives (European Commission, 2015; EBRD, 2024). The alignment process involved assessing the compatibility of the proposed NPB operational framework and strategic priorities with EU financial regulations, sustainability goals, and regional development policies. Additionally, this validation helped ensure that Albania's NPB would effectively leverage EU financial instruments, enhance regional integration, and support sustainable economic growth in line with European Union standards and expectations.

Model of the Research

The overarching methodological model integrates critical strategic insights derived from core documents provided by the European Commission (COM, 2014; COM, 2015). These insights were complemented by extensive evaluations of economic convergence patterns documented in EBRD studies (EBRD, 2024), alongside practical consultations and focused workshops organized by World Bank specialists (Gutierrez, 2025). Additionally, the practical expertise and operational insights provided by CDP's experience and established institutional models significantly informed the methodological framework (CDP Blueprint, 2024).

CONCLUSION AND DISCUSSION

The establishment of Albania's National Promotional Bank (NPB) marks a significant institutional advancement designed explicitly to address persistent financial market inefficiencies and support the country's sustainable economic growth and development. Throughout the comprehensive review and analysis conducted in this study, the necessity of creating a specialized institution to manage strategic investments, particularly targeting underserved sectors such as SMEs and agriculture, became evident. Albania's economic environment, notably characterized by one of the lowest credit-to-GDP ratios within the Western Balkans region, has led to substantial underinvestment, constraining overall economic potential. This underinvestment is further illustrated by a considerable financial gap estimated at approximately 9.4% of GDP (around US$ 1 billion), underscoring the urgency of establishing an effective promotional bank dedicated to these pressing financial issues (World Bank Presentation, 2024).

A central conclusion emerging from the analysis pertains to the crucial role of robust governance frameworks. Such frameworks must prioritize institutional transparency, clear accountability mechanisms, strategic independence, and rigorous oversight. Best practices demonstrated by established European promotional banks, such as Italy's Cassa Depositi e Prestiti (CDP), Germany's KfW, and France's Bpifrance, highlight the importance of maintaining stringent governance structures. These institutions underscore the importance of distinct roles between strategic oversight and operational management, the implementation of comprehensive internal control systems, and effective regulatory compliance. Adopting these governance best practices in Albania will be instrumental in mitigating risks such as political interference, financial mismanagement, and operational inefficiencies, thereby enhancing the NPB's credibility, stability, and effectiveness in delivering on its developmental mandate (CDP Blueprint, 2024; Gutierrez, 2025).

Another vital conclusion from the research highlights the strategic importance of tailored financial instruments in effectively bridging identified market gaps. Instruments such as concessional finance, credit guarantees, subordinated bonds, and reverse factoring have proven particularly successful in European contexts, demonstrating a significant ability to mobilize private capital by reducing perceived investment risks. Specifically, credit guarantees have shown great potential in overcoming local banks' risk aversion towards SMEs and agriculture, sectors that are critical for Albania's economic structure but significantly underserved due to perceived risks and collateral constraints. Similarly, concessional financing and subordinated loans are pivotal tools to stimulate private investment by enhancing project viability and reducing initial capital barriers, thus fostering broader financial inclusion and sectoral growth (World Bank Presentation, 2024; EBRD, 2024).

The strategic alignment of Albania's proposed NPB with EU integration frameworks emerged as another critical pillar of the model. Specifically, aligning with major EU initiatives like the European Green Deal and InvestEU allows Albania to effectively mobilize additional international financial resources, technical support, and regulatory frameworks to achieve sustainable development objectives. Such alignment not only enhances the NPB's operational efficacy but also contributes significantly to Albania's broader ambitions for EU accession. In this regard, strategic alignment with EU policies will further ensure that funded projects, particularly in green and digital sectors, adhere to rigorous international environmental and economic standards, thereby facilitating both financial and institutional convergence with the EU (COM, 2014; EBRD, 2024).

Furthermore, it was found that leveraging strategic international partnerships and enhancing cross-border collaboration could significantly bolster Albania's financial market capacities. By drawing on the expertise and experience of peer institutions in Europe, particularly Italy's CDP, Germany's KfW, and France's Bpifrance, the Albanian NPB can effectively implement advanced financial mechanisms and sophisticated risk management practices. Such collaborations can facilitate knowledge transfer, strengthen institutional capacities, and foster innovative financial solutions tailored to Albania's unique economic context (COM, 2015; ELTI, 2023).

Overall, the findings underline the substantial potential impact of establishing an NPB on Albania's economic landscape, particularly concerning financial inclusion, market stability, and economic resilience. The rigorous application of international best practices in governance and operational frameworks, coupled with strategic alignment with EU objectives, is critical to realizing these potential benefits. Further research could involve quantitative assessments of the specific economic impacts of investments made by Albania's NPB, thereby providing additional empirical evidence to guide future policy decisions and operational adjustments.

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COMPARISON OF CATALYTIC APPLICATIONS OF CAO-AG BIMETALLIC NANOPARTICLES AND ITS COMPOSITE: CAO-AG/NA-ALG/PANI

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Abstract

Silver (Ag) particles embedded on the surface of calcium oxide (CaO) bimetallic nanoparticles (BNPs) are synthesized using a chemical reduction method. Bio-waste eggshells were used as the source of CaO, while silver nitrate ($AgNO_3$) was used to provide Ag for the preparation of CaO-Ag BNPs. The nanocomposites CaO-Ag/Na-alg, CaO-Ag/PANI and CaO-Ag/Na-alg/PANI were fabricated via an in-situ polymerization method. The crystalline nature of the BNPs and nanocomposites was revealed by X-ray diffraction (XRD) analysis, showing the following order of crystalline nature: CaO > Ag > PANI > Na-alg. Scanning electron microscope (SEM) images showed that irregular shapes were exhibited by the CaO-Ag BNPs and that Ag particles, reduced from $AgNO_3$ in the presence of $NaBH_4$ were embedded on the surface of the CaO particles. Energy dispersive X-ray (EDX) spectroscopy confirmed that only Ca, O and Ag elements were contained in the synthesized of CaO-Ag BNPs. Essential functional groups were identified by Fourier transform infrared (FTIR) spectroscopy, with bands around 669, 868, 1077, and 1541 cm^{-1} corresponding to CaO, Ag, Na-alg and PANI respectively. After characterization, the BNPs and nanocomposites were evaluated as catalysts for reducing different organic dyes. The catalytic performance was assessed by comparing different kinetic parameters, including the apparent rate constant (k_{app}), reduction time, % reduction and half-life. The best catalytic reduction of methyl blue (MB) was demonstrated by the CaO-Ag/Na-alg/PANI nanocomposite compared to other dyes. k_{app} of 0.181 min^{-1}, a % reduction of 86%, a reduction time of 18 min and a half-life of 4 min for MB dye was observed for the CaO-Ag/Na-alg/PANI nanocomposite.

INVESTIGATION OF CAPACITIVE AND NON-CAPACITIVE BEHAVIOUR IN A COMPOST-BASED SYMMETRIC ENERGY STORAGE DEVICE

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Abstract

The widespread availability of compost and its role in the bio-circular economy, where bio-waste is efficiently converted into compost, make it an appealing material for exploration as a novel biomaterial for renewable energy storage. In this study, the capacitive and non-capacitive charge storage characteristics in a compost-based symmetric device configuration have been examined. Capacitive charge storage generally aligns with dielectric or electrolytic capacitance principles, which are non-faradaic in nature, while non-capacitive charge storage in batteries is dominated by faradaic processes. Given the complexity of compost, various types of compost and current collectors were tested, using distilled water as an aqueous medium. The investigation focuses on both capacitive and non-capacitive charge storage mechanisms in a symmetric dual current collector device to distinguish between the different behaviours of capacitors and batteries. Test cells were optimized based on volume, current collector distance, and applied current. These optimized cells were then analyzed through cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) studies, and electrochemical impedance spectroscopy (EIS) to evaluate capacitive and non capacitive processes in terms of charge storage capability, charge/discharge time, specific capacitance, and specific capacity. Autoclave experiments with the best compost sample (baked at 120°C for 60 minutes) were conducted to observe the role of microorganisms in compost. Additionally, chrono-amperometry studies were performed to assess the stability of the device. The results reveal multifunctional charge storage behaviour in compost as a bio-media, laying the groundwork for a new, eco-friendly bio-media for charge storage.

Keywords: Compost, Charge storage, Non-faradaic, Faradaic, Stability, Corrosion

CROSS-BORDER MERGERS AND ACQUISITIONS IN NIGERIA AND OTHER JURISDICTIONS: LEGAL COMPLEXITIES AND REGULATORY CHALLENGES

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Abstract

Cross-border mergers and acquisitions are critical for global corporate development, allowing organizations to access new markets, acquire important assets, and gain a competitive edge. These transactions are governed by complex legal frameworks and strict regulatory scrutiny in Nigeria, as in other countries. This study investigates the legal difficulties and regulatory obstacles of cross-border mergers and acquisitions in Nigeria and compares them to those in other relevant jurisdictions. Antitrust restrictions, national security concerns, tax consequences, and sector-specific standards are all discussed, showing how these factors affect deal-making and corporate strategy. The paper finishes with strategic advice for navigating legal and regulatory environments, highlighting the need for extensive due diligence, robust legal preparation, and conformity to local legislation.

Keywords: Antitrust laws, business expansion, Cross-Border Mergers and Acquisitions

CYBERSECURITY IN HEALTHCARE: PROTECTING PATIENT DATA AND NURSING INFORMATION SYSTEMS IN NIGERIA

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ABSTRACT

Introduction and Purpose: The integration of information and communication technology (ICT) into healthcare has improved service efficiency and accessibility. However, it has also introduced significant cybersecurity challenges. This study examines cybersecurity risks in Nigerian healthcare settings, with a particular focus on vulnerabilities in nursing information systems. It also proposes strategies to enhance data security and protect patient information.

Methods: A systematic review was conducted following PRISMA guidelines, analyzing literature published between 2015 and 2023. In addition, anecdotal reports and non-participant observations were carried out in a tertiary healthcare facility in Abuja, Nigeria to assess real-world cybersecurity threats and current protective measures.

Results: Findings indicate that cybersecurity risks in Nigerian healthcare institutions stem from three primary factors:

1. Technological vulnerabilities – including medical device security flaws and ransomware attacks.

2. Human factors – such as phishing attempts, insider threats, and poor cybersecurity awareness among healthcare personnel.

3. Infrastructure deficiencies – including weak authentication protocols, inadequate data encryption, and inadequate user training.

Nursing information systems were found to be particularly susceptible to these risks, increasing the potential for data breaches and compromised patient confidentiality.

Conclusions: A proactive, multifaceted approach is necessary to strengthen cybersecurity in Nigerian healthcare institutions. Key recommendations include implementing multi-factor authentication and data encryption, establishing robust cybersecurity governance policies, and conducting regular risk assessments. Additionally, enhancing staff training programs is crucial for improving awareness, compliance, and overall cybersecurity resilience. Integrating these security measures into daily workflows without disrupting healthcare delivery will ensure a more secure and resilient digital healthcare environment.

Keywords: Cybersecurity, Data Breach, Healthcare, Nursing Information Systems, Patient Data.

INTRODUCTION

The coming of the internet and information communication technology brings relieve and succor to ease of doing business in the world. This brings with it digital healthcare.

World Health Organization (WHO) defined digital health technologies as: *"the field of knowledge and practice associated with the development and use of digital technologies to improve health… Digital health expands the concept of eHealth to include digital consumers, with a wider range of smart and connected devices. It also encompasses other uses of digital technologies for health such as the Internet of Things (IoT), advanced computing, big data analytics, artificial intelligence including machine learning, and robotics"(WHO, 2021).*

Digital Health, today, plays an incontrovertible role in the healthcare industry. It inculcates the use of information and communications tool, devices, software, platforms and sensors in the disease diagnosis, management of illnesses, risk identification to patients and wellness enhancement and improvement in the quality of life. The operation needs of the healthcare organizations and providers are also met through this digital health, for example, in the areas of clinic bookings/scheduling, billing, admissions and discharges and patient communication (Arnold, 2024; (Awati and Bernstein, 2024).

Some of the digital health devices applications are: smart elevators, smart heating, ventilation and air conditioning (HVAC) systems, infusion pumps, remote patient monitoring devices Wearable devices, Diagnostics tools, productive modeling, Mobile apps, Telehealth and telemedicine, Patient portals, Decision support systems, Digitized health record platforms, Bioinformatics tools, etc. These tools incorporate various forms of technologies (HIMSS, 2024).

All these innovations in digital health improve care to all the healthcare stakeholders which include, patients (who are at the centre of care), clinicians, researchers, application developer and medical device manufacturers and distributors (Awati and Bernstein, 2024).

The benefits of digital health are numerous to mention. Some of which are: Better Access to Care, **Communication Technology Enhancing Patient Experiences, Lower Delivery Costs, Centralized Data Management System, Continuity and Quality of Care, Data Analysis and Staff Efficiency, Encouragement for Healthcare Organizations, More Accurate Decision-making,** Faster Information Sharing, Improved Public Health Research. (Arnold, 2024; DENmaar, 2023; Ndayishimiye et al., 2023)

Despite numerous benefits and importance of digital health care, it is not without its challenges, disadvantages and threats. **Data Privacy and cybersecurity** issues are some of the challenges and threats of digital healthcare systems. The digital healthcare systems are prime targets for cyberattacks, including ransomware, phishing, and data breaches. Ensuring privacy of patients' data is another major challenge, especially with the increasing use of cloud storage and mobile devices (Nast, 2017).

According to Cybersecurity Infrastructure Security Agency (CISA) (2021) "Cybersecurity is the art of protecting networks, devices, and data from unauthorized access or criminal use and the practice of ensuring confidentiality, integrity, and availability of information".

Threats to digital health can come inform of cyberattack. This cyber-attack can present in form of **ransomware or malware** - attackers can encrypt patient data and demand a ransom for its release, potentially disrupting healthcare services. It can also come inform of **phishing**. cybercriminals use phishing attacks to gain access to sensitive information by tricking users into providing their credentials. There could also be cases of data breach. This is when there is an u**nauthorized Access** to data storage system. Hackers can gain unauthorized access to patient records, leading to data breaches that compromise patient privacy. Employees with access to sensitive data can intentionally or unintentionally cause data breaches (HEALTH-

ISAC, 2024; WHO, 2024).

With these challenges and threats, all hope is not lost, as there are cybersecurity strategies that can be deployed to counter or prevent some of these attacks from happening.

Healthcare facilities and organisations do handle a large amount of very sensitive data that include patients' records, medical histories and treatment plans. As healthcare systems adopt more digital and electronic health record (EHR) systems, safeguarding this information from cyber threats and attacks becomes increasingly very critical.

Some Basic security controls include the following: Anti-virus, Backup and restoration of files/data, Data loss prevention, Email gateway, Encryption at rest, Encryption for archived files/data, Encryption in transit, Firewall, Incident response plan, Intrusion detection and prevention system, Mobile device management, Policies and procedures, Secure disposal, Security awareness training, Vulnerability management program/patch management program, and Web gateway.

Advanced security controls include the following: Anti-theft devices, Business continuity and disaster recovery plan, Digital forensics, Multi-factor authentication, Network segmentation, Penetration testing, Threat intelligence sharing (also called information sharing), Vulnerability scans (HIMSS, 2024).

The study explored ways to Protect Patient Data and Nursing Information Systems from cyberattacks of any kind.

Study Objectives

1. To review the key cybersecurity risks in healthcare settings
2. To review the vulnerabilities in nursing information systems
3. To propose strategies for enhancing cybersecurity in healthcare institutions

CONCEPTUAL FRAMEWORK

Introduction to Cybersecurity in Healthcare

The need to protect health information of various healthcare organizations is something that efforts have been put in place to ensure. For an improved patient care, medical equipment and applications are very important and invaluable, which also make them to be targets of attack by some malicious attackers. These attackers often do these for some selfish and fraudulent reasons. Some organizations are forced to pay huge amount of ransom money for them to be able to gain access to their data that has been encrypted by the attackers. Implementing a well-coordinated and robust cybersecurity measures within the healthcare facility to ensure the safety of all the information is very important.

Historical Perspective on Cybersecurity Threats in Healthcare

Cybersecurity in healthcare has evolved significantly, paralleling technological advancements in medical devices, electronic health records (EHRs), and telemedicine. Historically, healthcare was not a primary target for cyberattacks, but its critical role in society and the wealth of sensitive patient data have made it increasingly vulnerable over time. From the early 1990s to the present, the scope and sophistication of threats have expanded significantly. Understanding this evolution provides context for current and future challenges in protecting healthcare information.

Early Cybersecurity Concerns (1990s–2000s)

The adoption of electronic health records (EHRs) in the late 20th century marked the beginning of significant cybersecurity challenges in healthcare. During this period, threats were primarily

internal, such as accidental breaches or theft of physical hardware containing patient data. Paper-based systems limited the scope and scale of breaches but also posed challenges in ensuring consistent protection and tracking of unauthorized access (Smith, 2005). Regulations like the Health Insurance Portability and Accountability Act (HIPAA) of 1996 in the United States laid the foundation for addressing these risks by mandating the protection of health information (Sittig & Singh, 2016).

The Rise of EHRs and Targeted Attacks (2000s - 2010s)

The adoption of EHRs under initiatives like the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 brought substantial improvements in data management. However, it also exposed healthcare systems to new risks. By the late 2000s, healthcare organizations began facing targeted cyberattacks, particularly through malware and phishing. A notable example was the Heartland Payment Systems data breach in 2008, which highlighted vulnerabilities in handling sensitive information (Ponemon Institute, 2015).

Another attack was the ransomware attacks of the infamous WannaCry attack in 2017, highlighted vulnerabilities in outdated healthcare IT systems. WannaCry paralyzed healthcare systems globally, including the UK's National Health Service (NHS), forcing hospitals to cancel appointments and delay care (Greenberg, 2017; Green, 2018). This period also saw the rise of phishing and data theft, with attackers exploiting the high value of health information on the dark web (McLeod & Dolezel, 2018).

Current Trends and Challenges (2020s) and Future Directions

Recent years have seen a surge in sophisticated threats, such as advanced persistent threats (APTs) and attacks on Internet of Medical Things (IoMT) devices. The COVID-19 pandemic accelerated the digital transformation of healthcare, including telemedicine and remote monitoring, but also increased cybersecurity risks. Healthcare organizations now face threats ranging from data theft to the manipulation of medical devices, jeopardizing patient safety and data integrity (Kaspersky, 2021). For example, in 2020, the U.S. Department of Health and Human Services faced a distributed denial-of-service (DDoS) attack aimed at disrupting pandemic response efforts (Kaiser, 2020).

Cybersecurity in healthcare must adapt to address emerging challenges, including artificial intelligence-driven attacks and vulnerabilities in interconnected medical devices. Strengthening regulatory frameworks, improving threat detection systems, and fostering a culture of cybersecurity awareness among healthcare professionals are critical steps forward.

The Importance of Protecting Healthcare Information Systems

Healthcare information systems (HIS) are critical to modern healthcare delivery, encompassing electronic health records (EHRs), medical devices, telehealth platforms, and administrative databases. It is essential for maintaining the confidentiality, integrity, availability of sensitive patient data and maintain operational efficiency, and ensure the continuity of care.

Safeguarding Patient Privacy and Confidentiality

Healthcare systems manage vast amounts of sensitive patient data, including medical histories, diagnoses, and financial information. Unauthorized access or breaches can lead to identity theft, medical fraud, and violations of patient confidentiality, undermining trust in healthcare providers (McLeod & Dolezel, 2018). The Health Insurance Portability and Accountability Act (HIPAA) mandates robust data protection to prevent such breaches and ensure compliance with legal standards (Office for Civil Rights, 2022).).

Ensuring Operational Continuity

Cyberattacks, such as ransomware, on HIS can disrupt essential healthcare operations, including appointment scheduling, diagnostics, and treatment planning services, by locking

access to critical systems. These attacks can delay care, jeopardize patient safety, and incur significant financial losses (Green, 2018). The interdependence of healthcare functions on these systems underscores the need for proactive cybersecurity measures. Ensuring uninterrupted access to medical records and communication systems is vital for patient safety and the delivery of timely care.

Mitigating Financial and Reputational Losses

Data breaches are costly. Healthcare organizations not only face direct costs, such as regulatory fines and legal fees, but also suffer reputational damage. The IBM and Ponemon Institute's *Cost of a Data Breach Report* consistently identifies healthcare as the most expensive industry for data breaches, with an average cost exceeding $10 million per incident (IBM, 2023).

Protecting Medical Devices and Patient Safety

The integration of Internet of Medical Things (IoMT) devices and telehealth services has enhanced patient care but also introduced new vulnerabilities. Unauthorized access to connected devices, such as infusion pumps or pacemakers, could compromise patient safety (Kaspersky, 2021).

Types of Cybersecurity Threats in Healthcare in Nigeria

As Nigeria’s healthcare sector undergoes digital transformation, including the adoption of electronic health records (EHRs), telemedicine, and cloud-based systems, it faces growing cybersecurity threats. These challenges are compounded by limited resources, inadequate cybersecurity awareness, and underdeveloped regulatory frameworks.

Ransomware Attacks

Ransomware is a prominent threat in Nigeria, as healthcare facilities are increasingly targeted due to their reliance on digital systems for patient care. Limited cybersecurity infrastructure in many Nigerian hospitals makes them vulnerable to ransomware, which can disrupt operations and compromise patient safety. For example, reports indicate that ransomware attacks in African countries, including Nigeria, have surged in recent years, primarily affecting industries with critical services (Adeoye et al., 2021; Kaspersky, 2021).

Phishing Attacks and Social Engineering

Phishing and social engineering attacks exploit human factors and are pervasive in Nigeria. Cybercriminals use fraudulent emails, messages, or phone calls to trick healthcare workers into divulging login credentials or downloading malicious files. The lack of robust cybersecurity training among healthcare staff exacerbates this threat, making phishing a common entry point for larger cyber campaigns (CSEA, 2022). These attacks are particularly effective in environments with low cybersecurity awareness. Healthcare staff may inadvertently click on malicious links, exposing sensitive patient data or enabling broader system breaches (Verizon, 2023).

Insider Threats

Insider threats, whether malicious or unintentional, pose significant risks to Nigerian healthcare facilities. Poor access controls, insufficient employee training, economic challenges or intentional misconduct by healthcare employees can lead to unauthorized access to patient records, negligent handling of data, deliberate misuse of system privileges or theft. Insider threats are particularly concerning in environments with low accountability and inadequate monitoring systems (Adekunle et al., 2020; Olaniyan et al., 2022).

Medical Device Vulnerabilities

The adoption of Internet of Medical Things (IoMT) devices in Nigeria is increasing, but these devices often lack robust security protocols. Outdated or poorly configured devices are

susceptible to hacking, potentially compromising patient safety. The lack of localized regulations on medical device cybersecurity exacerbates this challenge (NITDA, 2021; Adeleke et al., 2021).

Cloud Computing Risks

Cloud-based solutions are gaining traction in Nigeria's healthcare system due to their cost-efficiency and scalability. However, these systems face risks such as data breaches, weak encryption, and misconfigurations. Many healthcare providers lack advanced cybersecurity frameworks to protect cloud-based data, making them vulnerable to attacks targeting centralized repositories (Olufemi & Adebayo, 2023; Oladimeji et al., 2023).

Legal and Regulatory Frameworks

Protecting healthcare information systems requires adherence to legal and regulatory frameworks that safeguard sensitive patient data, ensure privacy, and promote accountability. Below are key regulations that shape cybersecurity and data protection in healthcare.

Health Insurance Portability and Accountability Act (HIPAA)

HIPAA, enacted in 1996 in the United States, establishes national standards for protecting sensitive patient information. The Act includes the following rules relevant to cybersecurity:

- **Privacy Rule**: Protects individuals' medical records and personal health information (PHI), giving patients control over their data.
- **Security Rule**: Requires healthcare providers and associates to implement administrative, physical, and technical safeguards to protect electronic PHI (ePHI).
- **Breach Notification Rule**: Mandates timely notification of affected individuals, the government, and sometimes the media in case of significant data breaches (U.S. Department of Health & Human Services, 2022).

General Data Protection Regulation (GDPR)

The GDPR, enforced in the European Union since 2018, has a global impact, influencing data protection practices worldwide. Key features include:

- **Data Minimization and Purpose Limitation**: Healthcare organizations must collect only necessary data and use it solely for specified purposes.
- **Right to Access and Erasure**: Patients have the right to access their data and request its deletion.
- **Mandatory Data Breach Reporting**: Organizations must notify authorities of breaches within 72 hours (European Commission, 2021). Although GDPR is not specific to healthcare, its stringent requirements apply to healthcare providers managing EU citizens' data, even outside the EU.

Other Relevant Regulations and Compliance Measures

1. **Nigerian Data Protection Regulation (NDPR):** The NDPR, implemented in 2019, is Nigeria's primary legal framework for data protection. It was enacted by the National Information Technology Development Agency (NITDA), to governs the processing of personal data in Nigeria. It mandates healthcare organizations to implement measures protecting patient data from unauthorized access and breaches

   - **Scope**: Covers the processing of personal data, including PHI, by public and private entities in Nigeria.
   - **Requirements**: Healthcare providers must obtain patient consent before data processing and ensure adequate security measures to protect data ((NITDA, 2021).

2. **Health Information Technology for Economic and Clinical Health (HITECH) Act**

An extension of HIPAA in the United States, the HITECH Act incentivizes the adoption of electronic health records (EHRs) while imposing stricter penalties for non-compliance with HIPAA's security provisions.

3. **ISO/IEC 27001**

This international standard outline best practices for information security management systems (ISMS). While not specific to healthcare, compliance with ISO/IEC 27001 helps organizations establish a robust cybersecurity posture.

4. **Other National Laws**

Various countries have enacted healthcare-specific regulations, such as the **Cybersecurity Law of China**, which includes strict data localization and security requirements for healthcare data.

Challenges in Protecting Nursing Information Systems

Protecting nursing information systems is critical for maintaining patient safety and data security. However, unique challenges make it difficult to implement robust cybersecurity measures. These challenges include operational complexities, resource limitations, and human factors.

Complexity of Nursing Workflows

Nursing workflows are inherently complex, involving dynamic patient interactions, medication administration, documentation, and care coordination. Cybersecurity measures such as frequent password changes, multi-factor authentication (MFA), or system downtime during upgrades can disrupt these workflows. Nurses may prioritize patient care over cybersecurity practices, inadvertently exposing systems to vulnerabilities (Simamora et al., 2021).

Integration with Other Hospital Information Systems

Nursing information systems often integrate with hospital-wide systems, including electronic health records (EHRs), laboratory information systems, and pharmacy management tools. While integration enhances care coordination, it increases the attack surface, creating more entry points for cyber threats. A vulnerability in one system can propagate across interconnected systems, compromising nursing data and overall hospital security (Khan et al., 2020).

Limited Cybersecurity Training for Healthcare Staff

Many nursing professionals lack formal training in cybersecurity best practices. Phishing attacks and social engineering campaigns often exploit this gap. In high-pressure healthcare environments, staff may inadvertently bypass security protocols, such as sharing passwords or clicking on malicious links. Education programs tailored to healthcare settings are essential but often overlooked (Ponemon Institute, 2021).

Budget Constraints and Competing Priorities in Healthcare Settings

Healthcare institutions, particularly in resource-constrained settings, face financial challenges that limit investment in cybersecurity. Budget allocations often prioritize medical equipment, staffing, and patient care over IT infrastructure and training. As a result, nursing information systems may rely on outdated software, increasing vulnerability to cyberattacks (Chigbu et al., 2022).

The Role of Nursing Information Systems in Patient Care

Nursing Information Systems (NIS) are essential for improving patient care by facilitating accurate data management, decision-making, and coordination of care. These systems support

nurses in their daily tasks, ensuring efficient workflows and enhancing patient safety. However, there are challenges, particularly in terms of cybersecurity incidents that can disrupt care. Below are key aspects of the role of NIS in patient care:

Importance of Accurate Data Recording and Accessibility

Accurate data recording and easy access to patient information are fundamental to safe and effective nursing care. NIS ensure that nurses have up-to-date, comprehensive patient data at the point of care, allowing them to make informed decisions. For instance, accurate documentation of vital signs, medication administration, and patient history ensures continuity of care across shifts and between departments. When data is accurate and accessible, it enhances communication among the healthcare team, reduces errors, and improves patient outcomes (McBride et al., 2019).

- **Impact on Patient Safety**: Accurate, real-time data reduces the risk of medical errors, such as medication mistakes or missed diagnoses, by providing clear and accessible records for all healthcare providers involved in the patient's care (Mackert et al., 2020).
- **Timeliness**: Immediate access to patient records during emergency situations can make the difference in life-threatening scenarios, ensuring timely interventions.

Use of Clinical Decision Support Systems (CDSS)

Clinical Decision Support Systems (CDSS) are integrated into nursing information systems to assist healthcare providers in making clinical decisions. CDSS can provide alerts, reminders, and recommendations based on patient data, such as abnormal lab results, potential drug interactions, or changes in vital signs. These systems improve the decision-making process by:

- **Reducing Errors**: By alerting nurses and doctors to potential issues, such as incorrect medication dosages or interactions, CDSS reduce the likelihood of preventable errors (Garg et al., 2020).
- **Enhancing Evidence-Based Practice**: CDSS facilitate the use of evidence-based guidelines in patient care, improving treatment outcomes and supporting standardized practices across healthcare settings.

However, reliance on CDSS may also present challenges, particularly if the system is not properly integrated or if alerts are too frequent or inaccurate, leading to alert fatigue (Keh, 2021).

Challenges Posed by Cybersecurity Incidents in Nursing Systems

Cybersecurity incidents can significantly disrupt the functionality of nursing information systems, with wide-ranging consequences for patient care. Cyberattacks, such as ransomware or phishing, can cause data breaches, system downtimes, or compromised access to patient records. These disruptions create critical challenges for nursing care, including:

- **Disrupted Access to Patient Data**: In the event of a cybersecurity breach, nurses may be unable to access crucial patient information, which can delay treatments and decision-making.
- **Impact on Clinical Decision Support**: If a system is compromised, the integrity of clinical decision support tools may be jeopardized, leading to faulty recommendations or missed alerts.
- **Increased Risk of Medical Errors**: Inadequate or delayed access to accurate data increases the likelihood of mistakes, such as prescribing the wrong medication or failing to notice critical changes in a patient's condition (Ponemon Institute, 2021).
- **Loss of Trust**: Frequent security breaches can undermine confidence in the reliability of nursing information systems, making staff hesitant to use them or trust the data they provide.

METHODOLOGY

The student did a scoping search and a systematic review using a PRISMA guideline on the topic of discussion: Cybersecurity in Healthcare: Protecting Patient Data and Nursing Information Systems in Nigeria.

Search Strategies

A systematic search was conducted across databases such as PubMed, Scopus, Google Scholar, and local Nigerian academic repositories using the following keywords:

- "cybersecurity data breaches Nigeria"
- "cybersecurity in healthcare institutions Nigeria"
- "cybersecurity in Nigerian hospitals"
- "cybersecurity nursing systems Nigeria"
- "cybersecurity risks healthcare Nigeria"
- "cybersecurity risks in Nigerian hospitals"
- "cybersecurity strategies Nigeria healthcare"
- "electronic health records Nigeria"
- "healthcare cybersecurity threats Nigeria"
- "healthcare data protection Nigeria"
- "nursing data breaches Nigeria"
- "nursing information systems vulnerabilities Nigeria"

The search covered publications from 2015 to 2023.

Selection Criteria:

- **Inclusion Criteria:**
  - Peer-reviewed studies and reports discussing cybersecurity risks specific to healthcare settings in Nigeria.
  - Peer-reviewed articles or conference proceedings that address vulnerabilities in nursing information systems in Nigeria.
  - Studies discussing weaknesses in the security of patient data and nursing records in Nigerian healthcare settings.
  - Articles focusing on cybersecurity threats, vulnerabilities, and breaches in Nigerian healthcare institutions.
  - Studies that discuss cybersecurity strategies tailored to Nigerian healthcare institutions.
  - Articles focusing on policy frameworks, technological solutions, and staff training to improve cybersecurity in Nigerian hospitals and clinics.
  - Published in English.
- **Exclusion Criteria:**
  - Studies not specific to Nigeria or African healthcare contexts.
  - Studies not focused on nursing information systems or not specific to the Nigerian healthcare context.

- Non-peer-reviewed publications, grey literature, and studies published before 2015.

The studies were synthesized and inferences made.

Anecdotal Report

Also, the student went to a tertiary health facility in the Federal Capital Territory, where Electronic Health Record (EHR) is been deployed. He had some informal discussions with the staff of the Health Information Unit, Information Technology Unit, Nurses and other healthcare practitioners. This was to elicit information on the objectives of the study and possibly to proffer strategies on how to solve some of the challenges identified.

RESULTS AND DISCUSSION

This section presents a systematic review of cybersecurity risks, vulnerabilities in nursing information systems, and strategies for enhancing cybersecurity in healthcare institutions in Nigeria, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This approach ensures a transparent, structured, and comprehensive analysis of the available literature regarding cybersecurity in Nigerian healthcare settings.

This review was done according to the set-out objectives:

Objective 1: Review of the Key Cybersecurity Risks in Healthcare Settings in Nigeria

Notable Findings:

The review revealed some cybersecurity risks affecting healthcare settings in Nigeria:

1. **Ransomware Attacks:** Ransomware attacks have been increasingly reported in Nigerian healthcare institutions, where hackers lock access to critical medical and patient data and demand a ransom for its release. These attacks disrupt patient care and can result in significant financial and reputational damage to healthcare organizations (Akinmoladun et al., 2020).

2. **Phishing and Social Engineering Attacks:** Phishing attacks, which use deceptive emails or messages to steal login credentials, are prevalent in Nigerian healthcare institutions. Cybercriminals exploit human vulnerabilities by sending fake communication that encourages healthcare workers to divulge sensitive information or click on malicious links. This risk is exacerbated by insufficient cybersecurity awareness among healthcare professionals (Akintoye et al., 2021).

3. **Data Breaches and Privacy Violations:** Data breaches are a significant concern, with reports highlighting unauthorized access to patient records, either by external attackers or internal staff. These breaches expose sensitive patient data, violating privacy and potentially leading to identity theft or fraud. Healthcare institutions in Nigeria are increasingly targeted due to the perceived low investment in robust security systems (Ibitoye et al., 2020).

4. **Lack of Secure Medical Device Integration:** With the growing use of Internet of Things (IoT)-connected medical devices, Nigerian healthcare facilities face risks related to the security of these devices. Many of these devices lack adequate security features, making them vulnerable to cyberattacks that can disrupt medical operations or compromise patient safety (Ezeani et al., 2021).

5. **Insider Threats:** Insider threats, either from disgruntled employees or those who inadvertently expose sensitive data, are a growing risk in Nigerian healthcare institutions. With limited cybersecurity training and lack of strict access control policies, healthcare workers may unknowingly compromise patient data security (Ajayi et al., 2021).

Data Synthesis:

The key cybersecurity risks in Nigerian healthcare settings are closely related to technological vulnerabilities (e.g., medical device security, ransomware), human factors (e.g., phishing, insider threats), and insufficient infrastructure. There is a pressing need for stronger cybersecurity frameworks and awareness training for healthcare staff.

Objective 2: Review of the Vulnerabilities in Nursing Information Systems in Nigeria

Significant Findings:

Some critical vulnerabilities in nursing information systems in Nigerian healthcare institutions were identified:

1. **Weak Authentication and Access Controls:** Nursing information systems in Nigeria often rely on weak authentication mechanisms, including simple passwords and shared user credentials, which make them vulnerable to unauthorized access. Insufficient role-based access control (RBAC) means that staff members may have access to sensitive information beyond their authorized scope, increasing the risk of misuse or data leakage (Oluwole et al., 2020).

2. **Lack of Data Encryption:** Many nursing information systems in Nigeria lack robust encryption protocols for storing and transmitting patient data. This leaves nursing records exposed to unauthorized access during data exchange, especially when systems are integrated with other healthcare or administrative platforms (Onyema et al., 2021).

3. **Inadequate Security Updates and Patch Management:** Nursing information systems in Nigerian healthcare institutions are often plagued by outdated software and failure to apply critical security patches. This makes these systems vulnerable to exploitation by cybercriminals who take advantage of known software vulnerabilities to breach systems (Obi et al., 2020).

4. **Insufficient Training of Nursing Staff on Cybersecurity:** Many nurses in Nigeria are not adequately trained in cybersecurity, which increases the likelihood of human error. Nurses often lack awareness of security best practices such as proper password management, identifying phishing attempts, and safeguarding patient data (Ayoade et al., 2020). This lack of training contributes to the vulnerabilities of nursing information systems.

5. **Limited Cybersecurity Governance:** Governance structures for cybersecurity are often inadequate in Nigerian healthcare institutions. Many hospitals and clinics lack dedicated cybersecurity teams, and there is often no clear policy governing data protection and the secure use of nursing information systems. This lack of structured oversight leaves systems vulnerable to exploitation (Saidu et al., 2021).

Data Synthesis:

The review indicates that nursing information systems in Nigerian healthcare institutions are vulnerable to both technical issues (e.g., weak authentication, lack of encryption) and human factors (e.g., insufficient training, lack of governance). Addressing these vulnerabilities requires systemic improvements in both technology and personnel education.

Objective 3. Strategies for Enhancing Cybersecurity in Healthcare Institutions in Nigeria

Major Findings:

Some strategies were identified to enhance cybersecurity in Nigerian healthcare institutions:

1. **Implementation of Multi-Factor Authentication (MFA):** The implementation of MFA for accessing sensitive patient data and nursing systems is essential in Nigerian healthcare institutions. MFA adds an extra layer of protection, making it harder for unauthorized users to breach systems, especially given the prevalence of weak password practices (Alabi et al., 2020).

2. **Cybersecurity Awareness and Training for Healthcare Workers:** Regular cybersecurity training for healthcare staff, including nurses, is vital. This training should cover basic concepts of data protection, secure password management, how to recognize phishing attacks, and the importance of securing devices and networks. Awareness programs can significantly reduce the risk of human error (Ajayi et al., 2021).

3. **Strengthening Data Encryption and Secure Communication:** Ensuring robust encryption protocols for patient data, both in transit and at rest, is crucial. Healthcare institutions should also implement secure communication channels for transmitting patient information between systems to prevent data breaches (Akinmoladun et al., 2020).

4. **Regular Vulnerability Assessments and Penetration Testing:** Nigerian healthcare institutions should adopt a proactive approach to cybersecurity by conducting regular vulnerability assessments and penetration tests. Identifying and addressing weaknesses in systems before they can be exploited by cybercriminals is essential for maintaining security (Oluwole et al., 2020).

5. **Cybersecurity Governance and Policy Development:** Establishing strong cybersecurity governance structures and comprehensive data protection policies is necessary. Hospitals and healthcare institutions in Nigeria should develop policies for data privacy, access control, and incident response. Appointing dedicated cybersecurity teams and leadership can drive these initiatives effectively (Saidu et al., 2021).

Data Synthesis:

The identified strategies for enhancing cybersecurity in Nigerian healthcare institutions involve a combination of technical measures (e.g., MFA, encryption), organizational policies (e.g., cybersecurity governance, risk assessments), and human-centered approaches (e.g., training and awareness programs). Together, these strategies can significantly reduce the cybersecurity risks and vulnerabilities in Nigerian healthcare institutions.

SUMMARY

The key cybersecurity risks in Nigerian healthcare settings are closely related to technological vulnerabilities (e.g., medical device security, ransomware), human factors (e.g., phishing, insider threats), and insufficient infrastructure. There is a pressing need for stronger cybersecurity frameworks and awareness training for healthcare staff.

Also, the review indicates that nursing information systems in Nigerian healthcare institutions are vulnerable to both technical issues (e.g., weak authentication, lack of encryption) and human factors (e.g., insufficient training, lack of governance). Addressing these vulnerabilities requires systemic improvements in both technology and personnel education.

Furthermore, the identified strategies for enhancing cybersecurity in Nigerian healthcare institutions involve a combination of technical measures (e.g., MFA, encryption), organizational policies (e.g., cybersecurity governance, risk assessments), and human-centered approaches (e.g., training and awareness programs). Together, these strategies can significantly reduce the cybersecurity risks and vulnerabilities in Nigerian healthcare institutions.

Anecdotal Report

In a tertiary health facility situated in the Federal Capital Territory, the student had an informal discussion with the staff of the healthcare facility. These are nurses, health information management staff, ICT staff and other healthcare staff that have something with patients' data.

Some of the outcome of the discussions are that, some healthcare providers who are in custody of patients' data are not really proactive about safeguarding such data. They sometimes allow unauthorized access to patients' data. Sometimes, they are careless with their login details. They will login and leave the system unattended to.

Some of the suggestions proffer by the staff on how to safeguard patients' data and nursing information systems were as follows:

Training of staff on the current trends in the management and safety of patients' data and nursing information system.

Multiple Factor Authentication should be activated in the nursing information system to ensure the safety of patients' data.

STUDY RECOMMENDATION

After doing a thorough search and anecdotal report, the study therefore suggests the following:

- The healthcare organisations should design security measures that is in line with workflows to reduce disruptions.
- The Nurses and by extension other healthcare providers should advocate for dedicated budget to cater for cybersecurity and ensure that all the systems remain secure and updated.
- All the newly employed and old staff of the organization should be trained on cybersecurity. This should be a routine and continuous process in the organization.
- There should be regular evaluation of the security of integrated systems to identify and address vulnerabilities.
- More students should be encouraged to undergo studies that specifically address the vulnerabilities, risks, and security solutions associated with nursing information systems.
- Research and develop comprehensive cybersecurity education programs tailored to nursing practice, with a focus on practical skills for preventing cyber threats in clinical settings.
- Conduct studies that assess the effectiveness of cybersecurity training programs and identify the most successful approaches for integrating cybersecurity awareness into nursing practice.
- Collaboration between academic researchers, healthcare institutions, and cybersecurity experts can ensure that the findings from research are translated into practical, implementable strategies for improving cybersecurity in nursing information systems.
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CONCLUSION

This review emphasizes the need for a comprehensive cybersecurity strategy that includes both technical and human-centered approaches, such as robust encryption, MFA, regular training, and strong governance. These measures are essential for protecting patient data and ensuring the safety of nursing information systems in Nigeria's healthcare institutions.

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ENSURING ETHICAL AI PRACTICES: CORPORATE ACCOUNTABILITY IN A DIGITAL WORLD

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ABSTRACT

The proliferation of Artificial Intelligence (AI) and Big Data in corporate governance has introduced unprecedented efficiencies in decision-making processes, ranging from predictive analytics and automated financial services to algorithmic hiring and consumer profiling. However, these advancements have also precipitated profound ethical and legal challenges, particularly concerning data privacy violations, algorithmic discrimination, opacity in AI decision-making, and the lack of corporate accountability. A fundamental concern arises in the realm of data privacy and informed consent, where corporations frequently leverage AI-driven analytics to process vast quantities of personal data without adequate regulatory oversight. The Cambridge Analytica scandal (2018) exemplifies the misuse of Big Data in electoral processes, contravening privacy laws such as the General Data Protection Regulation (GDPR). Similarly, AI-driven algorithms have been found to perpetuate systemic biases, as evidenced by Amazon's AI-based recruitment tool (2018), which demonstrated gender discrimination, and the Apple Credit Card case (2019), where AI-driven credit scoring systems disproportionately assigned lower credit limits to female applicants. The lack of transparency and accountability in AI decision-making, often characterized as the "black box" phenomenon, further complicates legal and ethical discourse. The COMPAS risk assessment tool, utilized in the US criminal justice system, disproportionately classified minority defendants as high-risk offenders, raising substantial concerns regarding due process, fairness, and the right to a fair trial. Despite legislative efforts, such as India's Digital Personal Data Protection Act (2023), the EU AI Act (2024), and the US AI Bill of Rights (2022), significant regulatory gaps persist, particularly in delineating liability for AI-induced harm and establishing a global framework for ethical AI governance. To address these concerns, corporations must integrate bias mitigation strategies, ethical AI frameworks, and robust data governance mechanisms into their operational structures. Strengthening legal accountability through enforceable AI regulations, ensuring greater transparency in algorithmic decision-making, and embedding AI ethics into Corporate Social Responsibility (CSR) initiatives are imperative to fostering an AI ecosystem that upholds fundamental rights, fairness, and corporate accountability. A balanced approach that harmonizes technological innovation with legal and ethical safeguards is essential to mitigate the risks posed by AI and Big Data in corporate governance.

Keywords- Corporate accountability, Ethical AI, Algorithmic bias, Data privacy, Regulatory Compliance

INTRODUCTION

Artificial Intelligence (AI) has become a fundamental driver of corporate decision-making, revolutionizing industries by optimizing efficiency, automating processes, and enhancing predictive capabilities. AI refers to computational systems that exhibit human-like intelligence by performing tasks such as data analysis, pattern recognition, natural language processing,

and decision-making with minimal human intervention. These systems rely on machine learning (ML), deep learning, and neural networks to process vast amounts of information and generate insights at speeds and scales unattainable by traditional methods. Big Data, on the other hand, denotes the massive volume of structured and unstructured data generated through digital interactions, business transactions, social media activity, and online behaviour. The defining characteristics of Big Data—volume, velocity, variety, veracity, and value, make it an invaluable resource for corporate entities seeking to gain competitive advantages through data-driven decision-making. Corporations across industries leverage AI and Big Data to enhance operational efficiency, forecast market trends, optimize supply chains, personalize customer experiences, and mitigate risks. In the financial sector, AI-powered automated trading algorithms analyse vast datasets in real time, optimizing investment strategies. In human resource management, AI-driven hiring platforms screen applicants based on predictive analytics, while in healthcare, AI enhances diagnostics and treatment recommendations. Additionally, corporate governance mechanisms increasingly integrate AI for compliance monitoring and fraud detection. However, despite these transformative benefits, the widespread deployment of AI and Big Data in corporate settings has sparked critical debates surrounding accountability, privacy, bias, and regulatory compliance, raising fundamental ethical and legal challenges that demand urgent attention.

The adoption of AI-driven decision-making and Big Data analytics has accelerated across sectors, with corporations recognizing the potential of these technologies to enhance profitability, optimize resource allocation, and improve risk assessment. Data-driven corporate strategies enable organizations to anticipate market fluctuations, tailor products and services to consumer preferences, and detect fraudulent activities with greater accuracy. AI-powered algorithms play a pivotal role in financial forecasting, credit scoring, and algorithmic trading, where real-time data analysis enhances precision and reduces human error. Similarly, e-commerce platforms utilize predictive analytics and recommendation systems to personalize user experiences, increase engagement, and drive sales. In the legal and regulatory domain, corporate compliance mechanisms now incorporate AI for automated contract analysis, regulatory risk assessment, and real-time monitoring of financial transactions. AI enhances due diligence by identifying potential compliance violations and reducing corporate liability exposure. Moreover, Big Data analytics in supply chain management helps organizations detect inefficiencies, optimize logistics, and predict supply chain disruptions, leading to improved operational resilience. While these applications demonstrate AI’s transformative potential, their unchecked deployment raises significant ethical and legal dilemmas. The reliance on AI for decision-making introduces concerns regarding algorithmic bias, discrimination, privacy breaches, and accountability gaps, especially when AI-generated decisions impact fundamental rights such as employment, financial access, healthcare, and criminal justice outcomes. Without robust legal frameworks and regulatory safeguards, corporations risk violating data protection laws, anti-discrimination statutes, and consumer protection regulations. The opaque nature of AI algorithms often described as the "black box problem" exacerbates accountability challenges, as businesses struggle to ensure transparency, explainability, and fairness in AI-driven decision-making. While AI and Big Data have undoubtedly revolutionized corporate efficiency and innovation, their widespread use has triggered significant ethical and legal concerns that necessitate urgent scrutiny. The integration of AI in corporate decision-making processes has led to data privacy violations, algorithmic bias, lack of transparency, and regulatory non-compliance, all of which pose serious risks to individual rights and corporate accountability. These issues are compounded by the fact that existing legal frameworks struggle to keep pace with AI advancements, resulting in a fragmented regulatory landscape that fails to establish clear liability for AI-driven harms. A primary concern is the erosion of data privacy and consent, as corporations collect, store, and process vast amounts of personal data without adequate safeguards. AI-powered surveillance systems, predictive analytics, and personalized marketing algorithms raise significant data protection and consumer rights

concerns, particularly under laws such as the General Data Protection Regulation (GDPR) in Europe and the Digital Personal Data Protection Act (2023) in India. Many AI systems operate without explicit user consent, leading to unauthorized data exploitation, targeted misinformation, and discriminatory profiling. The infamous Cambridge Analytica scandal (2018) exemplifies the unethical use of Big Data to manipulate voter behaviour, highlighting the potential for AI to undermine democratic processes when used irresponsibly.

Furthermore, algorithmic bias and discrimination remain pressing issues in AI-driven corporate operations. AI systems trained on historically biased datasets can reinforce existing inequalities, disproportionately disadvantaging marginalized groups in critical areas such as hiring, credit scoring, and law enforcement. For instance, Amazon's AI recruitment tool (2018) was discontinued after it was found to discriminate against female candidates by favouring male-dominated résumés. Similarly, the Apple Credit Card scandal (2019) revealed that AI-based credit assessment models systematically assigned lower credit limits to women compared to men, despite having comparable financial backgrounds. These cases underscore the urgent need for corporate accountability mechanisms that mandate bias audits, fairness assessments, and transparency in AI model development. Beyond bias, the lack of explainability and accountability in AI decision-making poses legal challenges for corporations. Many AI-driven decisions remain opaque and untraceable, making it difficult to assess their fairness, legality, and compliance with regulatory standards. The COMPAS risk assessment tool, used in the U.S. criminal justice system, exemplifies this challenge. The algorithm, which predicts the likelihood of reoffending, has been criticized for systemic racial bias, disproportionately categorizing Black defendants as high-risk. The inability to challenge or contest AI-generated decisions raises significant due process concerns, particularly when these decisions affect employment opportunities, access to financial resources, or criminal sentencing. The absence of a global regulatory consensus further exacerbates these accountability gaps, as different jurisdictions adopt varying approaches to AI governance. Addressing these challenges requires corporations to integrate ethical AI principles into their governance frameworks and comply with stringent regulatory standards. The emergence of legal instruments such as the EU AI Act (2024), India's Digital Personal Data Protection Act (2023), and the US AI Bill of Rights (2022) represents an important step toward regulating AI and Big Data. However, these regulations must be strengthened to ensure corporate liability for AI-driven harms, promote algorithmic fairness, and establish enforceable guidelines for responsible AI use. Transparency, accountability, and fairness must become the foundational principles of AI governance, preventing the unethical exploitation of AI technologies in corporate decision-making. In light of these concerns, the paper explores the legal and ethical dilemmas posed by AI and Big Data in corporate settings, critically examining issues of data privacy, algorithmic bias, accountability gaps, and regulatory challenges. Through an analysis of case studies, legal frameworks, and emerging regulatory trends, this study seeks to highlight the imperative for stronger corporate governance mechanisms, enhanced legal safeguards, and ethical AI deployment strategies. By addressing these challenges, corporations can harness AI's potential responsibly and equitably, ensuring compliance with legal standards while safeguarding individual rights and societal interests in the digital age.

THE ROLE OF AI AND BIG DATA IN CORPORATE DECISION-MAKING

Artificial Intelligence (AI) and Big Data have become indispensable tools in corporate decision-making, transforming how businesses analyse trends, predict consumer behaviour, allocate resources, and optimize operational efficiency. These technologies enable automated, data-driven decision-making across various sectors, including finance, human resources, insurance, marketing, and risk management. AI-powered algorithms leverage vast datasets to make predictive assessments, improve accuracy, and enhance corporate efficiency. However, the increasing reliance on AI in decision-making processes also raises concerns regarding bias,

fairness, transparency, and ethical accountability and explores the key applications of AI and Big Data in corporate governance, examining their impact on finance, hiring, customer profiling, and automated decision-making in insurance and credit scoring. A critical analysis of real-world case studies and empirical data further underscores the benefits and risks associated with AI-driven decision-making, emphasizing the need for ethical AI frameworks and legal accountability mechanisms.

Predictive Analytics in Finance, Hiring, and Customer Profiling

The financial sector is among the most significant adopters of AI and Big Data. Predictive analytics enables financial institutions to analyse market trends, customer spending habits, and investment patterns, allowing businesses to make informed decisions about risk assessment, investment strategies, and fraud detection. AI-powered tools such as Robo-advisors, automated trading systems, and AI-driven credit scoring models are now standard in modern banking and financial services. One of the most prominent applications of AI in finance is credit risk assessment. Traditional credit scoring models relied on fixed parameters such as income, employment history, and past credit performance. In contrast, AI-driven models analyse alternative data sources, including social media behaviour, transaction history, and online activity, to predict a borrower's creditworthiness. While this enhances financial inclusion by considering non-traditional borrowers, it also raises privacy and bias concerns. AI-based credit models have been criticized for perpetuating discriminatory lending practices, disproportionately denying loans to low-income or minority borrowers due to biased training data. AI has significantly transformed corporate recruitment and talent acquisition, streamlining the hiring process by automating resume screening, conducting behavioural assessments, and predicting candidate success. Companies employ AI-driven Applicant Tracking Systems (ATS) to analyse thousands of resumes efficiently, reducing human bias and improving hiring speed. Predictive analytics tools assess candidate suitability based on historical hiring data, allowing organizations to identify potential top performers. However, AI-driven hiring systems have also reinforced existing biases, often replicating and amplifying discriminatory hiring patterns present in historical datasets. One notable example is Amazon's AI-powered recruitment tool (2018), which systematically discriminated against female candidates due to biased training data that favoured male applicants. This case highlights the dangers of unregulated AI in corporate hiring, emphasizing the need for ethical AI deployment, bias audits, and regulatory oversight in recruitment processes.

Corporations extensively use Big Data analytics and AI-driven customer profiling to enhance targeted marketing, personalized recommendations, and consumer engagement strategies. AI algorithms analyse customer demographics, purchasing behaviour, online activity, and preferences to develop highly personalized marketing campaigns. Platforms like Netflix, Amazon, and Google employ AI-driven recommendation engines that predict user preferences based on past interactions. While AI-powered customer profiling increases marketing efficiency and user engagement, it also raises ethical and legal concerns regarding consumer privacy, consent, and data protection. Companies often collect and analyse consumer data without explicit consent, leading to data privacy violations. The Cambridge Analytica scandal (2018) is a prime example of Big Data misuse, where AI-driven analytics manipulated voter behaviour through unauthorized personal data collection, violating privacy laws such as the General Data Protection Regulation (GDPR).

Automated Decision-Making in Insurance, Credit Scoring, and Pricing Models

The insurance industry has embraced AI-driven automated decision-making for underwriting, risk assessment, and claims processing. AI algorithms assess policyholder risk profiles, predict

claim likelihood, and detect fraudulent activities, significantly improving operational efficiency. Predictive analytics tools evaluate health records, driving behaviour, and financial history to determine insurance premiums. However, AI-driven risk assessment models have faced criticism for discriminatory practices, particularly in health and auto insurance. AI algorithms may unintentionally discriminate against certain demographics, charging higher premiums to individuals based on gender, ethnicity, or medical history. The lack of transparency in AI underwriting decisions has led to regulatory scrutiny, with legal experts calling for greater explainability and fairness in insurance AI models. AI-powered credit scoring models have reshaped loan approval processes, replacing traditional credit assessment methods with machine learning algorithms that analyse a borrower's risk profile. AI credit scoring considers non-traditional factors, such as social media activity, online behaviour, and spending habits, making loan decisions more inclusive and data-driven. However, algorithmic bias in AI-based credit assessments has raised concerns about discriminatory lending practices. The Apple Credit Card case (2019) exposed significant gender bias, as female applicants received lower credit limits than their male counterparts, despite comparable financial profiles. This incident prompted regulatory investigations into AI bias in financial decision-making, reinforcing the need for bias audits, algorithmic transparency, and compliance with financial regulations.

AI-driven dynamic pricing algorithms adjust product prices in real time based on demand patterns, competitor pricing, and customer purchasing behaviour. Companies such as Uber, Amazon, and airline industries utilize AI to optimize pricing strategies, maximizing revenue while adapting to market conditions. However, dynamic pricing raises ethical concerns related to price discrimination and consumer exploitation. AI algorithms may charge higher prices to vulnerable consumers, reinforcing economic disparities. Regulatory bodies have called for fair pricing transparency laws, ensuring that AI pricing models do not engage in unfair or discriminatory pricing practices.

Case Study: Amazon AI Hiring Bias (2018)

Amazon's AI-powered hiring tool, introduced to streamline recruitment, serves as a notorious example of algorithmic bias in AI-driven corporate decision-making. The AI system was trained on historical hiring data, which predominantly favoured male candidates for technical roles. As a result, the algorithm systematically downgraded resumes containing words associated with female applicants, reinforcing gender discrimination. Amazon discontinued the tool in 2018, acknowledging its bias. This case underscores the need for AI bias detection, diverse training datasets, and human oversight in AI-driven hiring. Legal frameworks, such as the EU AI Act (2024), mandate bias audits and transparency in AI recruitment systems, ensuring compliance with anti-discrimination laws.

ETHICAL IMPEDIMENTS IN AI AND BIG DATA USE

Artificial Intelligence (AI) and Big Data have transformed corporate decision-making by enabling predictive analytics, automation, and efficiency-driven operations. However, the ethical challenges that arise from their widespread implementation cannot be ignored. While AI-driven systems promise innovation, they also raise concerns about privacy violations, algorithmic bias, transparency issues, and the ethical use of consumer data. The use of AI in decision-making processes often involves analysing vast amounts of personal data, which, if misused, can lead to significant legal and ethical repercussions. Furthermore, the opaque nature of AI algorithms raises accountability issues, particularly when biased or unfair decisions negatively impact individuals.

Data Privacy and Consent Violations

One of the most significant ethical concerns in AI and Big Data usage is the issue of data privacy and consent violations. The growing reliance on AI for decision-making has led to the collection of vast amounts of personal data, often without the explicit consent or knowledge of individuals. Corporations, social media platforms, and data analytics firms frequently collect and store sensitive consumer information, including browsing history, purchasing behaviour, financial transactions, health records, and even private conversations. This information is used for targeted advertising, predictive analytics, and behavioural profiling, often without clear disclosure to consumers regarding how their data is being utilized. The lack of transparency in data collection practices raises fundamental ethical and legal concerns. Many companies embed vague and complex data policies within their terms and conditions, which users often accept without understanding the extent of data sharing involved. Furthermore, businesses frequently sell consumer data to third-party entities, including political organizations and marketing agencies, which further exacerbates privacy risks. The unauthorized collection and misuse of personal data not only violate fundamental rights but also expose individuals to risks such as identity theft, financial fraud, and psychological manipulation.

The Cambridge Analytica scandal of 2018 stands as one of the most infamous examples of AI-driven data privacy violations. The political consulting firm harvested data from over 87 million Facebook users without their consent to manipulate voter behaviour during the 2016 United States presidential elections and the Brexit referendum. By leveraging AI-driven psychographic profiling, Cambridge Analytica was able to deliver highly personalized political advertisements that influenced electoral outcomes. The scandal exposed the ethical dangers of unregulated AI and Big Data usage, leading to widespread public outcry and legal action. In response to such incidents, various jurisdictions have implemented stringent data protection regulations. The European Union’s General Data Protection Regulation (GDPR) mandates that organizations must obtain explicit user consent before collecting personal data. It also grants individuals the right to access, rectify, and erase their data. Companies that fail to comply with these regulations face heavy financial penalties, with fines reaching up to four percent of global annual revenue. Similarly, India introduced the Digital Personal Data Protection Act in 2023, aiming to regulate corporate data collection practices by ensuring informed consent, stricter penalties for unauthorized data usage, and data localization requirements to prevent foreign misuse of Indian citizens' personal information. Despite these legal safeguards, the enforcement of data privacy laws remains a challenge, as companies continue to exploit legal loopholes to engage in covert data collection.

Algorithmic Bias and Discrimination

Another major ethical dilemma in AI and Big Data use is the issue of algorithmic bias and discrimination. AI models rely on vast datasets to make predictions and automate decision-making processes. However, these datasets often reflect historical biases present in society, leading to discriminatory outcomes in areas such as hiring, credit scoring, facial recognition, and law enforcement. Since AI systems learn from past data, they may inadvertently reinforce and perpetuate existing social inequalities rather than eliminating them. One of the most well-documented cases of algorithmic bias in AI occurred in 2019 when Apple and Goldman Sachs introduced an AI-driven credit card that allegedly discriminated against women. Several female applicants, including high-profile software developer David Heinemeier Hansson’s wife, reported that they received significantly lower credit limits than their male counterparts despite having similar financial backgrounds. When complaints were raised, Goldman Sachs defended the AI system by stating that the algorithm's decision-making process was not transparent enough to determine whether gender bias played a role. The controversy underscored the risks associated with unregulated AI-driven financial assessments and the need for stronger

oversight in algorithmic decision-making. Research has further demonstrated that AI algorithms often exhibit racial and gender-based biases. A 2020 study conducted by MIT Media Lab found that facial recognition systems had significantly higher error rates for darker-skinned individuals compared to lighter-skinned individuals. The study revealed that some AI models had an error rate of 34.7 percent when identifying darker-skinned individuals, while the error rate for lighter-skinned individuals was as low as 0.8 percent. Such disparities in facial recognition technology have led to wrongful arrests and discriminatory surveillance practices, particularly against minority communities. The ethical and legal challenges posed by algorithmic bias demand immediate intervention. Policymakers and AI researchers have called for diverse and representative training datasets to mitigate bias in AI systems. Regular algorithmic audits and bias detection frameworks must be implemented to ensure fairness in AI decision-making. Additionally, governments need to establish legal accountability mechanisms for companies that deploy biased AI models, ensuring that affected individuals have access to legal remedies in cases of discrimination.

Lack of Transparency and Accountability

A critical issue in the ethical debate surrounding AI and Big Data is the lack of transparency and accountability in AI-driven decision-making. Many AI models operate as "black box" systems, meaning that their decision-making processes are not explainable even to the developers who created them. This opacity raises concerns about the fairness and reliability of AI-generated outcomes, particularly in high-stakes scenarios such as criminal sentencing, loan approvals, and medical diagnoses. The use of AI in the criminal justice system has raised serious ethical concerns, particularly in the case of the COMPAS algorithm in the United States. COMPAS, an AI-based risk assessment tool, was widely used in US courts to predict the likelihood of a defendant committing future crimes. Investigations revealed that the algorithm disproportionately classified African American defendants as high-risk while assigning lower risk scores to white defendants, even in cases where both had similar criminal records. The lack of transparency in the algorithm’s functioning made it difficult for defendants to challenge their risk assessments in court, raising significant due process concerns. From a legal perspective, the absence of clear AI explainability laws in most jurisdictions exacerbates these accountability issues. Many existing legal frameworks do not mandate transparency in AI decision-making, allowing companies and government agencies to deploy AI models without disclosing their internal logic. This has led to calls for stronger AI governance policies, including the right to an explanation for AI-generated decisions, algorithmic auditing requirements, and legal liability frameworks for companies that use AI in critical decision-making processes.

Ethical Use of Big Data in Consumer Profiling

The ethical implications of AI-driven consumer profiling have sparked significant debates, particularly regarding its impact on targeted advertising, political manipulation, and misinformation. AI algorithms analyse vast amounts of consumer data to create detailed behavioural profiles, which are then used to tailor advertisements, product recommendations, and political messaging. While such profiling increases marketing efficiency, it also raises concerns about manipulation, consumer autonomy, and misinformation. A notable example of unethical AI-driven consumer profiling is Facebook’s use of AI-targeted political advertisements during the 2016 US presidential elections. Facebook’s algorithms enabled political campaigns to deliver highly personalized ads based on users’ psychological traits, online behaviour, and personal interests. Critics argued that this practice contributed to the spread of misinformation, deepening political polarization and undermining democratic processes. Public sentiment toward AI-driven consumer profiling has been largely negative. A

2022 Pew Research report revealed that 79 percent of consumers feel they have little to no control over how their personal data is used by companies. The growing concern over data privacy has prompted legal reforms aimed at regulating AI-based advertising and consumer profiling. Some jurisdictions have introduced transparency requirements for AI-driven advertisements, ensuring that consumers are informed about why they are receiving specific content. The ethical challenges posed by AI and Big Data demand comprehensive legal and regulatory interventions. Addressing issues such as data privacy violations, algorithmic bias, AI transparency, and ethical consumer profiling requires a combination of robust legislation, ethical AI design principles, and corporate accountability measures. Without these safeguards, the misuse of AI and Big Data will continue to threaten fundamental human rights and societal fairness.

LEGAL FRAMEWORK AND REGULATORY CHALLENGES

The rapid integration of artificial intelligence (AI) and Big Data into corporate and governmental operations has outpaced existing legal frameworks, raising significant regulatory challenges. As AI-driven decision-making systems increasingly influence critical sectors such as finance, healthcare, law enforcement, and governance, concerns regarding data privacy, accountability, and ethical compliance have intensified. While several jurisdictions have introduced AI and data protection laws to address these concerns, regulatory gaps persist, leaving crucial issues unaddressed. The lack of a global consensus on AI governance further exacerbates the problem, making it difficult to establish universally accepted principles for ethical AI deployment. Various national and regional regulatory bodies have recognized the necessity of AI governance and have enacted laws aimed at ensuring ethical AI use. The European Union's General Data Protection Regulation (GDPR), India's Digital Personal Data Protection Act, 2023, and the United States AI Bill of Rights (2022) represent some of the most notable attempts at regulating AI and Big Data. These legal instruments aim to protect individual privacy, ensure algorithmic transparency, and impose accountability measures on AI-driven systems.

The European Union's General Data Protection Regulation (GDPR)

The General Data Protection Regulation (GDPR) is one of the most comprehensive legal frameworks governing AI and data protection. Enforced in 2018, the GDPR sets stringent requirements on how corporations collect, process, and store personal data, with a particular focus on informed consent, transparency, and user control over personal information. Under the GDPR, companies must obtain explicit consent from individuals before processing their data, and they must provide clear disclosures about how AI algorithms make automated decisions that affect individuals. A critical feature of the GDPR is the right to explanation, which mandates that individuals subjected to AI-driven decision-making have the right to understand how and why decisions were made. This provision is crucial in ensuring algorithmic transparency and preventing AI bias. For example, if an AI model denies a person's loan application, the individual has the legal right to request an explanation for the decision. Additionally, companies found in violation of GDPR regulations can face significant financial penalties—up to €20 million or 4% of their global annual turnover, whichever is higher. Despite its robustness, GDPR does not directly address AI liability in cases where autonomous systems cause harm. The lack of clear accountability mechanisms for AI-generated errors or biases remains a challenge, as affected individuals often struggle to seek legal remedies against AI-driven injustices.

India's Digital Personal Data Protection Act, 2023

Recognizing the increasing reliance on AI and Big Data, India enacted the Digital Personal Data Protection Act (DPDPA), 2023, to regulate corporate data practices and ensure individual privacy. This law establishes a legal framework for processing personal data, mandates explicit user consent, and imposes penalties for unauthorized data collection and breaches. The DPDPA applies to both Indian and foreign entities processing the personal data of Indian citizens, ensuring broader compliance across multinational corporations operating in India. The law also introduces data localization requirements, compelling companies to store sensitive data within India's jurisdiction to prevent foreign misuse. This provision is particularly significant in the context of AI-driven businesses that process vast amounts of Indian consumer data. However, while the DPDPA focuses on data privacy, it lacks comprehensive provisions on AI transparency, algorithmic bias, and liability for AI-related harms. Unlike the GDPR, which explicitly includes provisions for automated decision-making, the DPDPA does not mandate algorithmic explainability, leaving gaps in accountability mechanisms for AI-driven discrimination or errors.

The United States AI Bill of Rights (2022)

In response to growing concerns over AI ethics, the United States introduced the AI Bill of Rights in 2022, outlining principles for ethical AI use. This document emphasizes the importance of data privacy, algorithmic transparency, and protection against AI bias, serving as an ethical guideline rather than a legally binding regulation. The AI Bill of Rights establishes five key principles:

- **Safe and Effective Systems** – AI models must be tested for risks before deployment.
- **Algorithmic Discrimination Protections** – AI systems must not perpetuate biases or discriminatory outcomes.
- **Data Privacy** – Consumers must have control over their personal data.
- Notice and Explanation – AI-driven decisions must be explainable to affected individuals.
- **Human Alternatives and Control** – Individuals should have the right to opt out of AI-driven decision-making where possible.

While these principles set a foundation for ethical AI use, the AI Bill of Rights remains a non-binding policy document rather than a legally enforceable statute. The lack of statutory enforcement mechanisms weakens its impact, as corporations are not legally obligated to comply with its provisions. Additionally, without a federal AI regulation law, companies in the U.S. operate under a fragmented regulatory landscape, where AI governance varies by state.

Gaps in AI Regulation

Despite these regulatory efforts, significant gaps remain in AI governance. The absence of a global regulatory framework, unclear AI liability laws, and inadequate oversight of AI-generated misinformation pose serious challenges in ensuring ethical AI deployment. One of the most pressing challenges in AI regulation is the lack of a harmonized global approach to AI governance. While regional laws like GDPR and the DPDPA exist, there is no universal legal framework governing AI development and use. This creates regulatory fragmentation, allowing corporations to engage in jurisdictional arbitrage by relocating their AI operations to countries with weaker regulatory oversight. For example, multinational technology companies often base their AI research and data processing centers in countries with lax data protection

laws, enabling them to exploit regulatory loopholes. Without a globally coordinated approach, ethical AI deployment remains inconsistent, and corporations continue to develop AI models without standardized accountability measures. Another critical regulatory gap concerns liability in cases where AI systems cause harm. Most existing laws do not specify who should be held responsible when an AI-driven system generates false information, engages in discriminatory decision-making, or causes financial loss. Traditional liability frameworks assume human intent, making it difficult to assign legal responsibility to autonomous AI models. For instance, in cases where self-driving cars cause accidents, courts struggle to determine whether the manufacturer, software developer, or end-user should bear responsibility. Similarly, in financial AI applications, when AI-driven trading algorithms result in market crashes or biased loan approvals, affected individuals face significant challenges in holding AI developers accountable.

Case Study: OpenAI's ChatGPT Misinformation Issues (2023)

The issue of AI-generated misinformation has become increasingly prominent, as seen in the case of OpenAI's ChatGPT in 2023. ChatGPT, an advanced language model, was found to generate false information, including fabricated legal citations, misleading medical advice, and inaccurate historical accounts. Legal professionals and policymakers raised concerns about the absence of regulatory oversight, as OpenAI faced no legal consequences for the misinformation produced by its AI system. In one notable incident, ChatGPT falsely attributed non-existent legal precedents in a court case, leading to severe legal repercussions for the attorney who unknowingly relied on the fabricated citations. The case underscored the urgent need for AI liability regulations, ensuring that AI developers take responsibility for misinformation and users are protected from the harmful consequences of AI-generated content.

CORPORATE ACCOUNTABILITY: THE WAY FORWARD

The rapid expansion of artificial intelligence (AI) and Big Data in corporate decision-making has raised significant ethical and legal concerns, necessitating a structured approach to corporate accountability. As AI-driven technologies continue to shape industries such as finance, healthcare, and employment, companies must adopt responsible AI practices to mitigate risks related to bias, privacy violations, and lack of transparency. Strengthening AI and Big Data regulations, ensuring ethical AI development, and integrating AI ethics into corporate social responsibility (CSR) initiatives are crucial steps toward establishing corporate accountability.

Ethical AI Development and Fair Data Practices

A key aspect of corporate accountability is ensuring that AI systems are developed ethically and trained on fair data. Algorithmic bias, stemming from flawed training datasets, can result in discriminatory decision-making, disproportionately affecting marginalized communities. To combat these issues, companies must implement bias audits, conduct fairness assessments, and adopt transparent AI models. Algorithmic bias occurs when AI systems inherit and reinforce historical inequalities due to biased training data. This issue is particularly evident in hiring algorithms, loan approval systems, and predictive policing models. To mitigate such biases, corporations must conduct regular bias audits by assessing how AI models make decisions and identifying discriminatory patterns in the data. For example, Google's AI Fairness and Ethics Team actively works on identifying and reducing bias in machine learning models. The team has developed fairness indicators that allow AI engineers to detect biased outcomes before deploying algorithms in real-world applications. By incorporating diverse training datasets and

subjecting AI systems to rigorous testing, companies can ensure that AI decision-making remains fair and unbiased. Additionally, explainable AI (XAI) is an essential component of ethical AI development. Unlike traditional "black box" models that provide no insight into their decision-making processes, XAI techniques allow users to understand the logic behind AI-generated outcomes. Explainable AI fosters trust, enabling stakeholders ranging from consumers to regulators to scrutinize AI decisions for potential biases or inaccuracies. AI systems rely on vast amounts of personal data to make accurate predictions and decisions. However, unauthorized data collection and lack of informed consent raise significant ethical and legal concerns. Companies must adopt privacy-preserving AI techniques such as differential privacy, federated learning, and encryption to safeguard user data. For example, Apple's approach to differential privacy ensures that personal data remains anonymous while still being used for AI-driven analytics. Unlike centralized data collection models, differential privacy adds statistical noise to datasets, preventing AI models from identifying specific individuals. This approach aligns with data protection laws such as the EU's General Data Protection Regulation (GDPR) and India's Digital Personal Data Protection Act, 2023, which emphasize the need for informed user consent in data processing.

Strengthening AI and Big Data Regulations

While several jurisdictions have introduced AI governance frameworks, existing regulations remain fragmented and inconsistent. A unified global approach to AI governance is necessary to prevent regulatory arbitrage, where corporations exploit weaker legal frameworks in different regions. Strengthening AI regulations requires the development of international legal instruments, industry-specific guidelines, and robust enforcement mechanisms. The absence of a globally recognized AI regulatory framework has resulted in inconsistent legal standards, allowing corporations to bypass stricter AI regulations by operating in jurisdictions with weaker oversight. A harmonized AI governance model similar to international trade agreements—could ensure that ethical AI standards are upheld across all industries and regions. For instance, the EU AI Act (2024) represents a significant step toward AI regulation by categorizing AI applications based on their level of risk. Under this act:

Unacceptable-risk AI (e.g., social scoring by governments) is banned.

- **High-risk AI** (e.g., biometric surveillance, hiring algorithms) must comply with strict transparency and fairness requirements.
- **Limited-risk AI** (e.g., chatbots) must disclose their AI nature to users.
- **Minimal-risk AI** (e.g., spam filters) is largely unregulated.

This tiered approach ensures that AI applications posing the greatest risks to human rights and corporate accountability are subjected to the highest levels of scrutiny. However, global cooperation is essential to avoid discrepancies in enforcement. Countries with lax AI regulations could still serve as safe havens for unethical AI development unless international agreements mandate uniform standards. Another pressing regulatory gap concerns AI liability determining who is legally responsible when an AI system causes harm. Traditional legal frameworks assume human intent behind actions, making it difficult to assign responsibility when autonomous AI systems make wrongful decisions. A well-defined AI liability framework must clarify:

- Who is responsible for AI-generated errors? (Developers, corporations, or end-users?)
- What compensation mechanisms exist for victims of AI-driven harm?
- How can companies ensure AI-generated decisions remain accountable?

For example, if an AI-driven financial system wrongfully denies a loan application based on biased data, affected individuals should have the legal right to contest the decision and seek redress. Governments must impose stricter accountability mechanisms, such as mandatory third-party audits of high-risk AI applications to prevent discriminatory outcomes.

Corporate Social Responsibility (CSR) and Ethical AI

Corporate Social Responsibility (CSR) initiatives provide an opportunity for companies to self-regulate AI practices beyond legal requirements. By integrating AI ethics into CSR policies, corporations can ensure that their AI deployment aligns with human rights, fairness, and sustainability principles. Companies leading in AI innovation have begun incorporating ethical AI commitments into their CSR frameworks. For instance, Microsoft's AI for Good initiative focuses on deploying AI ethically across healthcare, education, and environmental sustainability. Microsoft has invested in AI-driven early disease detection programs and climate modelling tools, ensuring that AI serves socially beneficial purposes rather than purely profit-driven motives. Similarly, IBM's AI Ethics Board oversees the responsible deployment of AI models by ensuring that transparency, fairness, and accountability remain central to their AI strategies. By establishing internal governance bodies dedicated to AI ethics, corporations can proactively identify and mitigate risks before regulatory intervention becomes necessary. Governments and corporations must collaborate through public-private partnerships to develop AI frameworks that balance innovation with ethical considerations. Such partnerships can focus on:

- Developing AI ethics training programs for corporate leaders.
- Funding interdisciplinary AI research that includes legal, ethical, and technological perspectives.
- Creating AI transparency standards that corporations must follow to avoid ethical breaches.

For instance, the Partnership on AI (PAI)—a coalition of AI developers, governments, and civil society organizations—works on developing best practices for AI ethics. By fostering open discussions between regulators and corporations, such initiatives can ensure that AI governance evolves alongside technological advancements.

CONCLUSION

AI and Big Data have revolutionized corporate decision-making, offering efficiency, precision, and predictive capabilities that were previously unimaginable. Businesses now rely on AI-driven analytics to optimize operations, enhance customer experiences, and gain insights from vast datasets. From AI-powered fraud detection systems in banking to machine learning algorithms in healthcare diagnostics, the positive impact of these technologies is undeniable. However, this rapid technological advancement has also introduced profound ethical and legal challenges, raising concerns about privacy, bias, accountability, and regulatory gaps. While AI provides unparalleled opportunities, its misuse or unregulated deployment can result in significant harm, making it imperative for businesses and regulators to strike a balance between innovation and responsibility. One of the most pressing concerns is the issue of data privacy. AI systems are trained on massive datasets, often sourced from individuals without their explicit consent. Companies collect, process, and analyse consumer data, often without clear disclosures on how this data is used. This lack of transparency raises ethical questions about user autonomy and the right to privacy. The Cambridge Analytica scandal serves as a stark example of how AI-driven data analytics can be exploited for unethical purposes, influencing elections through unauthorized data harvesting. Existing legal frameworks, such as the

European Union's General Data Protection Regulation (GDPR), have attempted to address these concerns by enforcing strict data protection rules. However, enforcement remains inconsistent across jurisdictions, and businesses often exploit legal loopholes to continue intrusive data practices. Algorithmic bias is another major ethical dilemma, as AI models trained on historical data inherit and amplify societal inequalities. AI-driven hiring systems, credit scoring algorithms, and predictive policing models have all demonstrated discriminatory outcomes. The Apple Credit Card gender bias controversy, where women were assigned lower credit limits than men despite similar financial backgrounds, is a telling example of how biased AI decision-making can reinforce systemic discrimination. Studies have shown that facial recognition technologies exhibit higher error rates when identifying individuals from marginalized groups, leading to wrongful arrests and misidentifications. The lack of diverse datasets and oversight mechanisms allows these biases to persist, making AI a tool that, if left unchecked, exacerbates rather than eliminates inequality.

The opacity of AI decision-making further complicates the issue of accountability. Many AI models operate as "black boxes," where even developers struggle to explain how decisions are made. This lack of transparency is particularly concerning in high-stakes areas such as criminal sentencing, loan approvals, and medical diagnoses. The COMPAS algorithm, used in U.S. courts for criminal risk assessment, disproportionately classified Black defendants as high-risk compared to their white counterparts, despite similar circumstances. Without clear legal mechanisms to challenge AI-driven decisions, individuals are left without recourse when they are subjected to unfair treatment. The absence of explainability laws in most jurisdictions further aggravates this issue, allowing companies to evade responsibility for AI-driven errors.

The regulatory landscape for AI and Big Data remains fragmented, with different jurisdictions adopting varying levels of oversight. While the European Union has taken a proactive approach with the GDPR and the proposed AI Act, other countries, including the United States, lack comprehensive AI-specific regulations. India's Digital Personal Data Protection Act, 2023, is a step toward addressing AI governance, but gaps remain in defining corporate liability for AI-driven harm. One of the greatest legal challenges is determining liability in cases where AI systems cause harm. Traditional legal principles are built around human intent, but AI operates autonomously, raising questions about whether responsibility should lie with the developers, corporate users, or the AI itself. The 2023 misinformation issues related to OpenAI's ChatGPT highlighted the difficulty in holding AI developers accountable when their systems generate false or harmful content.

To address these concerns, businesses must integrate ethical AI principles into their corporate governance structures. Companies should conduct regular bias audits, implement fairness assessments, and adopt explainable AI models to ensure that their systems operate transparently. Google's AI Fairness and Ethics Team has made progress in reducing algorithmic bias by introducing fairness indicators and diverse training datasets. Similarly, privacy-enhancing technologies such as differential privacy and federated learning can help minimize data risks while allowing AI models to function effectively. Without such measures, AI will continue to operate in an ethical gray area, leaving individuals vulnerable to its unintended consequences. Legal frameworks must also evolve to keep pace with AI advancements. Governments should establish global AI governance frameworks that create uniform standards across industries and jurisdictions. The European Union's AI Act, expected to be implemented in 2024, categorizes AI applications based on risk levels, imposing strict regulations on high-risk systems such as biometric surveillance and AI-driven hiring tools. Other regions must follow suit, ensuring that AI is developed and deployed within legally enforceable ethical boundaries. AI liability laws must be redefined to establish clear accountability mechanisms for businesses that use AI irresponsibly. This could include mandatory third-party audits for high-risk AI applications, legal avenues for individuals to challenge AI decisions, and penalties for companies that fail to uphold ethical standards.

Corporate social responsibility (CSR) also plays a crucial role in promoting ethical AI development. Businesses must go beyond regulatory compliance and actively work toward socially responsible AI deployment. Initiatives like Microsoft's AI for Good, which focuses on using AI for healthcare and environmental sustainability, demonstrate how AI can be leveraged for ethical and beneficial purposes. Similarly, IBM's AI Ethics Board oversees responsible AI practices, ensuring that their technology aligns with fairness and transparency principles. Public-private partnerships can further drive ethical AI governance by fostering collaboration between regulators, businesses, and civil society organizations. Establishing AI ethics training programs, funding interdisciplinary research, and creating transparency standards can help ensure that AI serves humanity rather than corporate interests alone. As AI and Big Data continue to shape the future of business and society, the urgency for global AI governance cannot be overstated. If left unchecked, AI has the potential to deepen inequalities, violate privacy, and erode trust in corporate institutions. However, with well-defined legal frameworks, corporate accountability measures, and ethical AI development practices, businesses can harness AI's potential while safeguarding fundamental rights. Governments, corporations, and civil society must work together to create a regulatory environment where AI serves as a tool for fairness, efficiency, and responsible innovation. Without immediate and coordinated action, the unchecked power of AI and Big Data could pose irreversible ethical and legal consequences, making global AI governance a necessity rather than a choice.

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ETHNOBOTANICAL PLANT USE IN PEDIATRIC DERMATITIS IN OSARA, ADAVI LOCAL GOVERNMENT, KOGI STATE, NIGERIA

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ABSTRACT

Skin diseases are many and are frequently occurring health problem affecting all categories of humans from the neonates to the elderly. This study is aimed to document the traditional pediatric skin diseases remedies used in Osara, and evaluate the phytochemical properties of the most commonly used plants. A survey visit to traditional healers and caregivers in the community was conducted using semi-structured questionnaires to gather information on the traditional pediatric skin diseases remedies used in Osara. A total of 3 plant species most commonly used for pediatric skin care in osara was collected from the neighbourhood. The Phytochemical constituents of the plant species were determined by solvent (ethanol and water) extraction method. The survey revealed that the respondents used traditional remedies to treat pediatric ailments. The most used part of the plants is the leaf. The phytochemical evaluation revealed the presence of bioactive compounds, including alkaloids, reducing sugar, saponins, flavonoids, phlobatanins, coumarins, fat & oil, and quinones. The phytochemical evaluation of the traditional remedies used in this region provides a scientific basis for their use in harness these plants for industrial and pharmaceutical utilization and could be potential for the development of new drugs.

FILM MEDIUM AND INTERCULTURALISM IN THE DIGITAL ERA. A STUDY OF FRANK RAJAH ARASE'S *GHANA MUST GO*

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Abstract

Recently, advocacies to ensure that cultural diversity is recognised by all and further the course of promoting dealings, understanding, acceptance and respect between people of different cultural and ethnic affiliations has intensified. This is driven by the belief that everyone would benefit when we enthusiastically and dynamically encourage relations between people from different cultures. The African continent being a multi-faceted cultural society has been devilled with ethno-tribal conflicts that have in many occasions, snowballed into full blown wars. Thus, leaving bitter pills in the mouths of those caught in-between, with wanton obliteration of lives and properties, alongside irreparable loss of both individual and collective heritages. This makes the need to accelerate and maximize exploration of ingenious ways of communicating harmonious living in a culturally diverse modern-day Africa of utmost importance. Film, a beneficiary of the digital era wherein it could be accessed by the audience on different digital platforms provides a veritable medium for the course of interculturalism. On this premise, the study anchors on Pierre Sorlin's interpretative analytical approach to examine Frank Rajah Arase's visual reflection of the concept, in view of determining the veracity of the usefulness of film in the promotion of interculturalism in Africa. The paper concludes that through communication of tolerance and selflessness, films are veritable tools in the actualization of interculturalism in Africa.

Keywords: Film, Nollywood, Media, Culture, Interculturalism, Digital Era

FOREIGN DIRECT INVESTMENT, MIGRATION AND INTERNATIONAL RELATIONS: CATALYSTS FOR ECONOMIC DEVELOPMENT IN CENTRAL ASIAN COUNTRIES

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Abstract

Foreign Direct Investment (FDI), migration and international relations constitute pivotal catalysts for economic development in Central Asian countries (Kyrgyzstan, Kazakhstan, Uzbekistan, Turkmenistan and Tajikistan). This study investigates the dynamic interplay of these factors in shaping the region's economic landscape by examining the investment climate, migration trends and evolving frameworks of international cooperation. Analysis of FDI inflows reveals that while resource-rich sectors such as oil, gas and mining attract substantial capital, industries like manufacturing, high-tech and renewable energy remain underdeveloped.

FDI has been instrumental in modernizing local industries, upgrading infrastructure and integrating national economies into global value chains. Simultaneously, migration - both internal and external - has emerged as a defining feature of the region's socio-economic dynamics. Labor migration, driven by the pursuit of higher wages and improved living conditions, particularly towards neighboring countries such as Russia and Turkey, generates significant remittance flows that bolster domestic consumption. However, this migration also results in a brain drain and critical labor shortages in key sectors, potentially undermining the long-term benefits of FDI.

International relations further influence the economic trajectory of Central Asia by leveraging its strategic location and abundant natural resources to attract global investors and forge strategic alliances. Recent regional integration initiatives and bilateral agreements have improved political stability and governance, yet challenges persist due to regulatory barriers and weak institutional frameworks. Drawing on data from national statistical agencies, UNCTAD and OECD, this study offers policy recommendations aimed at enhancing legal protections for investors, promoting balanced regional development and fostering economic resilience. These findings contribute to the broader discourse on sustainable investment strategies and the creation of robust economic frameworks in Central Asia.

Key words: foreign direct investment, investment climate, region, sustainable development, investment potential, FDI in Central Asia, migration, international relations, economic growth, Central Asian countries.

INTRODUCTION

Central Asia, a vast and historically significant region, has long played a peripheral role in global affairs. Stretching from the Caspian Sea to Mongolia and encompassing five former Soviet republics - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan - the region remains landlocked and geopolitically complex. Despite its rich natural resources and strategic position at the crossroads of Eurasia, Central Asia faces significant economic and political challenges that hinder its full integration into the global economy.

Historically, Central Asia thrived as a key transit zone along the Silk Road, linking China to Europe and the Middle East. However, with the decline of overland trade routes and the dominance of maritime trade, the region lost much of its economic significance. The Soviet era further shaped Central Asia's economy, turning it into a supplier of raw materials such as cotton, uranium and oil while limiting its economic diversification. Following the collapse of the Soviet Union in 1991, the newly independent states struggled with economic restructuring, weak governance and limited global connectivity.

Today, Central Asia remains an underdeveloped investment destination despite its vast reserves of oil, gas and minerals. Kazakhstan, the region's largest economy, has made significant strides in attracting foreign direct investment, particularly in energy and mining. Uzbekistan, with its recent economic reforms, is emerging as a promising market, while Kyrgyzstan and Tajikistan remain heavily reliant on remittances. Turkmenistan, despite possessing the world's fourth-largest natural gas reserves, remains highly isolated.

The region's integration into global trade remains constrained by political instability, corruption and underdeveloped infrastructure. However, new opportunities are emerging through China's Belt and Road Initiative (BRI), regional economic partnerships and digital transformation efforts. For Central Asia to realize its full potential, it must prioritize governance reforms, economic diversification and stronger regional cooperation. By doing so, the region can transition from being a geopolitical periphery to a dynamic economic hub in Eurasia's evolving global landscape (Laruelle et al, 2015).

Foreign Direct Investment (FDI) plays a crucial role in the economic development of Central Asian countries. These investments stimulate economic growth, improve infrastructure, introduce new technologies and increase employment opportunities in the region (OECD, 2023).

LITERATURE REVIEW

Barry, M. P. (2009) emphasizes Central Asia should take a balanced approach to economic development. While expanding oil and gas production can boost welfare, over-reliance on this sector may harm other industries by reducing output and exports. Key sectors like cotton, manufacturing, food and textiles could suffer if natural gas investment is prioritized at their expense. To ensure sustainable growth, Central Asian states should attract foreign investment in oil and gas while also supporting the development of other industries through well-rounded policies and strategies.

Doytch et al. (2012) analyze factors influencing FDI inflows in Eastern Europe and Central Asia, focusing on agriculture, manufacturing and services. They consider two less-explored aspects: human capital and natural resources. The findings indicate that institutional quality has a stronger impact on FDI in agriculture and manufacturing than in services. Democratic accountability boosts FDI in these sectors, while natural resources attract investment in agriculture and manufacturing but not in services. In the services sector, human capital is the key determinant of FDI, as investors prioritize skilled labor over low-cost labor.

Oliphant, C. (2013) provides a preliminary analysis of Central Asia's evolving geopolitical landscape. While Russia remains the dominant external power in terms of political ties, security cooperation and investment, China's economic influence is steadily increasing. Since 2010, China has overtaken Russia as the leading trade partner in several Central Asian countries, raising questions about its future political role in the region. Moscow continues to view Central Asia primarily through a security lens, preferring to manage risks rather than expand its involvement. This cautious approach was evident in its non-intervention during the 2010 Kyrgyz crisis. Meanwhile, multilateral organizations like the CSTO and SCO reinforce Russia's presence but struggle with internal divisions among Central Asian states. Russia's

strategy will likely remain focused on bilateral engagement, particularly with Kazakhstan. Its approach is rooted in maintaining economic influence in exchange for geopolitical alignment, treating Central Asia as a vital part of its traditional sphere of influence. The coming years will be crucial in determining how regional dynamics evolve, particularly in light of shifting economic and geopolitical interests.

Yildirim et al. (2014) examine the FDI and human capitals are key drivers of economic growth, influencing each other. A skilled workforce attracts FDI, while multinational companies contribute to knowledge transfer and workforce training. However, this study, analyzing Azerbaijan, Uzbekistan, Kazakhstan, and Kyrgyzstan from 1999–2011 using Panel OLS, finds that FDI does not significantly improve education levels in these countries. Several factors may explain this: FDI in the region is not focused on high-tech industries, many investments do not require skilled labor, and human capital levels may not be sufficient for FDI spillover effects. While some multinational corporations support education through scholarships and training, their contributions remain limited. To maximize FDI's impact, developing countries should prioritize investments in high-tech sectors that enhance both social and economic development, ensuring that human capital is effectively strengthened.

Farruhbek, M. (2019) notes that while Central Asian countries have made progress in attracting FDI since the Soviet collapse, the effectiveness of reforms remains uncertain. Weak rule of law, lack of transparency and unpredictable legal frameworks pose major challenges. Some countries, including Turkmenistan, Tajikistan and Uzbekistan, limit investment treaties through domestic laws, reducing their appeal to foreign investors. Many prefer international legal protections over national regulations, which often provide weaker safeguards. Unclear and inconsistent policies increase risks, discouraging investment. To improve FDI attractiveness, the region must enhance transparency, ensure legal predictability, and align with international standards. Investors consider both economic conditions and legal stability, as a secure environment minimizes risks and supports long-term investment.

Ashurov et al. (2020) examines the key factors influencing FDI in CIS countries, refining previous methodologies and addressing endogeneity issues. Findings show that GMM estimators provide more accurate results than traditional models. Five variables significantly impact FDI: previous year's FDI, GDP, labor force, trade openness, and taxation, while total debt service has no notable effect. For Central Asian countries to attract more FDI, governments should focus on institutional improvements, ensuring effective tax enforcement, labor market development and greater trade openness. Maintaining stable GDP growth is also crucial, as it enhances the region's investment appeal.

Doytch, N. (2021) explores the possibility that certain international capital movements, particularly FDI flows, may not always follow expected cyclical patterns. The sectoral distribution of FDI throughout the business cycle plays a crucial role in understanding the volatility of international capital flows, which in turn affects both monetary and fiscal policy. Managing these fluctuations is essential for macroprudential stability, requiring measures to mitigate the volatility of capital inflows during economic downturns and ensuring fiscal discipline during periods of economic growth.

Kayani, F. N. (2022) examines the link between remittances and poverty, finding no significant impact. Labor migration is crucial for Uzbekistan's economy, with most migrants moving to Russia due to language and proximity. A recent trend shows many Uzbek migrants relocating permanently with their families. Data indicates that 40% stay in Russia for at least two years, and 25-30% remain longer. Additionally, 33% of male and 50% of female migrants are accompanied by their spouses.

DATA AND METHODOLOGY

This study investigates the relationship between FDI, migration and international relations as catalysts for economic development in Central Asian countries, with a particular focus on the Kyrgyz Republic, covering the period from 2015 to 2023. The analysis employs a mixed-method approach, combining quantitative and qualitative research methods.

Quantitative data were primarily obtained from reputable international databases, namely the United Nations Conference on Trade and Development (UNCTAD) and the World Bank. These sources provided key economic indicators including FDI inflows, regional economic performance metrics and migration statistics. These indicators served as a quantitative foundation for assessing the overall investment environment and economic conditions across Central Asia, enabling comparisons between regions within the Kyrgyz Republic and other Central Asian countries.

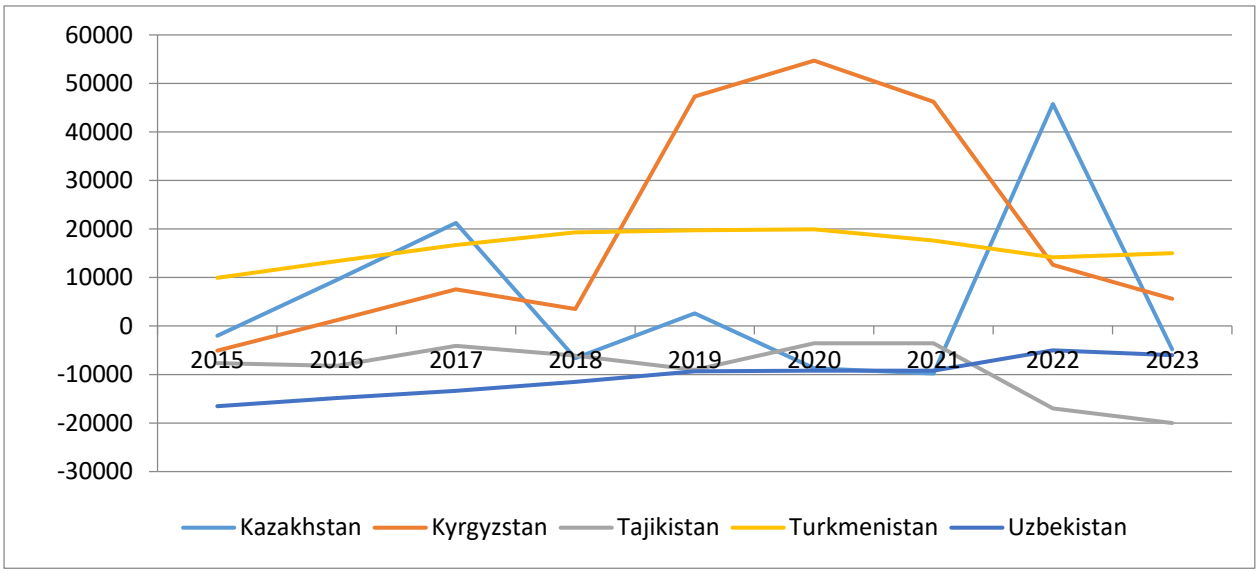
In addition to quantitative analysis, this study conducted an extensive qualitative review of existing scholarly articles, reports and policy documents related to investment climates, migration trends and international relations in Central Asia. This qualitative component provided deeper insights into the challenges and opportunities faced by investors in the region, highlighting factors such as institutional effectiveness, regulatory frameworks, political stability and socioeconomic conditions that influence investment decisions and migration patterns.

By integrating quantitative data from UNCTAD and the World Bank with qualitative insights from scholarly literature, this methodology ensures a comprehensive understanding of how FDI, migration dynamics and international relations collectively influence economic development in Central Asia. The combined approach allows for robust analysis and meaningful policy recommendations.

RESULTS AND DISCUSSION

Central Asian countries have consistently experienced negative net migration over the past several years (2015–2023). Economic factors such as unemployment, limited job opportunities, low wages, lack of economic diversification and poor living standards are the primary reasons driving citizens to migrate abroad. To address this issue effectively, governments in the region need to create more employment opportunities, improve economic conditions and infrastructure, enhance social services and education quality, and implement policies aimed at improving overall living standards (Figure 1).

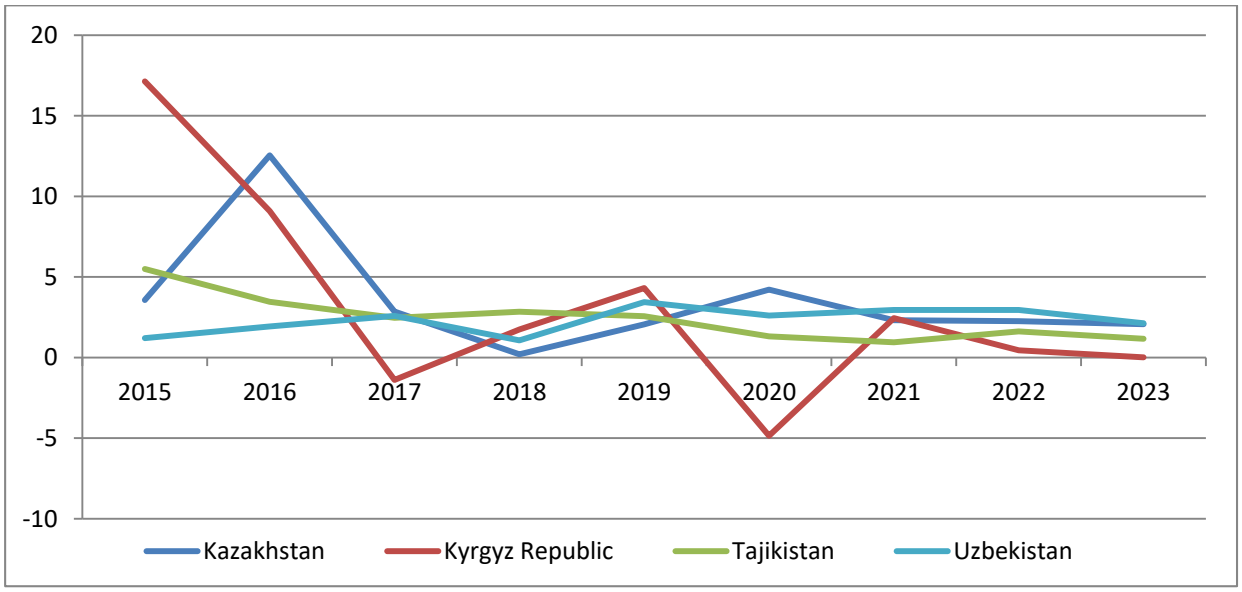
Figure 1. Net migration in Central Asia (people).



Source: https://data.worldbank.org/indicator

The FDI net inflows in Central Asia (2015-2023) show volatile trends, with Kazakhstan and Uzbekistan attracting the most investments due to natural resources and economic reforms. Kyrgyzstan and Tajikistan struggle with low and unstable FDI (Figure 2).

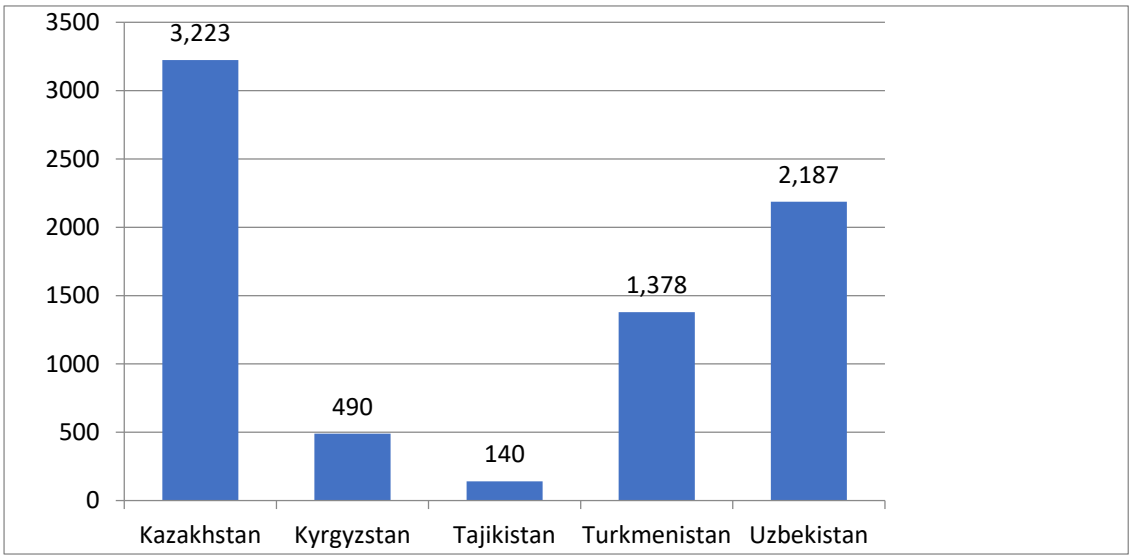
Figure 2. Foreign direct investment in Central Asia (2015-2023), net inflows (% of GDP).



Source: https://data.worldbank.org/indicator

The FDI inflows in Central Asia (Figure 3) show Kazakhstan leading with $3,223 million, followed by Uzbekistan ($2,187 million) and Turkmenistan ($1,378 million).

Figure 3. Foreign direct investment in Central Asia, 2023 (millions of dollars).



Source: https://unctad.org/publication/world-investment-report-2024

Kyrgyzstan ($490 million) and Tajikistan ($140 million) received significantly lower investments. This reflects Kazakhstan and Uzbekistan's stronger economies and better investment climates compared to smaller economies (Figure 3).

CONCLUSION

Migration remains a critical issue for Kyrgyzstan, Tajikistan, and Uzbekistan, shaping their economic and diplomatic strategies. These nations experienced rapid population growth after the Soviet Union's collapse while simultaneously facing economic instability due to the transition from a planned to a market economy. The decline of major industries and agricultural enterprises, which had relied heavily on Soviet-era economic ties, led to widespread unemployment and a large-scale outflow of workers seeking opportunities abroad.

Despite the risks, governments in these countries recognize the importance of labor migration for their economies. Remittances from migrant workers have become a vital source of income for families and a stabilizing factor in national economies. However, dependency on labor export has placed these nations in a vulnerable position, making them reliant on external economic conditions, particularly in Russia. As Russia faces economic slowdowns and tightens migration policies, Central Asian states are actively seeking alternative labor markets and strategic partnerships.

Migration diplomacy is now an essential component of foreign policy for these countries. Effective labor migration policies could turn workforce mobility from a burden into a tool for strengthening economic, political and social ties with key regional actors. Well-structured labor diplomacy can help Central Asian nations negotiate better conditions for their workers, secure new employment destinations and enhance their global economic standing.

Beyond migration, sustainable development in Central Asia hinges on FDI and regional cooperation. Initiatives such as China’s Belt and Road Initiative (BRI) and the Eurasian Economic Union (EAEU) present new economic opportunities. To maximize these benefits, countries must adopt comprehensive strategies that integrate labor migration, FDI attraction and diplomatic engagement.

In conclusion, transforming migration into an advantage requires a multi-faceted approach. By fostering investment, strengthening diplomatic ties and ensuring well-managed migration

policies, Central Asian nations can achieve long-term economic stability and secure a stronger position in the global economy.

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A SPECTRAL CONJUGATE GRADIENT METHOD VIA HYBRIDIZATION APPROACH FOR SYSTEM OF NONLINEAR EQUATIONS

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Abstract

This paper present an effective conjugate gradient method via hybridization approach of classical Newton direction and conjugate gradient search direction, the method scheme satisfies the sufficient decent condition. Under mild condition, the global convergence result for the method is established. Preliminary numerical results for some large-scale benchmark test problems reported in this work, demonstrate that, the method is practically effective and competitive to some existing methods,

Keywords: System of nonlinear equations, Conjugate gradient parameter, Jacobian matrix, Conjugacy condition, Global convergence

Introduction

Consider the general form of system of nonlinear equations:

$$F(x) = 0 \tag{1}$$

Where $F: \mathbb{R}^n \to \mathbb{R}^n$ is a nonlinear map which assumed to be continuously differentiable functions. The system of nonlinear equations arises in many areas of scientific computing and engineering applications. A variety of different iterative methods have been developed for solving problem (1), for example, Newton's method, quasi-Newton method, Gauss-Newton Method Abubakar, (2018) and their variants. However, they are not particularly suitable for

solving large-scale problems, because they need to solve linear system of equations using Jacobian matrix or its approximation at each iteration. It is vital to mention that, the conjugate gradient (CG) methods are among the popular methods used to solve large-scale system of nonlinear equations, due to their rapid convergence property, simple to implement and low storage requirement Yu-Hong, (1999) and Zhen-Jun, (2008) In fact, conjugate gradient method has played a vital role in solving optimization problems.

However, it generates a sequence of iterative points $\{x_k\}$ from an initial guess $x_0 \in \mathbb{R}^n$, using the iterative formula in Can, (2013)

$$x_{k+1} = x_k + \alpha_k d_k, \qquad k = 0,1,2, \ldots \tag{2}$$

Where x_k is the previous iterative point, x_{k+1} is the current iterative point, $\alpha_k > 0$ is the step-length computed via any suitable line search technique and d_k is the search direction defined by:

$$d_k = \begin{cases} -F(x_k), & if \ \ k = 0, \\ -F(x_k) + \beta_k d_{k-1}, & if \ \ k \geq 1 \end{cases} \tag{3}$$

Where $F_k = F(x_k)$ and β_k is termed as conjugate gradient parameter. Conjugate gradient methods differ in their way of defining the CG update parameter β_k because different choices of β_k give rise to distinct conjugate gradient methods with quite different computational efficiency and convergence properties.

Moh'd et al., (2014) presents a Hybrid Broyden-Fletcher-Goldfab-Shanno (HBFGS) method which used the search direction of the conjugate gradient methods with quasi-Newton update where their numerical result provides strong evidence that the proposed HBFGS method is more efficient than the ordinary BFGS method. Furthermore, Mustapha et al. (2014) followed the approach in Mohammad, (2014) to present a Hybrid BFGS CG method for solving unconstrained optimization problems; the method has been presented based on combining search directions between conjugate gradient method and quasi-Newton method where the methods have shown some significant improvement for solving large-scale problems with less number of iterations and CPU time respectively. However, Hamed et al. (2019) equally modified the work in Mohammad et al (2014) and Mustapha et al. (2014) and presented a new algorithm for convex Nonlinear Unconstrained optimization problems by proposing the search direction as defined in Mohammad et al (2014) and Mustapha et al. (2014). The new search direction is defined as:

$$d_{k+1} = -\lambda_k g_{k+1} + \rho_k H_{k+1} g_{k+1} \tag{4}$$

Where H_{k+1} is the approximation matrix of BFGS updated matrix and λ_k is a positive constant. And the parameters λ_k and ρ_k are respectively defined as:

$$\lambda_k = \frac{(1+t)s_k^T g_{k+1}}{y_k^T g_{k+1}}, \tag{5}$$

and

$$\rho_k = \frac{\lambda_k y_k^T g_{k+1} - t s_k^T g_{k+1}}{s_k^T g_{k+1}}. \tag{6}$$

Where $t > 0$ and the conjugate gradient (CG) parameter is obtained as:

$$\beta_k = \frac{\psi_k \rho_k y_k^T g_{k+1} + s_k^T y_k g_{k+1} s_k^T - \lambda_k s_k^T y_k g_{k+1}^T s_k}{\|s_k\|^2 s_k^T y_k} \tag{7}$$

Therefore, it is very important to state that, solving BFGS-CG methods is severally used in unconstrained optimization problems , they are particularly efficient due to their rapid

Convergence properties, simple to implement and low storage requirement Waziri, (2015) and Hamed, (2019). However, they are very scanty in solving system of nonlinear equations, this is what motivated us to write this paper. Furthermore, (1) can come from an unconstrained optimization problem, a saddle point and equality constrained problem Li, (1999). Let f be a norm function defined by;

$$f(x) = \frac{1}{2}||F(x)||^2. \quad (8)$$

Then the nonlinear equation in problem (1) is equivalent to the following global optimization problem Waziri, (2015) and Sun, (2006).

$$minf(x), \quad x \in \mathbb{R}^n. \quad (9)$$

We organize the paper as follows. In the next section, we present the details of our proposed method, convergence result is presented in section 3. Some numerical results are reported in section 4. Finally, conclusions are made in section 5.

Derivation of the method

In this section, we present new hybrid conjugate gradient (CG) update parameter β_k, via two other parameters λ_k and ρ_k. This is made possible by combining the search direction proposed by Hamed et al. (2019), given by:

$$d_{k+1} = -\lambda_k F(x_{k+1}) + \rho_k J_{k+1}^{-1} F(x_{k+1}), \quad (10)$$

together with the classical Newton direction given by:

$$d_{k+1} = -J_{k+1}^{-1} F(x_{k+1}) + \lambda_k d_k. \quad (11)$$

Where J_{k+1}^{-1} is the inverse Jacobian matrix. Multiplying equation (10) and (11) by y_k^T we have;

$$y_k^T d_{k+1} = -\lambda_k y_k^T F(x_{k+1}) + \rho_k y_k^T J_{k+1}^{-1} F(x_{k+1}), \quad (12)$$

and

$$y_k^T d_{k+1} = -y_k^T J_{k+1}^{-1} F(x_{k+1}) + \lambda_k y_k^T d_k. \quad (13)$$

By conjugacy condition;

$$y_k^T d_{k+1} = 0. \quad (14)$$

And also from weak secant condition, i.e

$$y_k^T J_{k+1}^{-1} = s_k^T. \quad (15)$$

We assume J_{k+1}^{-1} is symmetric. By applying (14) and (15) in (12) we obtain:

$$\lambda_k = \frac{s_k^T F(x_{k+1})}{y_k^T d_k}. \quad (16)$$

Also, substituting equations (14) and (15) in (12) we have;

$$\rho_k = \frac{\lambda_k y_k^T F(x_{k+1})}{s_k^T F(x_{k+1})} \quad (17)$$

Recall that the classical CG direction is defined to obtain an updated version of the conjugate gradient method associated with new parameter β_k, we compare the standard CG direction;

$$d_{k+1} = -F(x_{k+1}) + \beta_k s_k, \quad (18)$$

with

$$d_{k+1} = -\lambda_k F(x_{k+1}) + \rho_k J_{k+1}^{-1} F(x_{k+1}). \quad (19)$$

Therefore, form (18) and (19) we have;

$$-\lambda_k F(x_{k+1}) + \rho_k J_{k+1}^{-1} F(x_{k+1}) = -F(x_{k+1}) + \beta_k s_k \ . \quad (20)$$

Multiplying (20) by y_k^T we have;

$$-\lambda_k y_k^T F(x_{k+1}) + \rho_k y_k^T J_{k+1}^{-1} F(x_{k+1}) = -y_k^T F(x_{k+1}) + \beta_k y_k^T s_k \quad (21)$$

After some algebraic simplifications, we obtain our proposed parameter β_k as;

$$\beta_k = \frac{\rho_k s_k^T F(x_{k+1}) + y_k^T F(x_{k+1}) - \lambda_k y_k^T F(x_{k+1})}{y_k^T s_k}. \quad (22)$$

(22) further simplifies to:

$$\beta_k = \frac{\rho_k s_k^T F(x_{k+1}) + (1-\lambda_k) y_k^T F(x_{k+1})}{y_k^T s_k}. \quad (23)$$

Finally, substituting (16) and (17) in (23), our CG parameter β_k becomes:

$$\beta_k = \frac{y_k^T F(x_{k+1})}{y_k^T s_k}, \quad (24)$$

and our search direction is given by:

$$d_{k+1} = -F(x_{k+1}) + \left(\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right) s_k \quad (25)$$

Remark 2.1

For our search direction to satisfy the sufficient decent condition;

$$F_k^T d_k \leq -c||F_k||^2, \qquad c>0 \quad (26)$$

we re-define our search direction as follows;

$$d_{k+1} = -\theta F(x_{k+1}) + \left(\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right) s_k, \quad (27)$$

where θ is a parameter to be determined in such a way the search direction satisfies the decent condition in (26). Multiplying equation (27) by F_{k+1}^T gives:

$$F_{k+1}^T d_{k+1} = -\theta||F_{k+1}||^2 + \left(\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right) F_{k+1}^T s_k$$

$$\leq -\theta||F_{k+1}||^2 + \left|\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right| ||F_{k+1}^T s_k| \quad (28)$$

$$\leq -\theta||F_{k+1}||^2 + \frac{||y_k||||F_{k+1}||^2}{y_k^T s_k}||s_k||$$

The second inequality follows from Cauchy-Schwartz inequality. But $m||s_k|| \leq ||y_k|| \leq M||s_k||$ (see **Lemma 3.2** of [9]), i.e $y_k^T s_k \geq m||s_k|| = \frac{1}{y_k^T s_k} \leq \frac{1}{m||s_k||^2}$ $for\ M > m > 0.$

Inequality (28) implies that:

$$F_{k+1}^T d_{k+1} \leq -\theta||F_{k+1}||^2 + \frac{M||s_k||^2}{m||s_k||^2}||F_{k+1}||^2$$

$$\leq -\theta||F_{k+1}||^2 + \frac{M}{m}||F_{k+1}||^2 \qquad (29)$$

$$\leq -\left(\theta - \frac{M}{m}\right)||F_{k+1}||^2.$$

For the search direction to satisfy (26), we need;

$$\theta \geq c + \frac{M}{m}, \qquad (30)$$

where c is a positive constant. Without loss of generality, we select:

$$\theta = c + \frac{M}{m}. \qquad (31)$$

Hence, the inequality in (29) becomes;

$$F_{k+1}^T d_{k+1} \leq -\left(c + \frac{M}{m} - \frac{M}{m}\right)||F_{k+1}||^2 = -c||F_{k+1}||^2. \qquad (32)$$

Which clearly shows that, our conjugate gradient search direction satisfies the sufficient decent condition in (26).

Furthermore, to compute the step-length α_k, we apply the derivative-free line search procedure proposed by Li and Fukushima in Li, (1999).

Let $\omega_1 > 0,\ \omega_2 > 0\ and\ r \in (0,1)$ be constants and let $\{\eta_k\}$ be a given positive sequence such that:

$$\sum_{k=0}^{\infty}\eta_k < \eta < \infty \qquad (33)$$

$$f(x_k + \alpha_k d_k) - f(x_k) \leq -\omega_1\left|\left|\alpha_k F(x_k)\right|\right|^2 - \omega_2\left|\left|\alpha_k d_k\right|\right|^2 + \eta_k f(x_k), \qquad (34)$$

where $\alpha_k = r^{i_k}$ and i_k is the smallest non-negative integer i such that (34) holds with α_k replaced by r^{i_k}.

We can describe the algorithm of our method as follows:

Algorithm 1 (Spectral Hybrid Conjugate Gradient Algorithm)

Algorithm 1 **(SHCGA)**

Step 1: Given $x_0 \in \mathbb{R}^n,\ \varepsilon > 0, d_0 = -F(x_0),\ set\ \ k = 0.$

Step 2: Compute $F(x_k)$.

Step 3: If $||\ F(x_k)|| \leq \varepsilon,\ then\ stop,\ else,\ go\ to\ step\ 4.$

Step 4: Compute the step-length α_k using (34).

Step 5: Set $x_{k+1} = x_k + \alpha_k d_k$.

Step 6: Compute $F(x_{k+1})$.

Step 7: Compute $y_k = F(x_{k+1}) - F(x_k)$.

Step 8: Compute $\lambda_k\ and\ \rho_k$ from (16) and (17).

Step 9: Compute β_k using (23).

Step 10: Update d_{k+1} using (27).

Step 11: Set $k = k + 1$ and go back to step 2.

Convergence Analysis

This section is devoted to a study of the global convergence of our method (SHCGA). To begin with, let us define the level set:

$$\Omega = \{x: ||F(x)|| \leq ||F(x_0)||\} \quad (35)$$

The following basic assumptions are required in order to analyze the convergence of our algorithm 1.

Assumptions:

(1) There exists $x^* \in \mathbb{R}^n$ such that $F(x^*) = 0$.

(2) F is continuously differentiable in a neighborhood of x^*.

(3) The level set Ω as defined by (35) is bounded.

(4) CG direction is a good approximation to Newton direction, i.e

$$||F'(x_{k+1})d_{k+1} - (d_{k+1} - \beta_k s_k)|| \leq \varepsilon ||F(x_{k+1})||, \quad (36)$$

where $\varepsilon \in (0,1)$ is a small quantity [12], [22] and [24].

(5) The Jacobian of F is bounded and positive definite on N. i.e there exists positive constants $M > m > 0$ such that:

$$||F'(x)|| \leq M \quad \forall x \in N, \text{ and} \quad (37)$$

$$m||d^2|| \leq d^T F'(x) d \quad \forall x\ x \in N, \quad d \in \mathbb{R}^n. \quad (38)$$

Lemma 1 Suppose assumption 1 holds. Let $\{x_k\}$ be generated by the SHCGA algorithm, then

$$\lim_{k\to\infty} ||\alpha_k d_k|| = \lim_{k\to\infty} ||s_k|| = 0, \quad (39)$$

and

$$\lim_{k\to\infty} ||\alpha_k F(x_k)|| = 0 \quad (40)$$

Proof: From the line search in equation (34) and for all $k > 0$, we obtain:

$$\omega_2 ||\alpha_k d_k||^2 \leq \omega_1 ||\alpha_k F_k||^2 + \omega_2 ||\alpha_k d_k||^2$$
$$\leq ||F_k||^2 - ||F_{k+1}||^2 + \eta_k ||F_k||^2. \quad (41)$$

And by summing up the above k inequality, we obtain:

$$\omega_2 \sum_{i=0}^{k} ||\alpha_k d_k||^2 \leq \sum_{i=0}^{k} \left(||F(x_i)||^2 - ||F(x_{i+1})||^2 \right) + \sum_{i=0}^{k} \eta_i ||F(x_i)^2$$
$$= ||F(x_0)||^2 - ||F(x_{k+1})||^2 + \sum_{i=0}^{k} \eta_k ||F(x_i)||^2$$
$$\leq ||F(x_0)||^2 + ||F(x_0)||^2 \sum_{i=0}^{k} \eta_i$$
$$\leq ||F(x_0)||^2 + ||F(x_0)||^2 \sum_{i=0}^{\infty} \eta_i$$
$$\leq M^2 + M^2 \sum_{i=0}^{\infty} \eta_i \quad (42)$$

Therefore, from the level set and the fact that $\{\eta_k\}$ satisfies (33), then the series $\sum_{i=0}^{k} ||\alpha_k d_k||^2$ is convergent, which implies that (39) holds. using the same argument as above, with $\omega_1 ||\alpha_k F_k||^2$ on the left hand side, we obtain (40).

Lemma 2 Suppose assumption 1 holds. Let the sequence $\{x_k\}$ be generated by the SHCGA algorithm with update parameter β_k, then there exists a constant $m_2 > 0$ such that for k>0,

$$||d_k^{SHCGA}|| \leq m_2 \quad (43)$$

Proof: From (27) we have

$$||d_{k+1}|| = |\left|-\theta F(x_{k+1}) + \left(\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right) s_k\right|. \quad (44)$$

Applying triangular inequality we've;

$$||d_{k+1}|| \leq |\theta||F(x_{k+1})|| + \left|\left|\frac{y_k^T F(x_{k+1})}{y_k^T s_k}\right|\right| ||s_k|| \quad (45)$$

$$\leq |\theta||F(x_{k+1})|| + \frac{|y_k^T F(x_{k+1})||s_k||}{y_K^T s_k} \quad (46)$$

$$\leq |\theta||F(x_{k+1})|| + \frac{||y_k|||F(x_{k+1})||s_k||}{y_k^T s_k} \quad (47)$$

$$\leq |\theta|||F(x_{k+1}) + \frac{||y_k|||F(x_{k+1})||s_k||}{m||s_k||^2} \quad (48)$$

$$\leq |\theta||F(x_{k+1})|| + \frac{M||s_k||^2||F(x_{k+1})||}{m||s_k||^2} \quad (49)$$

Inequality (46) follows from Cauchy-Schwartz inequality. From the level set and (31) we have;

$$||d_{k+1}|| \leq \left(c + \frac{M}{m}\right)||F(x_0)|| + \frac{M||F(x_0)||}{m} \quad (50)$$

$$\leq ||F(x_0)|| + \frac{M||F(x_0)||}{m} \quad (51)$$

$$\leq \left(c + \frac{2M}{m}\right)||F(x_0)|| = m_2. \quad (52)$$

Therefore, (52) shows that (43) holds.

We are now going to establish the global convergence of our method, in order to show that under some suitable conditions, there exists an accumulation point of sequence x_k which is a solution of problem (1).

Theorem: Suppose assumption 1 holds and that the sequence $\{x_k\}$ is generated by the SHCGA algorithm. Also, assume that for all k>0,

$$\alpha_k \geq c\frac{|F(x_k)^T d_k|}{||d_k||^2}, \quad (53)$$

where c is some positive constant. Then $\{x_k\}$ converges globally to a solution of problem (1); i.e.,

$$\lim_{k\to\infty}||F(x_k)|| = 0. \quad (54)$$

Proof: By the boundedness of d_k, we have;

$$\lim_{k\to\infty}\alpha_k||d_k||^2 = 0. \quad (55)$$

From (53) and (55) we have

$$\lim_{k\to\infty}|F(x_k)^T d_k| = 0. \quad (56)$$

From our proposed direction, we have;

$$d_{k+1} = -F(x_{k+1}) + \beta_k s_k \quad (57)$$

Therefore, by multiplying (57) by $F(x_{k+1})^T$, we obtain:

$$F(x_{k+1})^T d_{k+1} = -F(x_{k+1})^T F(x_{k+1}) + \beta_k F(x_{k+1})^T s_k. \quad (58)$$

$$||F(x_{k+1})||^2 = -F(x_{k+1})^T d_{k+1} + \beta_k F(x_{k+1})^T s_k. \quad (59)$$

$$||F(x_{k+1})||^2 \leq |-F(x_{k+1})^T d_{k+1}| + |\beta_k F(x_{k+1})^T s_k|. \quad (60)$$

$$||F(x_{k+1})||^2 \leq |-F(x_{k+1})^T d_{k+1}| + |\beta_k|||F(x_{k+1})^T||||s_k||. \quad (61)$$

But (53) implies that;

$$\alpha_k||d_k||^2 \geq c|F(x_k)^T d_k|, \quad (62)$$

Since $||d_k||$ is bounded and $\lim_{k\to\infty}|F(x_k)^T d_k| = 0$, we have $\lim_{k\to\infty}\alpha_k||d_k||^2 = 0$. Thus,

$$0 \leq c|F(x_k)^T d_k| \leq \alpha_k||d_k||^2 \to 0. \quad (63)$$

Then we have;

$$||F(x_k)||^2 \leq |-F(x_k)^T d_k| + |\beta_k|\left|\left|F(x_k)^T\right|\right|||s_k|| \to 0. \quad (64)$$

Therefore,

$$\lim_{k\to\infty} \alpha_k ||d_k||^2 = 0. \quad (65)$$

The proof is completed.

Numerical Results

In this section, the performance of our method for solving systems of nonlinear equations compared with NHCG method for symmetric nonlinear equations [1] and NHCGP [18] is reported.

SHCGA stands for our method and both cases, we set the following:

$\omega_1 = \omega_2 = 10^{-4}, \quad r = 0.2.$

The codes were written in MATLAB 8.9.0 (R2014a) and run on a personal computer 2.00GHz CPU processor and 3GB RAM memory. We stopped the iterations if the total number of iterations exceeds 1000 or $||F(x_k)|| \leq 10^{-4}$. We tested the three methods using twenty two (22) test problems with different initial starting points (x_0), and dimensions (n-values). We present here some of the benchmark test problems with dimensions 1,000, 10,0000, 20,000, 50,000 and 100,000 respectively used to test our proposed method in this research (i.e SHCGA).

Table 1: The Summary of Numerical Results is reported Here.

	ALGORITHMS			
	SHCGA	**NHCG**	**NHCGP**	Undecided
Total number of problems	120	120	120	
Total number of problems	110	110	110	
Problems solved with less number of iterations	95	10	12	13
Percentage	77.27%	4.54%	6.36%	11.83%
Problems solved with less CPU time	90	10	8	12
Percentage	72.72%	9.09%	7.27%	10.92%

To illustrate the performance of the three methods, a summary of the results is presented in table1. The summarized data shows the number of problems for which method is a winner, in terms of number of iterations and CPU time respectively. The corresponding percentages of number of problems solved by each method are also reported. The summary reported in table 1 indicates that the SHCGA scheme is a winner with respect to number of iterations and CPU time. The table shows that, the SHCGA method solves 77.27% (95 out of 120) of the problems with less number of iterations, compared to the NHCG method, which solves 4.54% (10 out of 120)

and NHCGP method which solves 6.36% (12 out of 120). The summarized result also shows that both methods solve 13 problems with the same number of iterations, which translates to 11.83% and is reported as undecided. Also, the summary indicates that the SHCGA scheme outperforms

the NHCG and NHCGP methods as it solves 72.72% (90 out of 120) of the problems with less CPU time compared to 9.09% (10 out of 120) solved by the NHCG method and 7.27% (8 out of 120) by the NHCGP method. Therefore, it is evident from figures 1 and 2 and the

summarized result in table 1 that, our method is more effective than the NHCG and NHCGP methods, and therefore, more suitable for solving large-scale system of nonlinear equations.

Figure 1: Performance profile of **SHCGA, NHCG** and **NHCGP** Algorithms with respect to the number of iterations for the problems

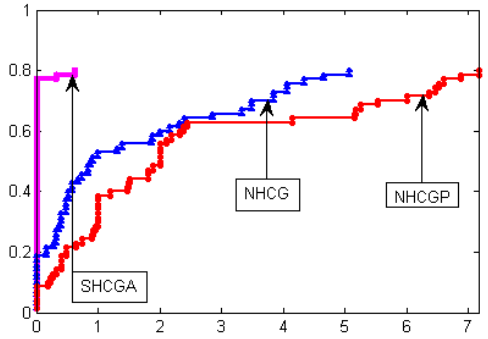
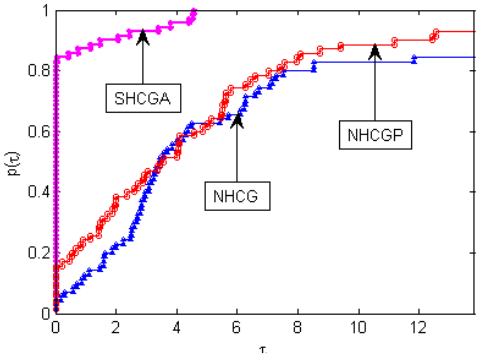


Figure 2: Performance profile of **SHCGA, NHCG** and **NHCGP** Algorithms with respect to the CPU time (in seconds) for the problems



Figures (1) and (2) show the performance of our method based on the number of iterations and CPU time respectively, which were evaluated using the profiles of Dolan, (2001). For each method, we plot the fraction $p(\tau)$ of the problems for which the method is within a factor τ of the best time. The top curve is the method that solved the most problems in a time that was within a factor τ of the best time. The summary of the numerical results of the three (3) methods are reported in Table 1. The summary of numerical results indicates that the proposed method, i.e SHCGA has minimum number of iterations and CPU time, compared to NHCG and NHCGP respectively. Except for problems 1 and 11 where the number of iterations in SHGCA of large dimension is more than that of NHCG and NHCGP. We can easily see that our claim is fully justified from the table, that is, less CPU time and number of iterations for each test problem with the exception of problems 1 and 11. Furthermore, on the average, our $||F(x_k)||$ is too small which signifies that the solution obtained is the true approximation of the exact solution compared to NHCG and NHCGP schemes.

Conclusion

In this paper, we presented a new spectral hybrid conjugate gradient algorithm (SHCGA), for solving large-scale system of nonlinear equations and compared its performance with that of (NHCG and NHCGP) methods for symmetric nonlinear equations by performing some numerical experiments. We however proved the global convergence of our proposed method,

using a derivative-free line search proposed by Li and Fukushima, and the numerical results show that our method is very effective. This research can be extended to large-scale nonlinear monotone system of equations with applications to signal and image recovery problems.

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THE INFLUENCE OF GUT MICROBIOTA ON NEUROGENESIS IN STROKE: IMPACT OF NEUROPOLEN

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Abstract

Background There is persuasive evidence that the gut microbiome plays a role in a variety of physiological processes in the central nervous system. Microbiota influences neurogenic processes, which can result in stroke. Adult neurogenesis (i.e., the life-long generation of new neurons from undifferentiated neuronal precursors in the adult brain) may contribute to brain repair after stroke.

Objectives Yet there is little data on the contribution of small molecule metabolites produced by the microbiome. Based on the existing research, we propose that the administration of Neuropolen could normalize the gut microbiome in stroke.

Materials and methods The gut-derived metabolites are in part responsible for regulating critical signaling pathways in the brain, especially during neural development. The microbiome has been implicated in neural development and function, and consequently, perturbation of the microbiota is implicated in stroke.

Results It is known that metabolites act as communication signals between host and microbiome in the form of neuromodulators or neurotransmitters. The vagus nerve and enteric nervous system are sensitive to gamma amino butyric acid, serotonin, histamine, and acetylcholine, all of which are produced by the gut microbiota. Small molecules such as short-chain fatty acids produced by the gut microbiota can enter the blood stream via the intestinal lumen and cross the blood-brain barrier where they can then interact with the brain and affect neural transmission.

Conclusion We consider this evidence from the perspectives of neuroinflammation, microbial-derived metabolites, neurotrophins, and neurotransmitters. This could therefore also represent a promising treatment strategy in stroke. Neuropolen improves motor recovery after a stroke.

Keywords: gut microbiota, microbial-derived metabolites, neurogenesis, stroke, Neuropolen

SMART WASTE MANAGEMENT SYSTEM USING IoT AND MACHINE LEARNING

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Abstract

The rapid urbanization and population growth have led to a significant increase in waste generation, posing a challenge for efficient waste management. Traditional waste collection methods are often inefficient, leading to overflowing bins, environmental pollution, and increased operational costs. This project proposes a **Smart Waste Management System** that leverages **Internet of Things (IoT)** and **Machine Learning (ML)** to optimize waste collection and disposal processes.

The system consists of IoT-enabled smart bins equipped with sensors to monitor waste levels in real-time. These sensors transmit data to a centralized cloud platform, where a machine learning algorithm analyzes the data to predict waste generation patterns and optimize collection routes. Municipal authorities and waste management companies can access this information through a user-friendly dashboard, enabling them to schedule collections based on actual need rather than fixed schedules.

Key features of the system include:

1. Real-time waste level monitoring using ultrasonic sensors.

2. Dynamic route optimization for waste collection vehicles to reduce fuel consumption and carbon emissions.

3. Predictive analytics to forecast waste generation trends based on historical data and external factors like weather and events.

4. Alerts and notifications to authorities when bins reach critical capacity levels.

GLOBALIZATION AND GEOPOLITICS: THE EVOLVING WORLD ORDER

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Abstract

Globalization and geopolitics have become deeply intertwined in shaping the evolving world order. While globalization has facilitated economic interdependence, technological advancements, and cultural exchanges, it has also intensified geopolitical rivalries and strategic competition among major powers. The post-Cold War optimism of a liberal international order is now being challenged by rising protectionism, regional conflicts, and the reassertion of nationalism. The shift from a unipolar to a multipolar world has led to a realignment of global power, with emerging economies like China and India playing a more assertive role in international affairs. Additionally, the increasing role of international organizations, multinational corporations, and non-state actors is redefining traditional geopolitical dynamics. Issues such as trade wars, technological decoupling, and energy security have further complicated global governance, creating both opportunities and challenges for cooperation. The COVID-19 pandemic and Russia-Ukraine conflict have underscored the vulnerabilities of globalization, leading to a reassessment of supply chains and strategic dependencies. As the world navigates these complexities, the balance between economic globalization and geopolitical interests will determine the trajectory of the 21st-century world order. This paper examines these evolving trends, highlighting key drivers of change and their implications for global stability and governance.

Keywords: Globalization, Geopolitics, Multipolarity, World Order and International Relations

ANALYZING THE STABILITY OF HEPATITIS B MODEL: A MATHEMATICAL APPROACH TO UNDERSTANDING DISEASE TRANSMISSION

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ABSTRACT

Hepatitis B, a viral infection causing liver inflammation is a significant global health concern. This research examines the transmission dynamics of hepatitis B using a five compartment model, categorizing individuals into Passively immune infants, Susceptible individuals, Infectious individuals, removed individuals (recovery), and exposed individuals. The model's validity and epidemiological significance are confirmed. Key metrics, including the basic reproduction number, are calculated using the next generation matrix approach. Equilibrium states are identified, and the local stability analysis of disease free equilibrium and the global stability of endemic equilibrium were investigated using Jacobian matrix approach and constructed lyapunov method respectively. Sensitivity analysis, employing normalized forward sensitivity indices, highlights critical parameters influencing hepatitis B transmission. The findings offer promising strategies for mitigating hepatitis B prevalence.

Keywords: Mathematical modelling**,** Hepatitis B**,** Sensitivity analysis, Basic Reproduction Number

INTRODUCTION

Hepatitis B is an infection of the liver caused by the hepatitis B virus. The infection can be acute (short and severe) or chronic (long term). Hepatitis B can cause a chronic infection and puts people at high risk of death from cirrhosis and liver cancer. It can spread through contact with infected body fluids like blood, saliva fluids and semen. It can also be passed from a mother to her baby. Hepatitis B can be prevented with a safe and effective vaccine. The vaccine is usually given soon after birth with boosters a few weeks later. It offer nearly 100% protection against the virus. Hepatitis B is a major global health problem. An estimates of approximately 254 million people were living with chronic hepatitis B infection in 2022, with 1.2 million people newly infected each year and also 1 million people were newly infected with hepatitis C virus (HCV). (WHO, 2022). Viral hepatitis effects more than 300 million globally.(WHO, 2024). Most people are not diagnosed or getting the treatment they need. Each day, 3500 people die from liver disease caused by viral hepatitis worldwide. Safe and effective vaccines, prevention, and treatments can avert liver disease and cancer caused by viral hepatitis. Increasing intervention and prevention methods can save money and lives. Chronic hepatitis B and hepatitis C cause 1.3 million deaths each year due to liver disease and cancer. (WHO, 2024).

The burden of infection is highest in the WHO Western Pacific Region and the WHO African region, where 97 million and 65 million people, respectively, are chronically infected. Sixty-one million people are infected in the WHO Eastern Mediterranean Region, 11 million in the WHO in the WHO European Region and five million in the WHO Region of the Americas. HBV is spread by needle stick injury, tattooing, piecing and exposure to infected blood and body fluids, such saliva and menstrual, vaginal and seminal fluids. Transmission of the virus may also occur through the reuse of contaminated needles and syringes or sharp objects either in health care settings, in the community or among persons who inject drugs. Hepatitis B infection acquired in adulthood leads to chronic hepatitis in less than 5% of cases, whereas infection in infancy and early childhood leads to chronic hepatitis in about 95% of cases. This is the basis for strengthening and prioritizing infant and childhood vaccination.

In its symptoms, most people do not usually experience any symptoms when newly infected. Some people have acute illness with symptoms that last several weeks: Yellowing of the skin and eyes (Jaundice), Dark urine, Feeling very tired, Nausea, Vomiting, and Pains in the abdomen. In hepatitis B prevention, Universal hepatitis B vaccination (HepB) of all infants beginning at birth provides a critical safeguard and prevents infection among infants born to people with HBV. In 2022, however, the global coverage of birth was only 45% of infants and 84% of children globally received three doses of HepB vaccine. In 2015, approximately 900,000 deaths from hepatitis B virus (HBV) infection were recorded, mainly due to complications like cirrhosis and hepatocellular carcinoma (HCC) (Raimondo, *et al*. 2010). Birth vaccination with hepatitis B is indeed a crucial strategy for preventing perinatal and horizontal HBV transmission. This approach has been instrumental in reducing the incidence of HBV infection and its associated complications. Hepatitis B Virus (HBV) poses significant public health risks due to its contagious nature and severe consequences. Fortunately, vaccination offers effective prevention against HBV infection and its complication (Hahne, *et al.* 2013). Research by (Wodajo & Mekonnenen, 2022) demonstrated the cost-effectiveness of viral hepatitis screening among immigrants from countries with moderate to high prevalence rates, highlighting the importance of screening as a crucial secondary prevention measure.

Mathematical models of infectious diseases have enhanced our understanding of disease transmission dynamics and control (Teklu & Rao, 2022). These models are crucial for

optimizing resources allocation and informing disease control strategies, ultimately aiding in the fight against infections as emphasized by Mekonnen, (2022). Khan et al. (2020) developed a stochastic SACR epidemic model to study HBV transmission, incorporating environmental fluctuations and random variations in transmission rates. Their analysis, validated using the Ito-Taylor stochastic scheme, revealed that noice intensity significantly impacts disease transmission. Liu et al. (2022) introduced a fractional HBV model using the Atangana-Baleanu derivative, incorporating non-singular and non-local kernels, and vaccination effects. Their study revealed that vaccination is highly effective method for preventing and controlling hepatitis B virus, emphasizing the importance of specialized vaccination programs and treatment strategies.

Yavuz et al. (2023) developed a fractional-order model for hepatitis B, using real data and sensitivity analysis. The results indicate that the fractional derivative order substantially impacts the model's dynamics, influencing hepatitis B transmission patterns. Anderson et al. (1992) employed a simple deterministic compartmental model to investigate the role of carriers in the transmission dynamics of hepatitis B. Faraol et al. (2023) developed a mathematical model to analyze effective intervention strategies for hepatitis B viral transmission. Their study identified perinatal infection rate, vaccination rate, and screening rate as key parameters influencing the effective reproduction number. The research recommended a multi-faceted approach, including vaccination, screening, and treatment, as the most effective strategy for controlling and suppressing HBV. Successful implementation of these initiatives is predicted to prevent new infections, ensure access to clinical care, and reduce the economic and social burden of hepatitis B at individual, country, and regional levels.

Therefore, in this work, our aim was to analyze the stability of hepatitis B model and understand the disease transmission. The results of this study can provide valuable insights for policymakers and public health officials seeking to develop effective control strategies for hepatitis B. The paper is organized as follows. Section 2 explains the model formulation and show the existence and uniqueness of the model. In Section 3, analyses of disease free equilibrium points and endemic equilibrium points of the hepatitis B model was carried out and likewise the basic reproduction number, the local and global stabilities of the model and the sensitivity analysis was computed in section 3. Section 4 presents the numerical simulations to support theoretical findings and section 5 ends with conclusion.

MODEL FORMULATION

In this study, the MSEIR model is presented. A population size of N(t) was partitioned into 5 subclasses of individuals which are; The passive immune infant, the Susceptible, Exposed, Infectious and Recovered class with sizes denoted by $M(t), S(t), E(t), I(t),$ and $R(t),$ respectively such that $N = M + S + E + I + R$ as shown in figure 1 below:

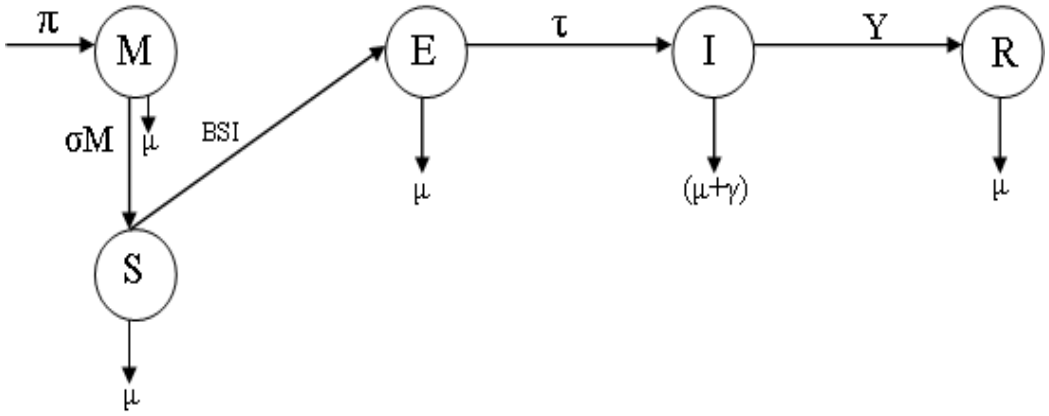

Figure 1: Transmission diagram for MEIRS

M(t): Passively immune infants-This are infants born to HBV-infected mothers who acquire temporary immunity through maternal antibodies. As the maternal antibodies wane, these infants become susceptible to HBV infection.

S(t): Susceptible class- These are individuals who are not infected with HBV and have not developed immunity. They have lost their passive immunity and are now vulnerable to infection. They can be infected with HBV through contact with infectious individuals or contaminated materials.

E(t): Exposed class are individuals who have been infected with HBV but are not yet infectious. This class represents the incubation period of HBV, during which the virus is replicating, but the virus is not yet transmitting the virus. They may not exhibit symptoms, but they can still transmit the virus to others.

I(t): Infectious population- These are individuals who are infected with HBV and are capable of transmitting the virus to others. The class includes individuals with acute or chronic, HBV infection who are shedding the virus. They can transmit HBV through bodily fluids such as blood, semen and saliva.

R(t): Recovered class- Individuals who have recovered from HBV infection and have developed immunity. The virus have been cleared and and are no longer infectious. Infact, they may still carry HBV antibodies, which provide long- term immunity against future infections.

The following system of ordinary differential equation of the proposed model is therefore considered:

$$\left.\begin{aligned}
\frac{dM}{dt} &= \pi - \sigma MS - \mu M \\
\frac{dS}{dt} &= \sigma MS - \beta SI - \mu S \\
\frac{dE}{dt} &= \beta SI - \tau E - \mu E \\
\frac{dI}{dt} &= -YI - \mu I - \gamma I + \tau E \\
\frac{dR}{dt} &= YI - \mu R
\end{aligned}\right\} \qquad (1)$$

$$M(0) = M_0, S(0) = S_0, E(0) = E_0, I(0) = I_0, R(0) = R_0, \qquad (2)$$

Table 1:Model variables and parameters are defined as follows:

Table 1: Model variables and parameters

Parameters/ variables	Description
π	Recruitment rate
β	Contact rate
μ	Natural death rate
σ	Reduction rate
γ	Natural mortality rate unrelated to hepatitis B
τ	Recovery rate of exposed population due to isolation.
Y	Successful cure of infectious class.
$M(t)$	Passively immune infants
$S(t)$	Susceptible population at a given time(t).
$I(t)$	Infectious population
$R(t)$	Recovery population at a given time
$E(t)$	Exposed population at a given time.

Existence and uniqueness of solution

The model is rigorously analyzed by proving the existence and uniqueness of solution

Theorem 1:

Let

$$\left.\begin{aligned}
\frac{dM}{dt} &= \pi - \sigma MS - \mu M & M(t_0) &= M_0 \\
\frac{dS}{dt} &= \sigma MS - \beta SI - \mu S & S(t_0) &= S_0 \\
\frac{dE}{dt} &= \beta SI - \tau E - \mu E & E(t_0) &= E_0 \\
\frac{dI}{dt} &= -YI - \mu I - \gamma I + \tau E & I(t_0) &= I_0 \\
\frac{dR}{dt} &= YI - \mu R & R(t_0) &= R_0
\end{aligned}\right\} \qquad (3)$$

Let

$$D = \left\{(S, V, I_1, I_2, T, A)\right| : |S - S_0| \le a, |V - V_0| \le b, \left|I - I_{1_0}\right| \le c, \left|I - I_{2_0}\right| \le d, |T - T_0| \le e, |A - A_0| \le f \Big\}$$

Then equation (3) has a unique solution in D with initial values

$$S(0) = S_0, V(0) = V_0,\ I_1(0) = I_{1_0},\ I_2(0) = I_{20},\ T(0) = T_0,\ A(0) = A_0$$

Proof:

Let

$$\left.\begin{aligned}
\frac{dM}{dt} &= f_1(S,V,I_1,I_2,T,A) = \pi - \sigma MS - \mu M \\
\frac{dS}{dt} &= f_2(S,V,I_1,I_2,T,A) = \sigma MS - \beta SI - \mu S \\
\frac{dE}{dt} &= f_3(S,V,I_1,I_2,T,A) = \beta SI - \tau E - \mu E \\
\frac{dI}{dt} &= f_4(S,V,I_1,I_2,T,A) = -YI - \mu I - \gamma I + \tau E \\
\frac{dR}{dt} &= f_5(S,V,I_1,I_2,T,A) = YI - \mu R
\end{aligned}\right\} \qquad (4)$$

Taking the partial derivative of each of the compartment of equation (1) at the disease free equilibrium point, then the following were obtained:

$$\left.\frac{\partial f_1}{\partial M}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = -\sigma S - \mu = -(\sigma S + \mu)$$

$$\left|\frac{\partial f_1}{\partial M}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \left|(\sigma S_0 + \mu)\right|$$

$$\left.\frac{\partial f_1}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = -\sigma M\Big|_{(M_0,S_0,,E_0,I_0,,R_0)}$$

$$\left|\frac{\partial f_1}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \left|\sigma M_0\right|$$

$$\left|\frac{\partial f_1}{\partial E}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_1}{\partial I}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left|\frac{\partial f_1}{\partial R}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_2}{\partial M}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \sigma S$$

$$\left.\frac{\partial f_2}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \sigma M - \beta I - \mu\Big|_{(S_0,V_0,I_{1_0},I_{2_0},T_0,A_0)}$$

$$\left|\frac{\partial f_2}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \left|(\sigma M_0 - \beta I_0 - \mu)\right|$$

$$\left.\frac{\partial f_2}{\partial E}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = -(\tau + \mu)$$

$$\left|\frac{\partial f_2}{\partial E}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \left|(\tau+\mu)\right|$$

$$\left.\frac{\partial f_2}{\partial I}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \beta S$$

$$\left|\frac{\partial f_2}{\partial I}\right| = \beta S_0$$

$$\left.\frac{\partial f_2}{\partial R}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left|\frac{\partial f_3}{\partial M}\right|_{M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_3}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \beta I_0$$

$$\left.\frac{\partial f_3}{\partial E}\right|_{(S_0,I_{1_0},I_{2_0},T_0,A_0)} = -(\tau+\mu)$$

$$\left|\frac{\partial f_3}{\partial E}\right|_{(S_0,I_{1_0},I_{2_0},T_0,A_0)} = \left|(\tau+\mu)\right|$$

$$\left.\frac{\partial f_3}{\partial I}\right|_{(S_0,I_{1_0},I_{2_0},T_0,A_0)} = \beta S$$

$$\left.\frac{\partial f_3}{\partial I}\right|_{(S_0,I_{1_0},I_{2_0},T_0,A_0)} = \beta S_0$$

$$\left.\frac{\partial f_3}{\partial R}\right|_{(S_0,I_{1_0},I_{2_0},T_0,A_0)} = 0$$

$$\left.\frac{\partial f_4}{\partial M}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_4}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_4}{\partial E}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = \tau$$

$$\left.\frac{\partial f_4}{\partial I}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = -(Y+\mu+\gamma)$$

$$\left|\frac{\partial f_4}{\partial R}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_5}{\partial M}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_5}{\partial S}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_5}{\partial E}\right|_{M_0,S_0,,E_0,I_0,,R_0)} = 0$$

$$\left.\frac{\partial f_5}{\partial I}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = Y$$

$$\left.\frac{\partial f_5}{\partial R}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = -\mu$$

$$\left|\frac{\partial f_5}{\partial R}\right|_{(M_0,S_0,,E_0,I_0,,R_0)} = |\mu|$$

Hence, by the condition of the theorem $\left|\frac{\partial f_i}{\partial M}\right|, \left|\frac{\partial f_i}{\partial S}\right|, \left|\frac{\partial f_i}{\partial E}\right|, \left|\frac{\partial f_i}{\partial I}\right|, \left|\frac{\partial f_i}{\partial R}\right|, i = 1...5$ are continuous and bounded. Therefore, the problem (1) has a unique solution.

Mathematical Analysis of the Model

The disease free equilibrium points: This is a state where the disease is completely eliminated from the population, that is, there is no infected individuals, no disease transmission and population is entirely susceptible.

At the equilibrium,

$$\frac{dM}{dt} = \frac{dS}{dt} = \frac{dE}{dt} = \frac{dI}{dt} = \frac{dR}{dt} = 0$$

At the disease free equilibrium, where

$$DFE = \left\{ \frac{\mu}{\sigma}, \frac{\beta\sigma - \mu^2}{\sigma\mu}, 0,0,0 \right\} \quad (5)$$

The endemic equilibrium points: The endemic equilibrium is a steady- state solution where the disease persists in the population at a stable level. At endemic equilibrium, $M \neq 0, S \neq 0, E \neq 0, I \neq 0, R \neq 0,$

Solving equations (1) simultaneously, we have the endemic equilibrium points of the HIV model (1) designated by $\varepsilon_0^* = \left(M^*, S^*, E^*, I^*, R^*\right)$ is obtained as

$$\begin{bmatrix} M^* \\ S^* \\ E^* \\ I^* \\ R^* \end{bmatrix} = \begin{Bmatrix} \frac{\mu}{\sigma}, \\ \frac{\beta I + \mu}{\sigma}, \\ \frac{Y + \mu + \gamma}{\tau} \\ \frac{\pi\mu\sigma(R_0 - 1) - \mu^3 R_0}{\beta(\sigma\pi + \mu^2 R_0)} \\ \frac{YI}{\mu} \end{Bmatrix} \quad (6)$$

Basic Reproduction Number , R_0 *:*

This is a threshold parameter. It represents the average number of secondary infections generated by a single infected individual in a completely susceptible population. For example if $R_0 < 1$, means Disease will decline and eventually die out. If $R_0 = 1$, Disease will remain stable and if $R_0 > 1$, Disease will spread and potentially lead to an outbreak. The basic reproduction number predicts disease spread and potential outbreaks, guides control measures (e.g., vaccination, quarantine), and helps evaluate effectiveness of interventions. The next-generation matrix is determined by analyzing new infection pathways and also infection transmission between compartments.

F_i and V_i are calculated as follows using the approach of (Van den Driessche and Watmough, 2002)

$$F_i = \begin{bmatrix} \beta SI \\ 0 \end{bmatrix}, V_i = \begin{bmatrix} (\tau + \mu)E \\ -\tau E + (Y + \mu + \gamma)I \end{bmatrix}$$

The Jacobian matrices of F_i and V_i at the disease free equilibrium point, $S_0 = \frac{B}{\mu}$, are

$$DF(E_0) = \left[\frac{\partial F_i(E_0)}{\partial x_j}\right] = \begin{bmatrix} 0 & \beta\frac{\pi}{\mu} \\ 0 & 0 \end{bmatrix} \quad (7)$$

$$DV(E_0) = \left[\frac{\partial V_1(E_0)}{\partial x_j}\right] = \begin{bmatrix} \tau + \mu & 0 \\ -\tau & Y + \mu + \gamma \end{bmatrix} \quad (8)$$

$$V^{-1} = \begin{bmatrix} \frac{1}{\tau+\mu} & 0 \\ \frac{\tau}{(\tau+\mu)(Y+\mu+\gamma)} & \frac{1}{Y+\mu+\gamma} \end{bmatrix} \quad (9)$$

$$FV^{-1} = \begin{bmatrix} \frac{\beta\pi\tau}{\mu(\tau+\mu)(Y+\mu+\gamma)} & \frac{\beta\pi}{\mu(Y+\mu+\gamma)} \\ 0 & 0 \end{bmatrix} \quad (10)$$

The basic reproduction number, which is the dominant Eigen-value of the product FV^{-1}, is therefore obtained as:

$$R_0 = \frac{\beta\pi\tau}{\mu(\mu+\tau)(Y+\gamma+\mu)} \quad (11)$$

Stability Analysis of Equilibrium

In matrix form, applying Perron's theorem, i.e $\overset{*}{X} = Ax + f(x,t)$

$$\begin{bmatrix} \overset{*}{M} \\ \overset{*}{S} \\ \overset{*}{E} \\ \overset{*}{I} \\ \overset{*}{R} \end{bmatrix} = \begin{bmatrix} -(\sigma S_0 + \mu) & -\sigma M_0 & 0 & 0 & 0 \\ \sigma S_0 & \sigma M_0 - \beta I - \mu & 0 & -\beta S & 0 \\ 0 & \beta I - \mu & -(\tau+\mu) & \beta S & 0 \\ 0 & 0 & \tau & -(Y+\mu+\gamma) & 0 \\ 0 & 0 & 0 & Y & -\mu \end{bmatrix} \begin{bmatrix} M \\ S \\ E \\ I \\ R \end{bmatrix} \quad (13)$$

We evaluate the Jacobian matrix of the model at the disease free equilibrium

$$DFE = \left\{ \frac{\mu}{\sigma}, \frac{\beta\sigma - \mu^2}{\sigma\mu}, 0, 0, 0 \right\} \quad (14)$$

$$A(E_0)=\begin{bmatrix} -\mu & -\sigma & 0 & 0 & 0 \\ \sigma S_0 & \sigma M-\mu & 0 & -\beta S & 0 \\ 0 & -\mu & -(\tau+\mu) & \beta S & 0 \\ 0 & 0 & \tau & -(Y+\mu+\gamma) & 0 \\ 0 & 0 & 0 & Y & -\mu \end{bmatrix} \quad (15)$$

The characteristic polynomial equation is obtained as

$$(\lambda+\mu)\left(\lambda^4 a_0+\lambda^3 a_1+\lambda^2 a_2+\lambda a_3+a_4\right)=0 \quad (16)$$

Clearly, $\lambda=-\mu$

Where,

$a_0=1,$

$$a_1=\frac{\left(\beta\sigma-\mu^2\right)\sigma^2}{\mu}+Y+\gamma+3\mu+\tau$$

$$a_2=\frac{\left(\beta\sigma-\mu^2\right)\sigma}{\mu}\left(3\mu\sigma+(Y+\gamma+\mu)\sigma-\tau\beta\right)+\mu\left(3\mu+2\left(Y+\gamma+\tau\right)+2\tau\right)+\tau\left(Y+\gamma\right)$$

$$a_3=\frac{\left(\beta\sigma-\mu^2\right)\sigma^2}{\mu}\left\{\mu\left(3\mu+2(Y+\tau+\gamma)\right)+\tau\left(Y+\gamma-\frac{\left(\beta\sigma-\mu^2\right)\sigma\beta}{\mu}\right)\right\}+\mu\left(\mu^2(1+Y+\gamma+\tau)\right)+\tau\left(Y+\gamma\right)$$

$$a_4=\left(\beta\sigma-\mu^2\right)\sigma\left\{\mu\left((Y+\gamma+\mu)\right)+\tau\left(\mu+\sigma(Y+\gamma)+\beta\mu\right)\right\}$$

$a_1>0, iff\ \ a_1=\left(\beta\sigma-\mu^2\right)>0\Rightarrow\beta\sigma>\mu^2$

$a_2>0, iff\ \ a_2=\left(\beta\sigma-\mu^2\right)>0\Rightarrow\beta\sigma>\mu^2$

$a_3>0, iff\ \ a_3=\left(\beta\sigma-\mu^2\right)>0\Rightarrow\beta\sigma>\mu^2$

$a_4>0, iff\ \ a_4=\left(\beta\sigma-\mu^2\right)>0\Rightarrow\beta\sigma>\mu^2$

Therefore,

$a_1>0, a_2>0, a_3>0, a_4>0$

Then by Routh Hurwitz criteria, the remaining four eigen values are negative. Hence, the disease free equilibrium is locally asymptotically stable.

Global asymptotic stability of endemic equilibrium

Theorem 3: If $R_0>1,$ then the endemic equilibrium point of the model equation is globally asymptotically stable in Ω, provided $M>M^*, S>S^*, E>E^*, I>I^*,$ and $R>R^*$

Proof: Consider a quadratic Lyapunov function $L: D\in R_+^6\rightarrow R_+$ defined by defined by

$$L=\frac{1}{2}\left[\left(M-M^*\right)+\left(S-S^*\right)+\left(E-E^*\right)+\left(I-I^*\right)+\left(R-R^*\right)\right]^2 \quad (17)$$

Then the derivative of the Lyapunov function is given by

$$\frac{dL}{dt} = \left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right] \frac{d}{dt}\left(M + S + E + I + R\right)$$
$$= \left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right] \left\{\pi - \mu\left(M + S + E + I + R\right)\right\}$$
$$= \mu\left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right] \left\{\left(M + S + E + I + R\right) - \frac{\pi}{\mu}\right\}$$

Since $N^* \le \frac{\pi}{\mu}$, then the following results is obtained

$$= -\mu\left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right] \left\{\begin{matrix}\left(M + S + E + I + R\right) - \\ \left(M^* + S^* + E^* + I^* + R^*\right)\end{matrix}\right\}$$
$$- \mu\left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right] \left\{\begin{matrix}(M - M^*) + \left(S - S^*\right) + \left(E - E^*\right) + \\ \left(I - I^*\right) + \left(R - R^*\right)\end{matrix}\right\}$$
$$- \mu\left[\left(M - M^*\right) + \left(S - S^*\right) + \left(E - E^*\right) + \left(I - I^*\right) + \left(R - R^*\right)\right]^2 \qquad (18)$$

Since the time derivative of the continuously differentiable function L is negative semi-definite i.e., $\frac{dL}{dt} \le 0$, then, the function L is a Lyapunov function. Therefore, $L = 0$ provided that $M = M^*$, $S = S^*$, $E = E^*$, $I = I^*$, and $R = R^*$. Then, by LaSalle's invariance principle (LaSalle, 1976), the largest invariance set for which $\frac{dL}{dt} = 0$ is the singleton set $\left\{\varepsilon^*\right\}$, which implies that the endemic equilibrium point of the HBV model (1) is globally asymptotically stable

Sensitivity Analysis of the basic Reproduction number

Sensitivity analysis assesses how changes in model parameters, assumptions or input affect the outcomes and conclusions of the model, providing insights into the robustness and reliability of the results. By identifying the most influential parameters, sensitivity analysis informs policymakers and decision-makers on where to focus resources and efforts to maximize impact and mitigate uncertainty.

Sensitivity analysis also allow us to measure the relative change in a state variable when a parameter changes. The normalized forward sensitivity index of a variable to a parameter is a ratio of the relative change in the variable to the relative change in the parameter. When a variable is differentiable function of the parameter, the sensitivity index may be alternatively defined using partial derivatives.

Using the approach of (Chitnis, 2008), the normalized forward sensitivity index of a variable "b" that depends differentiable on a parameter "m" is defined as

$$X_r^q := \frac{\partial q}{\partial r} * \frac{r}{q} \qquad (62)$$

As we have an explicit formula for R_0 in equation (46), and we derive an analytical expression for the sensitivity of R_0, as $X_h^g := \frac{\partial g}{\partial h} * \frac{h}{g}$ with respect to each of the parameters involved in R_0 as computed in table 2 below:

Table 2: Sensitivity Index of R_0 in terms of the Model's parameter baseline values

Variables	Baseline Value	Sensitivity Index
π	100	1.00000
β	0.009	1.00000
γ	3.4	0.4966404
τ	0.3	0.1329479
Y	3.4	-0.4966403
μ	0.046	-0.9939667

Interpretation of Sensitivity Indices*:* The above table represents the sensitivity index for the base line parameter values and it shows that recruitment rate (π) and transmission rate (β), are the most sensitive parameters. When the parameters β, and π increases while other parameters remain constant, the value of R_0 also increases. More so, when the parameters γ, τ, Y and μ increase while keeping other parameters constant, the value of R_0 also decrease. These parameters should be targeted by intervention strategies in order to have a stable and disease free environment. For instance, $X_{\pi}^{R_0} = +1.0000$ means that increasing or decreasing π by 10% increases or (decreases) R_0 by 10%. Also, $X_{Y}^{R_0} = -0.4966403\%$ means that increasing or (decreasing) R_0 by 10% means that increases or (decreases) R_0 by 4.966403% as seen in table 2 below. Others can be calculated following the same approach.

NUMERICAL SIMULATIONS AND DISCUSSION

A computational Simulation of the model was performed using Maple 18 mathematical software to elucidate the dynamic transmission patterns of Hepatitis B. This simulation enabled a thorough investigation of how different parameters impact the basic reproduction number, yielding valuable insights into their influence on the epidemic's progression..

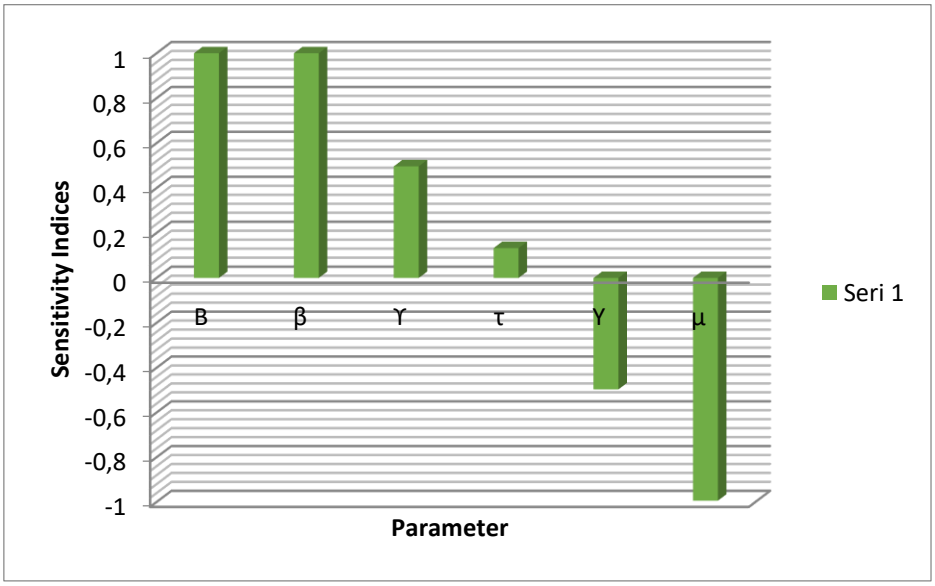

Fig 4. 1: Graphical Representation of the Sensitivity indices of R_0

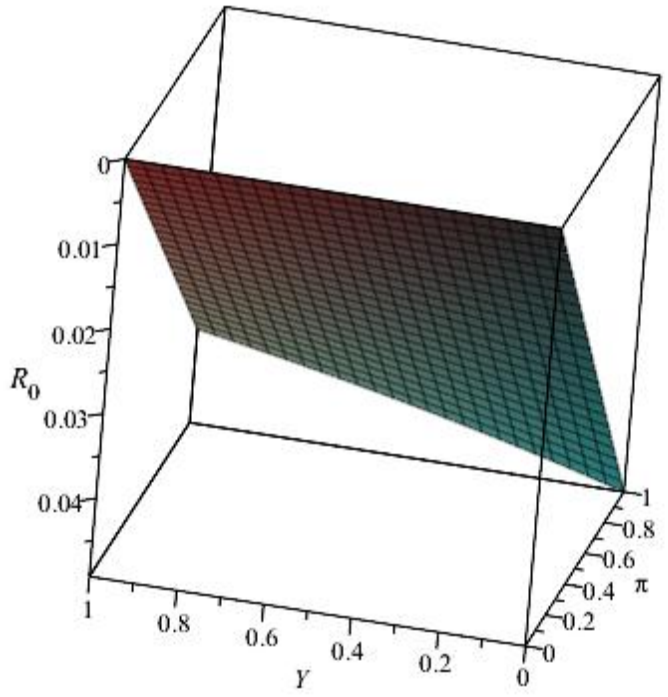

Fig 4.2: Sensitivity of the basic reproduction number to the parameters Y *and* π

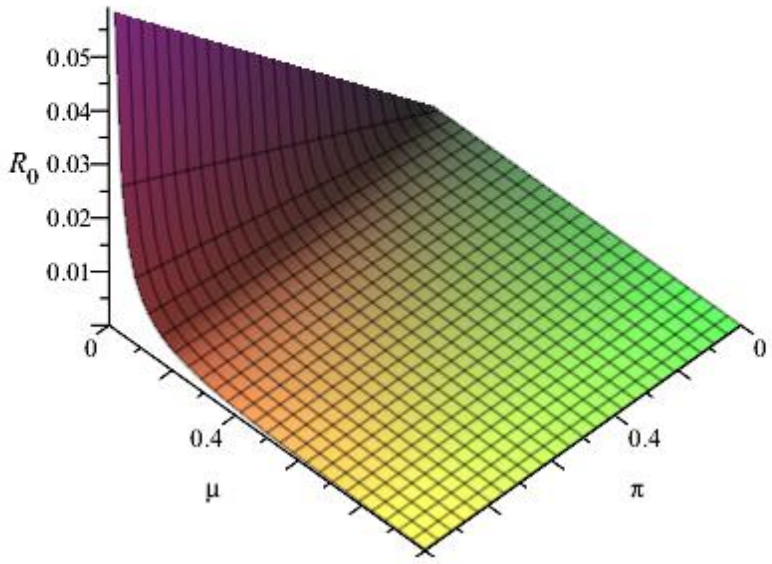

Fig 4.3: Sensitivity of the basic reproduction number to the parameters μ *and* π

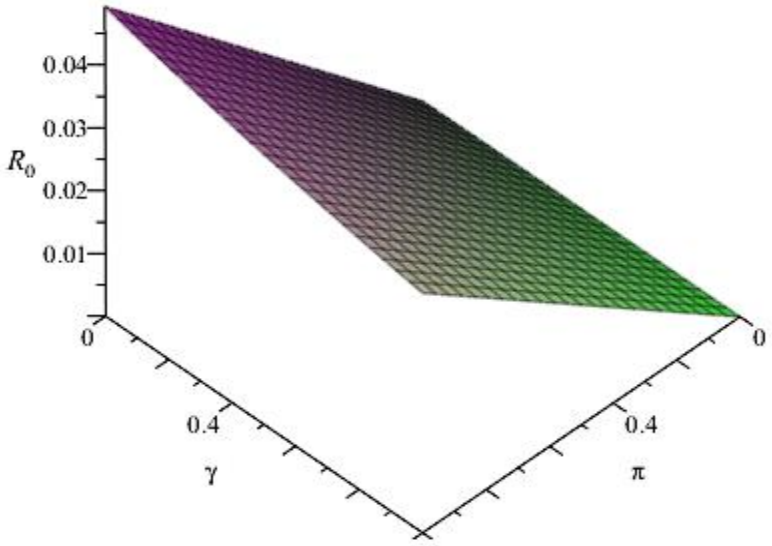

Fig 4.4: Sensitivity of the basic reproduction number to the parameters γ *and* π

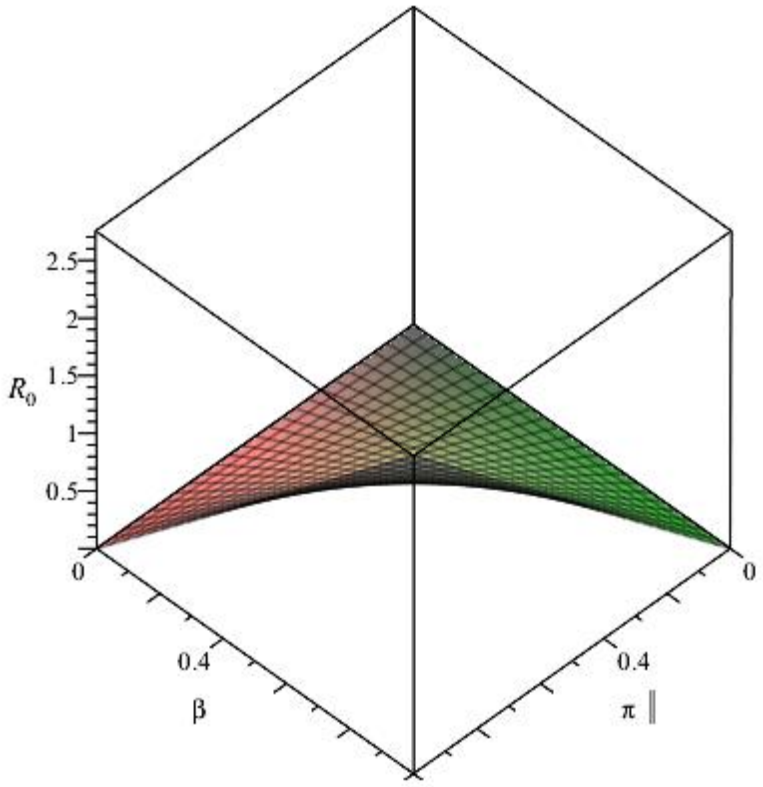

Fig 4.5: Sensitivity of the basic reproduction number to the parameters β *and* π

Discussion

Figure 4.1presents the basic reproduction number in a bar chart. Sensitivity analysis is crucial, as it quantifies parameter uncertainty and robustness of model predictions, The analysis identifies recruitment rate and transmission rate as the most sensitive parameters driving the model's behaviour. Increasing these parameters will elevate the basic reproduction number, informing targeted interventions to mitigate Hepatitis B transmission.

Figure 4.2 illustrates the relationship between recruitment rate of susceptible (π) and successful cure of infectious class (Y) on the basic reproduction number, Notably, as the recruitment rate increases, the basic reproduction number rises. Conversely, increasing (Y) leads to a decrease in the basic reproduction number. Fig 4.3 demonstrates that as the recruitment rate increases, the basic reproduction increases and likewise, an increase in (μ), leads to decrease in the basic reproduction number.

Figure 4.4 also shows the plot of Sensitivity of the basic reproduction number to the parameters (γ) and (π). It shows that increase in the value of (γ) and (π), led to a corresponding decrease in the basic reproduction number population. Figure 4.5 depicts the Sensitivity of the basic reproduction number to the parameters β and (π). It was shown that increase in parameters (β) and (π), results to a corresponding increase in the basic reproduction number indicating that higher transmission rates and recruitment rates enhance the spread of the disease.

CONCLUSSION

This study, 'Analyzing the stability of hepatitis B model: A mathematical approach to understanding disease transmission' provides a comprehensive examination of the hepatitis B mathematical model, offering valuable insights into the disease's transmission dynamics. The model's robust framework enabled the examination of various population groups, including those with passive immunity, susceptible populations, infected populations, exposed populations and recovery individuals. Both local and global stability analyses were conducted, revealing that achieving and maintaining a disease- free environment is feasible and sustainable. The findings emphasize the need for targeted interventions to eliminate Hepatitis B. Specifically, the results indicate that transmission rate and recruitment rate are the most sensitive parameters influencing disease dynamics. Therefore, health policymakers and stakeholders should prioritize interventions that reduce transmission rates and manage recruitment rates effectively, ultimately reducing the basic reproduction number and promoting a healthier environment.

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COST-EFFECTIVE FISHMEAL REPLACERS: COMPARATIVE EVALUATION OF ANIMAL BY-PRODUCTS IN *CIRRHINUS MRIGALA* DIET

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ABSTRACT

In recent years, the aquaculture sector has grown swiftly, but the only obstacle to its growth is unsustainability of fishmeal (FM). Thus, researchers are making significant efforts to find new substitutes for FM. Among the several potential alternatives for FM, various animal by-products (ABPs) have not yet been comparatively studied in *Cirrhinus mrigala* fingerlings. Therefore, this research was done to inspect the impacts of various ABPs diets on the physiological health of *C. mrigala* fingerlings. Six iso-nitrogenous and iso-lipidic test diets were prepared. As a control diet, FM was used. Other five diets contain poultry by-product meal (PBM), insect meal (IM), meat and bone meal (MBM), blood meal (BM) and feather meal (FeM). Fifteen fingerlings were kept in each triplicate for each test diet under controlled experimental conditions. After 70 days feeding trial, it was confirmed that IM caused maximum increase in weight gain (WG: 12.04g) and specific growth rate (SGR: 1.69%) in *C. mrigala* fingerlings superior to other groups. Fish fed with PBM also showed improved results in terms of growth rate (WG: 9.82g). No significant differences ($p>0.05$) were observed in digestibility of lipid, protein and gross energy in fish fed IM, PBM, MBM and control diets. Fish fed IM and PBM showed significant improvement in blood parameters such as RBCs, Hb, WBCs and PLTs while fish fed BM and FeM showed poor results. In conclusion, IM and PBM could be used as better alternatives to FM without compromising fish health.

Keywords: Fishmeal, Animal by-products, Growth performance, Digestibility, Insect meal

AI-DRIVEN INTELLECTUAL PROPERTY GOVERNANCE IN BRICS+NATIONS: CHALLENGES, STRATEGIES, AND GLOBAL IMPACT

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ABSTRACT

The rapid advancement of artificial intelligence (AI) has transformed global intellectual property (IP) frameworks, with BRICS+ nations emerging as a formidable counterforce to Western-dominated models. This research examines the evolving AI-driven IP strategies within BRICS+ countries, highlighting their diverse regulatory approaches, state-backed patent expansion, and alternative governance structures. While China leads in AI patent proliferation, Brazil and South Africa leverage blockchain-based registries and fair-use policies to ensure equitable knowledge dissemination. The study also explores the impact of AI on traditional IP frameworks, the role of international treaties such as TRIPS and WTO regulations, and the implications of the digital divide among BRICS+ nations.Key challenges such as regulatory inconsistencies, technological infrastructure disparities, and IP fragmentation are critically analyzed, emphasizing the need for a harmonized AI patent framework. Policy recommendations include strengthening cross-border research collaborations, enhancing AI infrastructure in underdeveloped economies, and fostering a balanced approach between patent-heavy models and open-access AI innovation. By asserting technological sovereignty while promoting inclusivity, BRICS+ nations are poised to reshape global AI governance, creating a multipolar innovation ecosystem that challenges existing Western-centric frameworks. This research underscores the necessity for collaborative legal reforms, ethical AI deployment, and a forward-looking strategy to ensure sustainable and equitable technological progress in the AI era.

Keywords: AI-driven IP, BRICS+ innovation, AI patent governance, intellectual property regulation, AI ethics policy.

Introduction

The BRICS+ nations—Brazil, Russia, India, China, South Africa, and associated partners—are increasingly positioning themselves as a formidable counterforce to the dominance of Western intellectual property (IP) regimes, particularly in the rapidly evolving domain of artificial intelligence (AI) innovation. Over the past two decades, AI has emerged as a critical driver of economic and technological transformation, necessitating robust yet adaptable approaches to IP governance. However, the traditional Western-centric framework, which emphasizes stringent patent protection and commercial exclusivity, has often been critiqued for stifling innovation in emerging economies. In response, BRICS+ countries have adopted a diverse range of IP strategies that either challenge the existing paradigm or seek to complement it through localized models of governance, ensuring that AI-driven advancements are both inclusive and aligned with their national development goals.

A key differentiator in the BRICS+ approach is the balance between state-led initiatives and open-access frameworks. China, for example, has aggressively pursued AI innovation through

a patent-driven model, filing over 1.2 million AI-related patents in 2022 alone. This reflects a broader strategic push toward technological sovereignty, with the Chinese government heavily investing in AI research, development, and commercialization. Conversely, India has embraced a more open-access approach through its "AI for All" initiative, which prioritizes knowledge-sharing, public-private collaboration, and the democratization of AI technologies. These divergent yet complementary models underscore the nuanced strategies BRICS+ nations employ to navigate the complexities of AI IP governance.

Beyond China and India, other BRICS+ nations have also devised unique frameworks to address AI-related IP challenges. Brazil, for instance, has pioneered the use of blockchain-based registries to protect indigenous knowledge and ensure equitable revenue-sharing mechanisms. The United Arab Emirates (UAE), an increasingly influential BRICS+ partner, has taken a proactive stance in regulating digital assets and virtual property rights through its ambitious Dubai Metaverse Strategy. Similarly, South Africa's Copyright Amendment Bill introduces critical fair-use exceptions that facilitate AI training while maintaining legal safeguards against undue exploitation. These case studies illustrate the dynamic interplay between regulation, innovation, and national interests in shaping the future of AI-driven IP governance within BRICS+.

In contrast to Western approaches that often prioritize corporate interests and stringent regulatory compliance, BRICS+ nations tend to emphasize innovation sovereignty, equitable access to AI advancements, and the need to bridge the global digital divide. This chapter delves into the key policy frameworks, legislative initiatives, and strategic imperatives that define AI-driven IP innovation in BRICS+ countries. It also explores the broader implications of these policies on global innovation ecosystems, technological competition, and the evolving landscape of international IP law. By examining both the opportunities and challenges inherent in these alternative models, the chapter aims to provide a comprehensive understanding of how BRICS+ nations are shaping the future of AI-driven intellectual property governance.

The rise of AI as a transformative force has heightened the importance of rethinking traditional IP frameworks to accommodate new technological realities. While BRICS+ countries have made significant strides in fostering AI-driven innovation, they also face numerous challenges, including disparities in digital infrastructure, legal uncertainties surrounding AI-generated content, and the ongoing tension between proprietary rights and open-access principles. By critically analyzing these issues, this chapter contributes to the broader discourse on how emerging economies can leverage AI for sustainable development while resisting the monopolization of knowledge by a select few global players. As BRICS+ continues to assert its influence in the global technology landscape, its approach to AI-driven IP governance will likely serve as a blueprint for other developing economies striving to establish their own innovation ecosystems.

The BRICS+ nations—Brazil, Russia, India, China, South Africa, and associated partners—are emerging as a counterforce to Western intellectual property (IP) hegemony, particularly in the realm of artificial intelligence (AI) innovation. The rise of AI-driven economic and technological growth has necessitated diverse approaches to IP governance, with BRICS+ countries adopting strategies that either challenge or complement existing Western-dominated frameworks. This chapter explores how these nations leverage AI innovation through distinct IP policies, contrasting China's aggressive patent-driven model with India's open-access "AI for All" initiative. Furthermore, it examines how emerging BRICS+ economies develop unique frameworks to balance technological sovereignty with equitable knowledge dissemination.

Historical Evolution of IP Policies in BRICS+

The historical evolution of intellectual property (IP) policies in BRICS+ nations reflects a broader trajectory of legal, economic, and technological transformations. Unlike Western economies, which have long-established IP frameworks, BRICS+ countries have experienced a more complex and diverse evolution, often shaped by colonial histories, economic restructuring, and global trade dynamics. The shift from traditional IP laws to contemporary digital-era regulations has been influenced by factors such as globalization, the rise of artificial intelligence (AI), and strategic national interests in fostering domestic innovation.In the pre-digital era, IP policies in BRICS+ nations were largely characterized by limited enforcement mechanisms, reliance on traditional forms of knowledge protection, and state-driven innovation models. Many of these countries initially adopted IP laws modeled on European legal systems due to colonial legacies. However, these frameworks often failed to account for indigenous knowledge systems, local technological capabilities, and the need for equitable access to innovation. Brazil and India, for instance, historically emphasized compulsory licensing and government-controlled patents to ensure that critical innovations, particularly in healthcare and agriculture, remained accessible to the broader population. China, on the other hand, initially followed a highly state-controlled approach that limited foreign patent registrations but gradually transitioned towards a more competitive, enterprise-driven IP regime in the late 20th century.

The advent of the digital era fundamentally altered the landscape of IP governance in BRICS+ nations. Rapid advancements in AI, software development, and digital trade necessitated reforms to existing IP laws, leading to a significant increase in patent filings, copyright protections, and regulatory oversight. China, for example, saw an exponential rise in AI-related patent applications, with over 1.2 million filings in 2022 alone, reflecting its strategic emphasis on technological self-reliance. Meanwhile, India pursued a different trajectory by promoting open-access policies, such as its “AI for All” initiative, which prioritizes knowledge-sharing and collaborative innovation over stringent patent protections. Brazil, recognizing the importance of digital transparency, integrated blockchain-based IP registries to safeguard indigenous knowledge and promote equitable IP distribution. The role of international agreements, particularly the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement and World Trade Organization (WTO) regulations, has been a crucial factor in shaping BRICS+ IP policies. While these agreements have established a standardized framework for global IP governance, BRICS+ nations have often sought to renegotiate or reinterpret certain provisions to align with their national interests. For instance, India and South Africa have repeatedly advocated for more flexible TRIPS provisions, particularly concerning pharmaceutical patents, to facilitate access to essential medicines in developing countries. Similarly, Brazil has pushed for greater recognition of traditional knowledge rights within the WTO framework, arguing that conventional IP laws do not adequately protect indigenous innovations. Despite these developments, challenges remain in achieving a cohesive and balanced IP strategy among BRICS+ nations. One key issue is the disparity in enforcement mechanisms, as countries like China have advanced patent enforcement systems, while others, such as Russia and South Africa, face ongoing difficulties in curbing IP infringement and streamlining patent approval processes. Additionally, the digital divide among BRICS+ nations has resulted in uneven technological capacities, affecting their ability to fully leverage AI-driven IP innovations. Ethiopia, for instance, lags in AI infrastructure, making it difficult to compete in AI patent creation despite its emerging role within the BRICS+ economic framework.

The following chart presents a comparative analysis of IP policies in BRICS+ nations, highlighting key differences between pre- and post-digital era frameworks:

Table 1: Comparative Analysis of IP Policies in BRICS+ (Pre-Digital vs. Post-Digital Era)

Country	Pre-Digital Era IP Policies	Post-Digital Era IP Policies
China	State-controlled, limited foreign patent access	AI-driven patent surge, strong enforcement mechanisms
India	Compulsory licensing, focus on public access	Open-access AI policies, flexible patent regulations
Brazil	Weak enforcement, focus on pharmaceuticals	Blockchain-based IP registries, indigenous knowledge protection
South Africa	Limited IP protection, state-driven models	Fair-use copyright laws for AI, increased patent filings
Russia	State-dominated innovation, weak IP laws	Strengthened digital IP laws, increased AI patenting

As BRICS+ nations continue to refine their IP governance models, it is evident that their approaches remain distinct from those of Western economies. Rather than adhering strictly to TRIPS and WTO mandates, these countries have sought to balance global compliance with local innovation priorities. Looking ahead, further harmonization of BRICS+ IP frameworks may be necessary to enhance cross-border collaborations, improve enforcement mechanisms, and ensure that AI-driven innovation contributes equitably to global technological progress.By tracing the historical evolution of IP policies in BRICS+ and comparing their pre- and post-digital era strategies, this section provides valuable insights into how emerging economies are redefining intellectual property rights in the context of AI and digital transformation. The next section will delve deeper into national strategies, focusing on case studies of individual BRICS+ nations and their unique approaches to AI-driven IP governance.

Case Studies: National Strategies for AI and IP Regulation

The evolution of AI and intellectual property (IP) regulation in BRICS+ nations reflects a strategic alignment between national priorities and global technological advancements. As AI-driven innovation continues to redefine economic and legal landscapes, countries within the BRICS+ framework have adopted diverse strategies to balance AI development with IP governance. This section presents case studies of China, Brazil, the UAE, and South Africa, focusing on their distinctive approaches to AI regulation, patent protection, and digital asset management.

China: State-Led AI Patents and the 2023 Generative AI Measures

China has emerged as a global leader in AI innovation, filing an unprecedented 1.2 million AI-related patents in 2022 alone. This surge is the result of a concerted national effort to establish China as a technological superpower, with heavy state intervention driving AI research, development, and commercialization. The government actively supports AI-driven enterprises through direct funding, tax incentives, and regulatory backing, ensuring that domestic companies maintain a competitive edge in global markets.

The **2023 Generative AI Measures** represent a crucial regulatory milestone in China's AI governance. This policy mandates that AI-generated content adhere to ethical standards, maintain transparency in algorithmic processes, and comply with stringent data security measures. These provisions underscore China’s commitment to balancing innovation with regulatory oversight, particularly in sectors such as finance, healthcare, and national security. By enforcing compliance among AI firms while continuing to encourage rapid patent proliferation, China has positioned itself at the forefront of AI-driven IP dominance.

Brazil: Blockchain-Based IP Registries for Amazonian Traditional Knowledge

Brazil has adopted a pioneering approach to IP regulation by integrating blockchain technology into its intellectual property governance framework. The primary objective is to safeguard indigenous knowledge systems, particularly those originating from the Amazonian region. Historically, indigenous intellectual contributions—spanning medicinal practices, agricultural innovations, and ecological sustainability—have been vulnerable to exploitation due to weak legal protections and a lack of centralized documentation.

To address this issue, Brazil has implemented **decentralized blockchain-based IP registries** that enable indigenous communities to document their knowledge securely. This system ensures that traditional innovations are legally recognized, preventing unauthorized commercial use while facilitating fair revenue-sharing mechanisms. Moreover, blockchain technology enhances transparency, ensuring that patents and IP claims remain tamper-proof and verifiable in perpetuity. This initiative aligns with global efforts to enhance digital equity and safeguard cultural heritage in an era of rapidly expanding AI applications.

UAE: Dubai's Metaverse Strategy and IP Rights for Virtual Assets

The United Arab Emirates (UAE) has distinguished itself as a leader in the regulation of digital economies, particularly within the context of AI-generated assets and virtual property rights. Through the launch of the **Dubai Metaverse Strategy**, the UAE aims to establish comprehensive regulatory frameworks for AI-generated content ownership, ensuring that digital assets remain legally protected while fostering innovation within the metaverse ecosystem.

A key feature of the Dubai Metaverse Strategy is the incentivization of IP protections for AI-generated works. This includes legal provisions for ownership disputes, licensing mechanisms, and valuation models for digital assets. By addressing the challenges associated with virtual property rights, the UAE is actively positioning itself as a hub for global investment in metaverse technologies. These measures are designed to attract multinational corporations and AI-driven enterprises, reinforcing Dubai's reputation as a center for cutting-edge digital innovation.

South Africa: Copyright Amendment Bill's Fair-Use Exceptions for AI Training

South Africa has taken a progressive approach to AI regulation through the introduction of the **Copyright Amendment Bill**, which incorporates fair-use exceptions specifically tailored for AI training. This landmark policy enables AI developers to access publicly available datasets without being subjected to excessive copyright restrictions, thereby fostering an innovation-friendly legal environment.

Prior to this amendment, restrictive copyright laws posed significant challenges to AI model training, limiting access to large-scale datasets that are critical for machine learning advancements. By allowing controlled exceptions, South Africa's framework ensures that AI research remains legally compliant while promoting technological inclusivity. This initiative aligns with broader efforts to enhance digital transformation in Africa, enabling local AI enterprises to compete on a global scale. Additionally, the fair-use provisions serve as a model for other nations seeking to balance IP protection with AI research needs.

Comparative Analysis of National Strategies for AI and IP Regulation

To provide a structured overview of these diverse approaches, the following chart compares the national strategies of China, Brazil, the UAE, and South Africa in AI and IP regulation:

Table 2: Comparative Analysis of AI and IP Regulation in BRICS+ Nations

Country	Key AI-IP Strategy	Regulatory Framework	Impact on Innovation
China	AI patent surge (1.2M in 2022)	2023 Generative AI Measures	Strengthened state control over AI and IP growth
Brazil	Blockchain-based IP registries	Indigenous knowledge protection laws	Secured traditional knowledge, ensured fair revenue-sharing
UAE	Dubai Metaverse Strategy	Virtual asset protection laws	Fostered global investment in metaverse and AI-driven content
South Africa	Fair-use exceptions for AI training	Copyright Amendment Bill	Expanded access to data for AI research, promoting inclusivity

These case studies illustrate the varied yet complementary approaches BRICS+ nations have taken to regulate AI and intellectual property. While China emphasizes patent dominance through state-led initiatives, Brazil focuses on digital transparency and the protection of indigenous knowledge. The UAE prioritizes virtual asset regulation, ensuring the sustainable growth of digital economies, while South Africa champions fair-use exceptions to facilitate AI training. These diverse strategies reflect the nuanced interplay between national interests, technological sovereignty, and global regulatory trends.As AI continues to shape the future of innovation, BRICS+ nations are likely to refine and expand their regulatory frameworks to address emerging challenges in digital governance. The next section will explore data-driven insights into AI patent trends and the broader impact of BRICS+ policies on the international IP landscape.

Data-Driven Insights: Trends and Challenges

The rapid expansion of AI-related intellectual property within BRICS+ nations has reshaped the global technological landscape, demonstrating an impressive 300% growth in AI patent filings between 2020 and 2023. This surge significantly outpaces the European Union’s 80% increase during the same timeframe, underscoring the aggressive patenting strategies adopted by BRICS+ countries. Among these, China has emerged as the undisputed leader, leveraging state-sponsored AI research and a well-structured regulatory framework to dominate global AI patent rankings. The Chinese government has actively supported AI development through direct investments, corporate subsidies, and expedited patent approval processes. As a result, China accounts for a substantial proportion of AI patent filings within the BRICS+ bloc, positioning itself as a technological superpower in the AI domain.

While China’s model is largely patent-driven, other BRICS+ nations such as India and Brazil have taken alternative routes to AI innovation, focusing on open-access policies and decentralized intellectual property governance. India’s "AI for All" initiative prioritizes equitable access to AI technologies, encouraging collaborative research and innovation rather than exclusive patent ownership. This approach facilitates widespread AI adoption across industries and enhances knowledge-sharing mechanisms. Similarly, Brazil has pioneered blockchain-based IP registries to protect indigenous knowledge and AI-driven innovations. By integrating decentralized ledger technologies into its IP system, Brazil ensures transparency, security, and equitable access to AI-generated intellectual property.

South Africa and the UAE have also made significant strides in AI patent development, albeit at different paces. South Africa’s AI patent growth rate has reached 120%, driven by recent legislative reforms such as the Copyright Amendment Bill, which introduces fair-use provisions for AI training. This legal adaptation allows AI developers to utilize publicly available datasets without facing excessive legal constraints, thereby fostering an inclusive AI innovation ecosystem. Meanwhile, the UAE has capitalized on its ambitious Dubai Metaverse Strategy to attract AI-driven investments and secure intellectual property rights for digital

assets. The UAE's AI patent growth, recorded at 150%, reflects its commitment to establishing a competitive AI industry that aligns with global technological advancements.

Despite these variations in approach, the overarching trend among BRICS+ nations is a deliberate move towards strengthening AI intellectual property frameworks to secure technological sovereignty. The following table provides a comparative overview of AI patent growth rates among BRICS+ nations and the European Union between 2020 and 2023:

Table 3: AI Patent Growth in BRICS+ vs. EU (2020–2023)

Country	AI Patent Growth (%)
China	300%
India	210%
Brazil	180%
South Africa	120%
UAE	150%
European Union	80%

While the above figures highlight BRICS+ nations' impressive growth rates in AI patent filings, it is important to acknowledge the disparities in digital infrastructure and technological capacity among these countries. While some, like China and the UAE, benefit from substantial government support and robust AI ecosystems, others struggle with foundational issues that hinder their competitiveness in AI innovation.Despite the remarkable expansion of AI intellectual property across BRICS+ nations, a persistent challenge remains in the form of technological inequities and gaps in AI infrastructure. Not all BRICS+ countries possess the same level of technological readiness, which results in uneven growth trajectories and disparities in AI patent contributions. Ethiopia, for instance, struggles with digital infrastructure deficiencies that limit its participation in the AI patent race. While China and India enjoy cutting-edge research facilities and high levels of AI investment, nations with underdeveloped technological landscapes face difficulties in securing the necessary resources to compete effectively.

A key barrier to equitable AI innovation within the BRICS+ bloc is the lack of standardized regulatory frameworks. While China has implemented an aggressive patent strategy supported by clear legal guidelines, other nations experience bureaucratic inefficiencies that delay patent approvals and hinder cross-border IP recognition. The absence of harmonized AI governance mechanisms further exacerbates the problem, making it difficult for BRICS+ countries to collaborate effectively in AI-related intellectual property development. This regulatory heterogeneity creates fragmentation within the bloc, reducing the potential for synergistic growth in AI-driven innovation.

Investment in AI infrastructure is another significant hurdle. Countries with advanced digital economies, such as the UAE and China, have dedicated substantial resources to AI research and development, enabling them to attract global talent and establish themselves as AI hubs. Conversely, nations with weaker digital infrastructures face difficulties in accessing the necessary funding and expertise to scale AI innovation. The disparity in AI funding not only affects the volume of AI patent filings but also influences the overall quality and impact of AI-driven technologies within BRICS+ nations.The AI patent filing process within BRICS+ nations involves multiple stages, each of which presents its own set of challenges. The following flowchart outlines the key phases of AI patent development within the BRICS+ bloc, illustrating the procedural steps from initial research to commercialization:

AI Patent Filing Process in BRICS+ Nations

Research and Development → 2. Government Incentives & Policy Support → 3. AI Model Development → 4. Patent Application Submission → 5. Regulatory Review → 6. Patent Approval & Commercialization

Each step in this process requires institutional backing, regulatory compliance, and access to cutting-edge AI research facilities. The initial phase of research and development is crucial, as it lays the foundation for AI innovations that will eventually be patented. Governments play a key role in incentivizing AI research through grants, subsidies, and strategic policy support. The development of AI models follows, involving extensive data training, testing, and refinement before a patent application is formally submitted.

Once submitted, patent applications undergo rigorous regulatory reviews, where national IP offices assess compliance with domestic and international patent laws. In some cases, the review process is expedited through government-backed initiatives that prioritize AI innovation. The final phase involves patent approval and commercialization, where AI-driven technologies are either licensed to companies or integrated into state-backed AI initiatives. However, countries with underdeveloped digital infrastructure often experience delays in these processes, limiting their ability to fully capitalize on AI patent advancements.

The evolution of AI-driven intellectual property within BRICS+ nations underscores both opportunities and challenges in the global AI governance landscape. While China has emerged as a dominant force in AI patent filings, other BRICS+ members contribute through alternative models, such as India's open-access initiatives and Brazil's blockchain-based IP registries. However, significant challenges remain, particularly in bridging the technological divide among BRICS+ nations. The disparities in AI infrastructure, regulatory frameworks, and investment capacities create an uneven playing field, affecting the overall competitiveness of the bloc.To address these challenges, BRICS+ nations must invest in AI infrastructure, enhance cross-border IP collaboration, and harmonize AI governance policies. A more integrated approach to AI patent development will not only strengthen BRICS+ nations' global influence but also promote a more equitable and inclusive AI innovation ecosystem. By fostering technological synergy and regulatory coherence, BRICS+ can establish itself as a formidable player in the evolving global AI landscape, challenging Western-dominated IP hegemony while advancing its own strategic interests in AI governance.

Comparative Analysis of Western vs. BRICS+ AI IP Strategies

The evolution of AI-driven intellectual property strategies has led to significant divergence between Western economies and the BRICS+ nations. This divergence is shaped by legal frameworks, innovation policies, and the role of government intervention in fostering AI research and commercialization. Western nations, particularly the United States and the European Union, emphasize a market-driven, patent-heavy model that incentivizes private-sector control over AI advancements. In contrast, BRICS+ countries have pursued varied approaches, including state-led patenting, open-access initiatives, and decentralized IP management systems. These contrasting strategies highlight key differences in efficiency, accessibility, and regulatory oversight, shaping the future trajectory of AI governance worldwide.

Patent-filing efficiency is a key metric in assessing the effectiveness of an AI IP strategy. The United States and European Union maintain highly structured and efficient patent systems, with well-established institutions such as the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO). These institutions have streamlined processes for evaluating AI innovations, allowing for a more predictable timeline from patent application to approval. The structured nature of these systems has contributed to stable AI patent growth in Western economies, though the high costs and complexity of obtaining patents can sometimes create barriers for smaller innovators.

Region	AI Patent Growth (2020–2023)	Average Patent Approval Time
China	300%	6–12 months
India	210%	18–24 months
Brazil	180%	24–30 months
South Africa	120%	24–36 months
UAE	150%	18–24 months
EU	80%	18–24 months
USA	100%	18–24 months

China has emerged as a global leader in AI patent filings, demonstrating a 300% growth in AI-related patents between 2020 and 2023. This rapid expansion is largely attributed to a state-backed approach that prioritizes AI research through subsidies, regulatory incentives, and an expedited patent approval process. India and Brazil, while also experiencing AI patent growth, rely on different models. India's open-access approach facilitates broader participation in AI research, while Brazil has incorporated blockchain-based IP registries to ensure transparency and protection of indigenous innovations. Other BRICS+ nations, such as South Africa and the UAE, face challenges related to bureaucratic inefficiencies and evolving regulatory frameworks, leading to delays in patent approvals and limited AI-related filings.

Beyond efficiency, a fundamental distinction between Western and BRICS+ AI strategies lies in their approach to intellectual property ownership. Western nations operate predominantly within a patent-heavy framework that prioritizes exclusivity and commercial control over AI innovations. In the United States, major tech corporations and research institutions leverage patents to secure market advantages, often leading to monopolistic control over key AI technologies. Similarly, the European Union enforces strong patent protections while incorporating regulatory constraints under frameworks such as the General Data Protection Regulation (GDPR), ensuring ethical considerations remain central to AI development.

Conversely, BRICS+ nations exhibit a more flexible approach to AI ownership and access. India's AI governance strategy, for example, promotes an open-access model that encourages public participation in AI research. This approach is designed to facilitate technological inclusivity, enabling startups, academic institutions, and small enterprises to leverage AI advancements without restrictive patent barriers. Brazil's implementation of blockchain-based IP registries represents another innovative strategy, ensuring transparent and decentralized management of AI-related patents while simultaneously protecting indigenous knowledge. South Africa's AI policies incorporate a hybrid model, granting fair-use exceptions for AI training while maintaining traditional copyright protections to balance innovation incentives with public accessibility.

The tension between these two models raises important questions about the future of AI knowledge dissemination. While Western economies argue that strict patent protections drive competitive innovation and market stability, critics highlight the risks of market monopolization and restricted access to AI technologies. On the other hand, BRICS+ nations champion a more inclusive model that fosters collaboration and equitable distribution of AI advancements, though challenges remain in enforcing regulatory consistency and safeguarding against potential exploitation of open-access frameworks.

An illustrative comparison of these contrasting approaches is seen in the differing ethical regulations governing AI innovation. The European Union's GDPR stands as a benchmark for AI ethics governance, imposing stringent regulations on data privacy, AI decision-making transparency, and user consent. These regulations ensure that AI developers adhere to strict accountability measures, preventing the unchecked exploitation of AI technologies. However, while GDPR's ethical safeguards provide critical protections, they can also slow AI development due to the extensive compliance requirements imposed on developers and corporations.

BRICS+ nations, in contrast, adopt more flexible regulatory frameworks that emphasize economic growth and AI deployment over stringent compliance mechanisms. China's 2023 Generative AI Measures exemplify this approach, introducing regulatory guidelines for AI-generated content without imposing overly restrictive limitations on corporate autonomy. India's AI policies incorporate ethical considerations but remain relatively relaxed compared to GDPR, ensuring that AI research and development continue unhindered by excessive legal constraints. This divergence reflects broader ideological differences—Western economies prioritize ethical AI governance with robust oversight, while BRICS+ nations balance innovation incentives with adaptive regulatory mechanisms that accommodate economic priorities.

The following flowchart illustrates the fundamental structures of Western and BRICS+ AI IP strategies. In the Western patent-heavy model, AI innovations follow a structured pathway from research and development to patent application, followed by legal review and eventual commercialization, often restricting access to AI knowledge. In contrast, the BRICS+ model incorporates a hybrid approach, with some nations pursuing open-source collaboration and decentralized patent frameworks, allowing for broader public and private utilization of AI technologies.

Western Model

Research & Development → 2. Patent Application → 3. Legal & Ethical Review → 4. Patent Grant → 5. Market Commercialization (Exclusive Rights)

BRICS+ Model

Research & Development → 2. Open-Access or Patent Filing → 3. Government Incentives & Review → 4. Public Utilization or Restricted Commercialization → 5. Decentralized IP Protection (Blockchain/IP Commons)

The comparative analysis of Western and BRICS+ AI IP strategies reveals deeply rooted ideological, economic, and legal differences in how nations approach AI governance. Western economies emphasize patent exclusivity and regulatory oversight, fostering competitive markets driven by private-sector control. In contrast, BRICS+ nations adopt varied approaches that blend state-backed initiatives, open-access research models, and decentralized IP mechanisms, ensuring broader participation in AI innovation. However, both strategies present challenges—Western models risk creating monopolistic AI ecosystems, while BRICS+ frameworks must navigate regulatory inefficiencies and enforcement complexities. The future of AI governance may ultimately require a balanced approach that integrates elements of both models, ensuring AI remains an engine for global innovation while maintaining equitable access and ethical integrity.

Policy Recommendations for Sustainable AI Innovation

The rapid expansion of artificial intelligence (AI) technologies in BRICS+ nations presents both opportunities and challenges for intellectual property (IP) governance. While some member states have excelled in AI-driven patent filings, others face significant structural barriers that hinder their ability to compete on the global stage. A sustainable AI innovation strategy requires comprehensive policy recommendations that address these disparities, ensuring a cohesive and forward-looking approach to AI governance across the BRICS+ bloc. Three primary areas of focus emerge: strengthening AI patent frameworks to prevent IP

fragmentation, enhancing AI infrastructure investments in underdeveloped BRICS+ economies, and encouraging cross-border AI research collaboration.

One of the core challenges facing BRICS+ nations is the risk of IP fragmentation due to differing legal and regulatory approaches to AI patents. Unlike Western economies, which follow a relatively standardized patent framework through institutions like the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO), BRICS+ countries have adopted diverse strategies for AI IP protection. China, for instance, has rapidly increased its AI patent filings, supported by a state-driven model, while India's emphasis on open-access AI research leads to reduced patent registration. This fragmentation not only complicates cross-border collaboration but also creates inconsistencies in IP enforcement.

To address this challenge, BRICS+ nations must work toward harmonizing their AI patent frameworks through a unified regional strategy. Establishing a BRICS+ AI Patent Cooperation Treaty (AI-PCT) could facilitate streamlined patent registration across member states, reducing duplication of filings and ensuring reciprocal recognition of AI-related patents. Such a framework would improve legal certainty for AI innovators and investors, fostering an environment conducive to long-term technological growth.Additionally, BRICS+ nations should adopt a balanced approach that integrates both strong patent protections and open-access innovation models. By creating tiered IP structures—where fundamental AI algorithms remain accessible for research while commercial applications are protected—BRICS+ can avoid the pitfalls of excessive monopolization while still incentivizing private sector participation in AI development. Strengthening patent examination standards, increasing transparency in AI-related patent approvals, and enhancing legal protections against IP theft and patent trolling will be essential components of this effort.

Despite the impressive AI advancements in countries like China and India, many BRICS+ nations face significant disparities in digital infrastructure, which directly impacts their ability to foster AI-driven innovation. Ethiopia, a potential BRICS+ member, lags in AI research due to inadequate computing resources, limited access to high-speed internet, and insufficient government funding for AI initiatives. Similarly, South Africa has struggled to develop a robust AI ecosystem, as infrastructural constraints impede the adoption of advanced AI applications.To bridge these gaps, BRICS+ must prioritize targeted investments in AI infrastructure, focusing on key areas such as high-performance computing, cloud-based AI services, and nationwide AI education programs. Governments should establish public-private partnerships to facilitate AI infrastructure development, leveraging investments from global technology firms while maintaining sovereign control over critical AI assets.

A dedicated BRICS+ AI Infrastructure Fund could be established to support underdeveloped economies in building AI research centers, expanding high-speed internet coverage, and increasing access to AI talent training programs. Countries like Brazil, which have experimented with blockchain-based IP registries, can serve as models for deploying cost-effective, decentralized solutions to enhance AI governance infrastructure. By ensuring equitable access to cutting-edge AI tools and fostering inclusive technological growth, BRICS+ nations can collectively strengthen their global AI competitiveness.

AI innovation thrives in environments that promote knowledge-sharing, interdisciplinary research, and cross-border collaboration. However, BRICS+ nations currently lack a comprehensive framework for AI research cooperation, with national policies often prioritizing domestic innovation at the expense of regional integration. Strengthening collaboration between BRICS+ research institutions, universities, and private enterprises is vital to accelerating AI development across the bloc.One of the most effective ways to foster cross-border AI research collaboration is through the establishment of a BRICS+ AI Research Consortium. This consortium could function as a centralized body coordinating joint AI projects, facilitating data-sharing agreements, and providing funding for multinational AI

research initiatives. By creating common AI research hubs across BRICS+ nations—mirroring the model of the European Union's Horizon research program—member states can pool resources and expertise, overcoming national limitations that hinder individual AI innovation efforts.

Furthermore, BRICS+ should implement standardized AI ethics guidelines to ensure that collaborative research adheres to shared principles of transparency, accountability, and inclusivity. Countries such as the UAE, which are pioneering digital rights frameworks for virtual assets, can play a leading role in shaping ethical AI development across BRICS+. Aligning AI research policies will not only streamline regulatory compliance but also enhance the credibility and global impact of BRICS+ AI innovations.As BRICS+ nations navigate the evolving landscape of AI-driven IP governance, a unified strategy is crucial to sustaining long-term innovation and competitiveness. Strengthening AI patent frameworks through harmonized policies will mitigate IP fragmentation and create a more predictable legal environment for AI innovators. Enhancing AI infrastructure investments in underdeveloped BRICS+ economies will address digital disparities, ensuring that all member states have equitable access to AI technologies. Finally, fostering cross-border AI research collaboration through joint initiatives and standardized ethics guidelines will drive collective technological progress.

By implementing these policy recommendations, BRICS+ nations can position themselves as a formidable global force in AI innovation, balancing technological sovereignty with collaborative knowledge-sharing. In doing so, they will not only challenge Western-dominated AI governance models but also establish a sustainable and inclusive framework for AI-driven growth in the Global South.

Conclusion

The BRICS+ nations are emerging as a pivotal force in shaping the future of AI-driven intellectual property governance, challenging Western-dominated norms and creating innovative frameworks tailored to their unique socio-economic landscapes. Their diverse approaches, ranging from China's aggressive patent-driven model to Brazil's blockchain-based IP registries and South Africa's fair-use policies for AI training, illustrate a commitment to fostering technological sovereignty while ensuring equitable knowledge dissemination. This divergence from traditional IP structures underscores the growing influence of BRICS+ nations in setting new standards for AI regulation, emphasizing accessibility, inclusivity, and strategic autonomy in innovation governance.

The exponential rise in AI-related patent filings across BRICS+ highlights not only the rapid technological advancements within these economies but also the increasing need for a harmonized approach to IP regulation. While China has taken a leadership role in patent proliferation, other BRICS+ nations are carving out distinct paths that prioritize open innovation, digital transparency, and ethical AI practices. However, this fragmented landscape presents both opportunities and challenges. On one hand, it fosters a dynamic, multi-faceted ecosystem of AI governance; on the other, it risks regulatory inconsistencies that could hinder cross-border cooperation and intellectual property protections within the bloc.

A significant barrier to uniform AI-driven IP innovation across BRICS+ nations remains the stark disparities in digital infrastructure and research capabilities. While some nations, such as China and India, possess advanced AI ecosystems with robust funding mechanisms, others struggle with limited computational resources, insufficient regulatory clarity, and inadequate AI research funding. Addressing these technological inequities is imperative for BRICS+ to solidify its role as a cohesive and competitive global entity in AI innovation. Strengthening AI infrastructure, expanding investment in research and development, and establishing regional

AI patent frameworks will be critical in mitigating these disparities and fostering an inclusive innovation environment.

The need for deeper collaboration among BRICS+ nations is evident, as strategic alliances will drive more effective AI governance mechanisms. A coordinated effort in AI research, policy development, and legal harmonization can create a unified front that enhances BRICS+'s influence on the global AI regulatory landscape. Initiatives such as a BRICS+ AI Patent Cooperation Treaty, joint AI research hubs, and cross-border IP agreements can provide structured pathways for cooperation, reducing IP fragmentation while fostering technological advancement within the bloc. Furthermore, the adoption of ethical AI principles, fair-use provisions, and open-access models will ensure that BRICS+ nations balance commercial interests with public benefits, ultimately fostering a more sustainable and inclusive AI innovation ecosystem.

Looking ahead, BRICS+ has the potential to redefine the global AI governance paradigm by establishing alternative, innovation-friendly regulatory frameworks that challenge monopolistic control over AI-driven IP. By prioritizing equitable access to AI technologies, investing in cutting-edge research, and strengthening legal protections, BRICS+ nations can position themselves as leaders in the evolving digital economy. However, to fully realize this vision, they must embrace a cohesive and forward-looking strategy that bridges infrastructural gaps, enhances legal harmonization, and fosters deeper international cooperation.In conclusion, BRICS+ stands at a crucial juncture in AI-driven intellectual property governance. Their collective approach has the potential to democratize AI innovation, disrupt conventional IP hierarchies, and create a more balanced technological landscape that benefits both emerging and developed economies. The next phase of AI governance within BRICS+ will depend on strategic policymaking, proactive infrastructure development, and sustained collaboration. If executed effectively, BRICS+ can not only counter Western hegemony in AI but also set a global precedent for equitable and sustainable technological progress in the era of artificial intelligence.

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LEVERAGING ARTIFICIAL INTELLIGENCE FOR EFFECTIVE CRISIS MANAGEMENT: ENHANCING PREDICTION, RESPONSE, AND COMMUNICATION

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ABSTRACT

AI is already transforming crisis management, making response faster, more precise and more effective. AI-powered systems can analyze large-scale datasets from social media, satellite imagery, sensors and more to identify early warning signals, track unfolding crises, and provide real-time assessments. With this information, AI allows the understanding of patterns and anomalies, which in turn leads to predictive modeling, helping to predict what will happen in a crisis and how to proactively respond. Moreover, this protective measure would analyze public sentiment during a crisis, thereby aiding an institution understand myriad perceptions, and optimally disseminate information. AI is also already being used for cybersecurity, such as in detecting and mitigating digital threats that can breach critical infrastructures. But using AI in crisis management must be guided by ethical principles and human supervision with relevant regulatory safeguards for responsible use. It seeks to clarify what AI can and cannot do and where there are opportunities and potential risks in its use for crisis management, suggesting six critical areas to consider for the future.

Keywords: Artificial Intelligence, Crisis Management, Predictive Analytics, Cybersecurity, Crisis Communication, AI Ethics

GLOBALIZATION AND INTERNATIONAL RELATIONS IN CONNECTION WITH BIOTECHNOLOGIES IN THE FOOD INDUSTRY

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ABSTRACT

Globalization has significantly impacted various industries, including the food industry, through the advancement of biotechnologies. The rapid development and global exchange of biotechnological innovations have reshaped agricultural practices, food production, and international trade policies. This paper explores the role of globalization in the dissemination of food-related biotechnologies and its implications for international relations.

The Role of Biotechnology in the Food Industry

Biotechnology in the food industry encompasses genetic modification (GM), precision breeding, fermentation technology, and food processing innovations. These advancements aim to enhance food security, improve crop yields, and reduce environmental impact. Genetically modified organisms (GMOs) and bioengineered foods have become a focal point of global discussions regarding food safety, sustainability, and economic competitiveness.

Globalization and the Spread of Food Biotechnologies

Globalization has facilitated the international transfer of biotechnological innovations, allowing multinational corporations and research institutions to collaborate on food production techniques. Countries with advanced biotechnological capabilities export expertise and products to developing nations, aiding in agricultural development and food security. However, disparities in access to these technologies highlight economic and ethical concerns, particularly in less developed regions.

International Trade and Regulatory Challenges

The global trade of biotech-based food products has led to varying regulatory frameworks across countries. While the United States and some Latin American nations have embraced GMOs, the European Union maintains strict regulations and labeling requirements. These regulatory differences create tensions in international trade agreements and complicate negotiations within organizations such as the World Trade Organization (WTO). The precautionary principle applied by some nations contrasts with the scientific risk assessments preferred by others, leading to ongoing debates over biotechnology acceptance.

Ethical and Environmental Considerations

The globalization of biotechnologies in the food industry raises ethical and environmental questions. The modification of genetic materials in crops and livestock has sparked concerns about biodiversity loss, unintended ecological consequences, and corporate monopolization of food production. Additionally, debates persist regarding consumer rights, transparency in labeling, and the socio-economic impact on small-scale farmers.

The Future of Biotechnology and Global Food Security

As biotechnology continues to evolve, international cooperation will be crucial in ensuring equitable access and sustainable practices. Global organizations, including the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), play essential roles in setting standards and promoting responsible biotech applications. Collaborative efforts in research, policymaking, and education can bridge gaps between nations and create a more inclusive and resilient global food system.

Globalization has accelerated the adoption and dissemination of biotechnologies in the food industry, influencing international relations and trade dynamics. While biotechnology offers promising solutions for food security and sustainability, regulatory, ethical, and environmental challenges must be addressed through global cooperation. The future of food biotechnology depends on balancing innovation with responsible governance, ensuring benefits are shared across all societies.

DECODING CONSUMER PURCHASE INTENTIONS: EXPLORING KEY DRIVERS OF MASSTIGE MARKETING SUCCESS

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Abstract

Masstige marketing, a blend of "mass" and "prestige," has emerged as a pivotal strategy in contemporary marketing, bridging the gap between luxury and mass-market products. This study examines the factors influencing consumer purchase intention in the context of masstige marketing, with a focus on the interplay between brand prestige, perceived quality, affordability, and aspirational value. Drawing on theoretical frameworks such as the Theory of Planned Behavior and Maslow's Hierarchy of Needs, the research explores how emotional, social, and functional benefits drive consumer decision-making. Key findings highlight the role of brand image, perceived uniqueness, and social influence as critical determinants of purchase intention, while price sensitivity and personal values moderate this relationship. The study provides valuable insights for marketers seeking to optimize masstige strategies and align them with consumer expectations in a competitive market. These findings contribute to the growing body of knowledge on consumer behavior and offer actionable implications for brands aiming to strike a balance between accessibility and exclusivity.

MECHANISMS FOR JOB CREATION IN THE REGIONS OF KYRGYZSTAN THROUGH FOREIGN INVESTMENTS AMID MIGRATION PROCESSES

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Abstract

Foreign Direct Investment (FDI) plays a crucial role in the economic development of the Kyrgyz Republic by fostering infrastructure growth, expanding production capacities and increasing export potential. One of the most significant benefits of FDI is its contribution to job creation, particularly in regions where unemployment remains high. However, the persistent challenge of labor migration significantly impacts the effectiveness of FDI in generating employment. High levels of outward migration, particularly of skilled workers, have led to labor shortages in key industries, while internal migration has resulted in uneven workforce distribution across regions.

This study examines the impact of FDI on employment generation in the regions of Kyrgyzstan, focusing on how migration dynamics shape labor market outcomes. The research provides a sectoral analysis of FDI inflows, identifying industries that have successfully generated employment and those that remain underdeveloped due to workforce constraints. Special attention is given to the role of FDI in introducing new technologies, enhancing workforce skills and addressing labor shortages in regions affected by high emigration rates. Additionally, the study explores regional disparities in FDI allocation and their correlation with migration patterns.

Despite the positive effects of FDI, challenges such as uneven regional distribution, sectoral imbalances and skill mismatches persist, exacerbated by migration trends. This study explores these issues in depth and offers policy recommendations aimed at improving investment conditions, attracting foreign capital to underdeveloped regions and mitigating the negative impact of migration on the labor market. The findings are based on data from the National Statistical Committee of the Kyrgyz Republic databases, ensuring a rigorous and evidence-based approach. This research contributes to the broader discussion on sustainable investment policies, labor migration management and regional economic development in Kyrgyzstan.

Key words: foreign direct investment, investment climate, region, investment attractiveness, sustainable development, investment potential, migration, FDI in Central Asia.

INTRODUCTION

Kyrgyzstan, historically an agrarian country, has undergone significant economic transformations since gaining independence in 1991. Structural shifts in the economy, declining agricultural employment and limited domestic financial resources have made foreign direct investment (FDI) a crucial driver of economic growth. However, one of the most pressing challenges facing the country today is the high rate of labor migration, as many citizens seek employment abroad due to limited job opportunities at home. In this context, FDI can serve as a powerful tool to create sustainable employment, reduce migration and foster long-term economic stability (Lee C. Y., 2019).

Migration has become an integral part of Kyrgyzstan's socio-economic landscape, with remittances from migrant workers playing a vital role in supporting household incomes. While these financial inflows contribute to economic stability, excessive reliance on migration poses risks such as brain drain, social fragmentation and vulnerability to external economic shocks. Additionally, internal migration has led to the rise of informal settlements around major cities, exacerbating issues related to land ownership, legal registration and access to social services. These challenges highlight the urgent need for a sustainable economic strategy that prioritizes job creation within the country.

FDI offers a viable solution by stimulating key sectors, increasing productivity, and generating employment opportunities. By attracting investment into industries such as manufacturing, energy, and technology, Kyrgyzstan can diversify its economy beyond agriculture and informal labor markets. Furthermore, FDI brings technological advancements, entrepreneurship opportunities and long-term commitments from international investors, contributing to the overall modernization of the economy. Countries that have successfully leveraged FDI have seen improvements in infrastructure, human capital development, and economic resilience, all of which are essential for Kyrgyzstan's sustainable growth.

To fully harness the benefits of FDI, Kyrgyzstan must ensure a stable investment climate, strengthen legal frameworks and promote policies that encourage foreign investors. Overcoming political and regulatory challenges, particularly the growing skepticism toward foreign investments, will be critical in unlocking FDI's potential. If properly managed, FDI can help Kyrgyzstan reduce its dependence on labor migration, create high-quality jobs and pave the way for long-term economic prosperity.

LITERATURE REVIEW

Yildirim et al. (2014) suggest that FDI and human capital are crucial factors influencing economic growth, interacting closely with each other. A skilled workforce typically attracts foreign investors, while multinational corporations (MNCs) facilitate knowledge transfer and provide training opportunities for local employees. However, their study, which analyzed data from Azerbaijan, Uzbekistan, Kazakhstan, and Kyrgyzstan over the period 1999–2011 using Panel OLS methodology, revealed that FDI had no significant impact on educational attainment in these countries. Several reasons could explain this outcome: firstly, foreign investments in this region often target sectors that are not technology-intensive and therefore do not require highly qualified personnel. Secondly, the existing human capital level might be insufficient for effective spillovers from FDI. Although some multinational companies offer training programs and educational scholarships, their overall contribution remains limited. To fully leverage the benefits of FDI, developing countries should prioritize attracting investments in advanced industries that support social and economic development and contribute meaningfully to enhancing local human capital.

According to Farruhbek (2019) although Central Asian nations have achieved some progress in attracting FDI following the dissolution of the Soviet Union, the effectiveness of implemented reforms remains unclear. Significant barriers persist, such as weak rule of law, insufficient transparency and unstable legal frameworks. Countries such as Turkmenistan, Tajikistan, and Uzbekistan impose restrictions on investment treaties through national legislation, which negatively impacts their attractiveness to foreign investors. Many investors favor international legal protections over domestic regulations, as national laws frequently offer weaker guarantees. Additionally, ambiguous and inconsistent policies heighten risks and deter investment. To enhance their appeal for FDI, Central Asian countries must improve transparency, establish predictable legal environments and adhere to international standards. Investors typically evaluate both economic factors and legal stability because a secure environment reduces risks and encourages long-term investments.

Ashurov et al. (2020) examines the key factors influencing FDI flows in CIS countries, refining previous research methodologies and addressing endogeneity issues. The findings highlight that Generalized Method of Moments (GMM) estimators provide a more accurate approach than traditional methods like OLS, Fixed Effects (FE) and Random Effects (RE). Empirical results indicate that FDI inflows are significantly influenced by five factors: the previous year's FDI, GDP, labor force size, trade openness and tax policies. However, total debt service (TDS) does not show a significant effect on attracting FDI.

Chepel, S. et al. (2021) examines the inclusive economic development in the CIS countries depends on strengthening state institutions, improving migration management and fostering industrial growth. Effective governance is essential to create favorable conditions for investment and employment, reducing reliance on labor migration. A key factor in economic inclusivity is education and human capital development. Establishing unified educational standards and regional competence centers can bridge skill gaps and reduce income disparities among CIS countries. Investing in education and workforce training will accelerate industrial development and attract foreign investment. Technological cooperation is another critical aspect. Creating joint technology platforms in sectors like energy, transport, healthcare, and IT can enhance innovation and efficiency. This approach will lower production costs, reduce dependency on Western and Chinese technologies and strengthen regional competitiveness. Furthermore, harmonizing trade, tax and legal policies can improve the investment climate. Simplifying economic regulations and establishing independent judicial bodies for dispute resolution will boost investor confidence and promote regional economic stability. Expanding technological trade and cooperation will also drive job creation and industrial diversification. To successfully implement these measures, a supranational coordination body should be established. This institution would facilitate collaboration between governments, businesses and society, ensuring a structured and sustainable approach to economic integration. By enhancing governance, education and technological advancement, CIS countries can achieve long-term, inclusive economic growth and strengthen their position in the global economy.

Makhmadisuf, S. et al. (2022) finds that FDI plays a crucial role in driving economic growth in Tajikistan, Turkmenistan, Uzbekistan and Kyrgyzstan. The analysis (1993–2017) highlights capital inflows, technology transfer and improved productivity as key benefits of FDI. However, inflation and excessive government spending negatively impact growth, while exports and private sector expansion contribute positively. Despite FDI's positive effects, uneven regional investment and inadequate infrastructure remain key challenges. To enhance FDI's impact, governments must improve institutional quality, stabilize macroeconomic conditions, and create favorable business environments. Strengthening human capital, investing in infrastructure and fostering innovation are essential steps toward long-term, sustainable development.

DATA AND METHODOLOGY

This study examines foreign direct investment (FDI) in the regions of the Kyrgyz Republic from 2018 to 2024, utilizing a combination of quantitative and qualitative methods. The primary data source is the National Statistics Committee of the Kyrgyz Republic, which provides key economic indicators such as FDI inflows, sectoral distribution, and regional economic performance. These indicators form the empirical basis for evaluating investment trends, regional disparities and the overall investment climate in Kyrgyzstan.

To complement the statistical data, this research incorporates a comprehensive review of academic literature and policy reports on investment environments and economic development. This qualitative approach allows for a deeper understanding of structural challenges, policy inefficiencies and investor perceptions in different regions. Additionally, comparative analysis

with global FDI indices provides insights into Kyrgyzstan's competitiveness in attracting and sustaining foreign investment.

The study also explores the relationship between FDI and migration trends, assessing how labor market dynamics influence investment patterns. Issues such as uneven regional investment distribution, sectoral imbalances and skill mismatches are analyzed to identify structural barriers to sustainable growth.

By integrating macro-level statistical analysis with qualitative assessments, this research ensures a rigorous, data-driven approach. The findings contribute to policy discussions on improving investment conditions, attracting FDI to underdeveloped regions and mitigating the negative effects of migration on the labor market. The ultimate goal is to provide practical recommendations for fostering a more balanced and resilient economic development strategy in Kyrgyzstan.

RESULTS AND DISCUSSION

In 2023, the labor force aged 15 years and older comprised more than 2.7 million people, of whom over 2.6 million were employed and 112 thousand were unemployed. Compared to 2022, the number of employed people aged 15 years and older increased by 3 percent, while the number of unemployed decreased by 15 percent. Among the total employed population, men (1.6 million) outnumbered women (1.0 million).

Table 1. Unemployment rate (percentage).

	2019	**2020**	**2021**	**2022**	**2023**
Republic of Kyrgyzstan	**5,5**	**5,8**	**5,3**	**4,9**	**4,1**
Batken region	8,2	7,4	6,6	6,1	5,9
Jalal-Abad region	5,5	11,0	11,8	10,8	8,2
Issyk-Kul region	7,8	7,4	6,3	5,5	5,1
Naryn region	8,3	7,3	6,3	5,8	5,1
Osh region	3,5	2,6	1,9	1,5	1,4
Talas region	2,5	2,6	2,6	2,3	2,0
Chui region	6,6	6,1	5,3	4,6	4,1
Bishkek city	5,9	5,0	4,1	4,0	3,5
Osh city	2,5	2,8	2,8	2,6	2,1

Source: National Statistics Committee of the Kyrgyz Republic.

In 2023, the employment rate of the population was 56 percent overall, a decrease of 0.8 percentage points compared to 2022. Employment rates among men (71 percent) were higher than among women (42 percent). The unemployment rate was 4.1 percent, decreasing by 0.8 percentage points compared to 2022 (Table 1).

Until 2022, the migration balance was consistently negative (Table 2), meaning that, according to registration data, more people left Kyrgyzstan than arrived. In 2023, Kyrgyzstan registered 14,453 arrivals from abroad, and this figure may include citizens of other countries who arrived in Kyrgyzstan for permanent residence. The majority of arrivals came from the Russian Federation (77%), followed by Tajikistan (7%), Kazakhstan (4%), and Uzbekistan (3%). In the same year, Kyrgyzstan recorded 4,610 departures abroad (NSC KR, 2024). Most of those who left Kyrgyzstan for another country went to the Russian Federation (66%) and Kazakhstan (24%). Between 2011 and 2021, the number of people leaving exceeded the number of arriving migrants. During this ten-year period, the migration balance fluctuated, but the gap between departures and arrivals gradually narrowed.

Table 2. Net migration, outflow on external migration (people).

	2020	**2021**	**2022**	**2023**	**2024**
Republic of Kyrgyzstan	**-4 861**	**-769**	**5 917**	**9 843**	**11 208**
Batken region	-73	643	962	1182	1315
Jalal-Abad region	-500	1 191	1 975	2462	2255
Issyk-Kul region	-246	-273	74	204	365
Naryn region	-28	42	62	71	87
Osh region	-1 140	1 508	2 221	2498	2528
Talas region	-120	-98	69	39	197
Chui region	-1 198	-2 226	-271	955	1249
Bishkek city	-1 248	-1 691	289	1785	2320
Osh city	-308	135	536	647	892

Source: National Statistics Committee of the Kyrgyz Republic.

In 2022, for the first time in ten years, the number of arrivals exceeded the number of departures, resulting in a positive migration balance of 5,917 people arriving for permanent residence. In 2023, the positive migration balance further increased to 9,843 people (NSC KR, 2024).

Compared to 2021, an increase in FDI inflows was observed in enterprises located in Batken, Talas and Jalal-Abad regions, as well as Osh. The majority of FDI inflows (over 95%) were directed towards enterprises in the mining sector, manufacturing industries, financial intermediation and insurance, wholesale and retail trade, as well as information and communications.

Table 3. Enterance of direct foreign investment by region (thsd. dollars USA).

	2018	**2019**	**2020**	**2021**	**2022**	**2023**
Republic of Kyrgyzstan (Total)	851 743,6	1 076 918,7	537 553,8	1 006 091,2	1 202 599,0	844 895,7
Batken region	2 152,2	11 470,6	3 009,3	334,8	36 647,6	305,4
Jalal-Abad region	128 806,7	255 388,8	79 266,3	359 833,3	511 197,4	179 938,5
Issyk-Kul region	91 256,9	259 189,8	150 818,6	5 843,9	983,8	26 074,1
Naryn region	4 096,8	171,6	-	-	133,6	24 106,3
Osh region	8 238,9	3 490,6	2 539,5	23 487,5	41 689,6	39 818,8
Talas region	909,7	29,8	36 581,4	81 845,5	127 900,8	117 547,8
Chui region	249 314,3	175 684,9	99 964,8	203 926,8	180 205,8	105 198,6
Bishkek city	57395,2	59556,0	47450,6	42852,8	42801,1	52776,7
Osh city	5416,0	5683,6	5549,5	5938,9	8434,2	8678,5

Source: National Statistics Committee of the Kyrgyz Republic: http://www.stat.kg/

According to the Statistical Committee of the Kyrgyzstan, in 2022, Jalal-Abad Region became the most attractive region for investors, receiving $511.2 million, which is 42.07% more than in the previous year. This is attributed to the presence of large industrial enterprises in the region, such as JSC "Talaskant," which produces aerated concrete blocks and slabs, JSC "Ak-Tilek Energo," which generates electricity from renewable sources, as well as major gold mining companies. The second most attractive region was Chui Region, which attracted $180.2 million in investments.

The volume of FDI's received by Kyrgyzstan from international investors also varies significantly across the regions of the country. For instance, 53.9% of all FDI is concentrated in just three regions: Jalal-Abad (21.3%), Talas (13.9%), Chui (12.5%) and the city of Bishkek (6.2%). In contrast, regions such as the city of Osh (1%), Osh Region (4.7%), Issyk-Kul Region

(3.1%), Naryn Region (2.9%) and Batken Region (0.04%) received negligible amounts of FDI in 2023 (Table 3).

CONCLUSION

Kyrgyzstan is facing a serious economic challenge due to high labor migration and a lack of FDI. The shortage of job opportunities forces young, educated workers to seek employment abroad, which slows down economic growth and creates long-term development risks. To address this issue, the country must focus on attracting foreign investors, particularly to regional economies, where new enterprises and industries can generate sustainable employment opportunities.

One of the key solutions is to direct FDI into productive sectors such as manufacturing, infrastructure and technology. These investments can drive industrialization, enhance innovation, and create stable jobs, reducing the need for migration. Additionally, the improvement of institutional frameworks, including transparent tax policies, strong labor regulations and simplified business procedures, will make Kyrgyzstan a more attractive destination for investors.

To ensure economic growth and job creation, the government should also focus on developing human capital by investing in education and vocational training. Skilled workers are essential for modern industries and by strengthening the workforce, the country can offer a more competitive environment for investors. Furthermore, regional cooperation and technological exchange with neighboring countries can help accelerate industrial growth and reduce dependence on external economies.

Another important strategy is the creation of special economic zones (SEZs) that offer incentives for foreign companies to invest in underdeveloped regions. These zones can attract multinational firms, stimulate local supply chains and promote economic diversification.

By implementing these measures, Kyrgyzstan can reduce outward migration, increase employment opportunities, and integrate more effectively into the global economy. Strengthening foreign investment policies and fostering a business-friendly environment will not only create jobs but also contribute to the country's long-term economic stability and development.

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THE FACTORS THAT AFFECT NURSES' ABILITY TO MAINTAIN THE HIGHEST STANDART OF HEALTHCARE QUALITY

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Abstract

Introduction: Based on an broad literature review,fatigue has been clearly described as a cause that may affect the ability of nurses to achieve the highest standard of health care quality.The fatigue response is the body's automatic response to any change in the internal or external environment and facilitates the availability of resources to respond to emergencies.

The purpose of the study: Evidence of causes that affect the work of the nurse in order to improve the quality of health care.

Methodology: The stady is Cross-sectional type Descriptive-Analytical. Data collection is using a self- administered questionnaire was completed by the nurses.

Results: Nurses reported that they feel tired in their work. By type of fatigue: 49.55% them have psychological fatigue, 41.44% have physical and psychological fatigue, 9% physical fatigue. According to the impact of fatigue on the quality of work, 49% think that fatigue has little effect on the quality of work, 43% say that it often affects work, 5% report fatigue does not affect at all their work and 3% of them say that it always affects work. According to the main cause of mistakes by often being tired, 47% declare fatigue as the main cause of committing mistakes. From the nurses daily tired 21% have declared fatigue.

Conclusions: Fatigue is a cause that affects the quality of work of the nursing staff. Nurses feel tired at work Nures feel more psychological than physical fatigue.

Keywords: identification of causes,fatigue,management.

NANOMATERIAL-BASED TRANSDERMAL DRUG DELIVERY FOR SKIN-RELATED DISORDER

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Abstract

Transdermal drug delivery systems (TDDS) have been extensively studied in recent decades due to their several advantages, including enhanced compliance among patients, optimized drug release, targeted administration to specific tissues, and bypassing the liver's systemic processing. Nevertheless, the outermost layer of the skin, known as the stratum corneum, acts as the primary barrier that limits the rate at which medications can pass through the skin. This has consistently been an obstacle in TDDS. Nanomaterial-based TDDS present a promising method for treating skin-related disorders, as they focus on the distinctive characteristics of nanomaterials to improve drug penetration, stability, and targeted delivery. The purpose of this study is to investigate the existing developments in NTDDS, with a particular emphasis on the various types of nanomaterials, such as liposomes, nanoparticles, nanoemulsions, and nanofibers, and the function that these nanomaterials play in infractions the stratum corneum barrier. These NTDDS can permeate the outermost layer of the skin, known as the stratum corneum, and acquire at the intended site. Novel nanocarriers can increase dermal localization of bioactive in dermatological treatments, delivering medications directly to target cells. It also explores the mechanisms of drug permeation, the potential for sustained and controlled drug release, and the specific advantages offered in treating conditions such as psoriasis, eczema, and skin cancers. This review aims to underscore their transformative potential in enhancing therapeutic outcomes and patient compliance in dermatological care.

Keywords: Drug Delivery, Nanocarrier, Stratum corneum, Skin Disorder, Topical Delivery, Target Cell

NETWORK UTILIZATION WITH PROXY ROUTERS TO IMPROVE INTERNET PERFORMANCE EFFECTIVENESS

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Abstract

The development of information and communication technology demands the availability of a stable and efficient internet network in various sectors, such as education, business, and government. However, many networks experience problems in bandwidth management, security, and connection stability, which hinder their effective use. This research aims to evaluate the use of Mikrotik Router in improving the effectiveness of internet work through more optimal bandwidth management, increased network security, and ease of monitoring for administrators.

The research method used is Network Development Life Cycle (NDLC), which includes needs analysis, design, implementation, and network evaluation. The results showed that after the implementation of the Mikrotik Router, bandwidth distribution became more equitable and controlled through the application of Simple Queue and Queue Tree, thereby reducing network congestion. Network security is increased by the Layer 7 Filter firewall and Network Address Translation (NAT) configuration which successfully prevents unauthorized access and blocks potentially threatening content.

Based on the research results, it can be concluded that the Mikrotik Router is an effective and efficient solution for improving internet network performance, both on a small scale such as offices and on a large scale such as educational and business institutions.

Keywords: Mikrotik router, bandwidth management, network security, connection stability, internet effectiveness.

INTRODUCTION

The utilization of information and communication technology is growing rapidly, especially in the management of computer networks which are the main infrastructure for internet access. In various sectors, such as education, business, and government, the need for a stable and efficient network is increasing. One of the main challenges in network management is how to ensure that every user gets an optimal connection without wasting bandwidth or interrupting access

Routers play an important role in network management, because they function to manage data flow, allocate bandwidth, and increase network security. Mikrotik as one of the widely used network solutions offers various excellent features such as firewall, NAT, routing, hotspot, DNS server, DHCP server, bandwidth management, and security system. Its ability to optimize

bandwidth usage makes it an efficient choice for managing internet connections at various network scales, whether in schools, offices, or other business environments (Ardianto, Feby, 2020)

However, in many cases, computer networks often experience an imbalance in bandwidth allocation, where some users can consume most of the internet capacity, while others get limited access. Another problem that often occurs is weak security systems and lack of network traffic monitoring, which can lead to uncontrolled access and vulnerability to cyberattacks (Gunawan & Ghiffari, 2018) .

This study aims to evaluate the use of Mikrotik Router in increasing the effectiveness of the internet through more optimal bandwidth management, increased network security, and ease of control for administrators. With proper implementation, it is expected that the computer network can run more stable, efficient, and provide a better internet experience for all users.

METHOD

This research uses the Network Development Life Cycle (NDLC) method to develop and manage networks with Mikrotik Routers to increase the effectiveness of internet work. This method was chosen because it is able to provide a systematic approach in analyzing, designing, implementing, and evaluating networks more optimally.

The first stage conducted in this research is a needs analysis, which aims to identify problems that exist in the previous network system. Some of the problems that often occur include imbalances in bandwidth distribution, weak network security systems, and lack of monitoring of data traffic. Through this analysis, a comprehensive picture of the network condition is obtained which then becomes the basis for making improvements and optimization (Admaja, 2021) .

After the needs analysis is carried out, the next stage is network design. At this stage, a network topology design is prepared which includes Mikrotik Router configuration, IP Address allocation, and Quality of Service (QoS) settings to manage bandwidth distribution to make it more efficient. In addition, this design also considers firewall mechanisms to improve network security and the implementation of a data traffic monitoring system so that administrators can easily monitor network performance (Admaja, 2021) .

The next stage is implementation and configuration, where the Mikrotik Router is configured using WinBox or a command-based terminal. Some of the main aspects in this stage include bandwidth management via Simple Queue or Queue Tree, firewall configuration to prevent unauthorized access, and the implementation of Netwatch as a network monitoring tool. In addition, in an effort to improve connection stability, traffic priority management is carried out for certain applications such as Zoom or Google Meet, so that activities that require a stable connection can run more smoothly.

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RESULT AND DISCUSSION

After the implementation of Mikrotik Router in network management, there was a significant improvement in the effectiveness of internet work. Tests were conducted by comparing network conditions before and after optimization, focusing on three main aspects: bandwidth management, network security, and connection stability.

Prior to optimization, networks often suffered from an imbalance in bandwidth distribution, where some users over-consumed internet capacity, while others experienced limited access. As a result, many activities were hampered, especially in work environments that depend on a stable internet connection. After Simple Queue and Queue Tree configurations were

implemented, bandwidth usage became more controlled. With this system, each user gets a fairer bandwidth allocation, so network congestion can be reduced and internet access becomes more stable (Sujalwo et al., 2020) .

In addition, network security before optimization is also a major issue. Without a good security system, the network was vulnerable to unauthorized access that could compromise the system. After the implementation of a firewall with Layer 7 Filter, various sites or content deemed a security threat were successfully blocked, thus reducing the potential for external attacks. Not only that, Network Address Translation (NAT) configuration and network traffic monitoring further strengthen security, making the system safer from the risk of misuse of access (Muin et al., 2017) .

In terms of connection stability, before optimization, the network often experienced interruptions, especially when used for video conferencing using applications such as Zoom or Google Meet. These interruptions caused communication to be unsmooth and often disconnected. However, after configuring the mangle rule and priority queue, the application connection becomes more stable, because the system can prioritize more important data traffic. Tests show that after optimization, latency when using Zoom or Google Meet is significantly reduced, so that online communication activities can run more smoothly without interference from other users who are browsing or downloading.

In addition to technical aspects, network optimization also provides benefits for administrators in system management. With the implementation of Netwatch and bandwidth monitoring features, administrators can easily monitor bandwidth usage in real-time. This allows them to immediately detect abnormal traffic spikes and perform troubleshooting faster when disruptions occur (Sujalwo et al., 2020) .

Overall, the results of this study prove that the use of Mikrotik Routers can significantly improve the effectiveness of internet work. Better bandwidth management provides more stable internet distribution, while the strengthened security system successfully protects the network from unauthorized access. In addition, the monitoring feature helps administrators control network usage more efficiently. Thus, Mikrotik can be an effective and efficient solution to improve network quality in various environments, such as educational institutions, offices, and businesses.

CONCLUSION

Based on the results of the research, it can be concluded that the use of Mikrotik Router has proven effective in increasing the effectiveness of internet work. The implementation of this system has a positive impact on bandwidth management, network security, and connection stability.

The implementation of Simple Queue and Queue Tree has enabled a more equitable and controlled distribution of bandwidth, thereby reducing network congestion and improving user experience in accessing the internet. In addition, the implementation of a firewall with Layer 7 Filter and Network Address Translation (NAT) configuration has improved network security by preventing unauthorized access and blocking potentially threatening content.

In terms of connection stability, the use of mangle rule and priority queue shows a significant improvement in internet service quality, especially for applications that require a stable connection such as Zoom or Google Meet. This allows online activities to run more smoothly without interruptions from uncontrolled bandwidth usage.

In addition, the implementation of Netwatch and bandwidth monitoring features provides great benefits for network administrators in monitoring and troubleshooting faster. With a better

monitoring system, administrators can easily control bandwidth usage and identify potential network problems before they have a major impact on users.

Thus, the results of this study confirm that Mikrotik Routers are an effective and efficient solution in improving computer network performance, both on a small scale such as offices, and on a large scale such as educational institutions and businesses. Proper implementation can help improve the stability, security, and overall quality of internet connections.

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GLOBAL AGING IN CRISIS: ADDRESSING ELDERLY VULNERABILITIES IN THE POST-PANDEMIC WORLD

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Abstract

Objectives: The COVID-19 pandemic has highlighted and intensified the vulnerabilities of the global elderly population, underscoring the urgent need for inclusive and adaptive interventions. This study aims to analyze the psychosocial and physical health impacts of the pandemic on older adults and to identify effective strategies for mitigating these effects.

Methods: A mixed-methods approach was employed, combining a qualitative case study with a quantitative analysis of the vulnerabilities associated with COVID-19 in elderly populations. Data were collected from epidemiological studies and policy responses worldwide to assess the relationship between age, disease severity, and healthcare accessibility.

Results: Findings reveal that social isolation, enforced by public health measures, significantly contributed to increased rates of depression, anxiety, and loneliness among older adults. Mobility restrictions further exacerbated sedentary behaviors, accelerating functional decline. Prioritizing elderly individuals in vaccination campaigns and ensuring equitable access to healthcare proved crucial in mitigating severe health outcomes. Effective strategies include the integration of digital technologies to reduce isolation, the expansion of telemedicine services, and the optimization of home care programs to enhance healthcare accessibility. Additionally, fostering international and intergenerational solidarity is essential in building long-term resilience.

Conclusions: As societies transition to a post-pandemic reality, continuous evaluation and adaptation of these interventions are necessary to address the evolving challenges faced by aging populations. Strengthening healthcare infrastructure and promoting digital inclusion will be key in fostering a more resilient and equitable global health system.

Keywords: global aging, elderly vulnerability, COVID-19, social isolation, digital inclusion, health equity.

HAITI - ITS CHRONIC POVERTY, ENVIRONMENTAL AND ECONOMIC DISASTER, CRISIS MANAGEMENT AND FOREIGN AID-TAKING A FRESH PERSPECTIVE RESIDING AT THE BACKYARD OF USA - THE BIGGEST AND RICHEST WESTERN NATION

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Abstract

The tropical land of Haiti is profoundly blessed with natural beauty and resources, so it may seem as Paradise to some. Indeed, may be it was until the tyrannous Christopher Columbus along with the west European colonizers invaded it and turned it to Hell, which led to nearly full extinguishment of the native human population, and gradual forceful repopulation with slaves mostly brought from Africa. The Haitian Revolution and the birth of the first free from slavery country in the West did not alleviate the chronic impoverishment and economy much as France imposed debilitating racism based indemnity payments which lasted up to the mid of XX-th century. Further the imposed isolation and trade blockades by the west European powers and their present or former colonies additionally shattered the fragile economy. Thus the overall development of this country was halted and greatly postponed for many decades in compare to its neighbors. In addition the environmental factors as the climate changes advent and geodynamics further challenge and devastate this misfortunate country.

In the present work the concept of insecurity that is chronically felt in Haiti is approached more broadly thanks to the multidimensional vulnerability, which takes into account the interaction of historical, economic, political, and ecological factors. These issues are also closely linked to international relations and geopolitical concerns in the whole Caribbean region. And special focus is paid to some of the results of such long-lasting insecurity as the migration and domestic violence and the attempts and approaches to solve or at least to mitigate them through foreign aids and management.

Key words: Haiti, Haiti's Economy, Migration, Foreign Aids, Climate Change, Disaster, Poverty, Food Insecurity.

CHAYOTE (*sechium edule):* INNOVATING HEALTHY CARBONATION THROUGH NATURAL EXTRACT

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ABSTRACT

In a world that is becoming more focused on environmental issues and individual health, the beverage industry is experiencing a notable shift. This change in consumer preferences has led to a merging of sustainability, wellness, and beverage brands. This study utilized chayote to develop a novel beverage. Chayote is an underutilized fruit in the Philippines compared to other fruits. It is grown as a vegetable, yet it is classified as a fruit. This study focused on developing a Chayote Carbonated Drink, an innovative healthy alternative to sugary soft drinks, using chayote, an underutilized fruit in the Philippines. The drink, made from chayote extract, pineapple juice, and honey syrup, underwent sensory testing, with the third formulation receiving the highest preference from panelists for its balanced flavor. Consumer acceptability tests yielded a high overall score of 8.56, it indicates that the majority of respondents liked the product very much, reflecting its positive reception in terms of sensory attributes such as appearance, aroma, flavor, and taste. Nutritional analysis revealed that the drink is rich in Vitamin B6, Folate, and Ascorbic Acid, making it especially beneficial for adolescents, young adult girls, and lactating mothers. A pH test showed an average of 4.06, indicating the drink's mild acidity, which helps with carbonation retention and microbial stability. The product also supports sustainable development goals by promoting local sourcing, reducing waste through eco-friendly packaging and by-product repurposing, and contributing to environmental sustainability. This research demonstrates the potential of chayote as a nutritious and sustainable beverage base, addressing both consumer health and environmental concerns.

Keywords: Carbonated Drink, Chayote, Product Development

INTRODUCTION

In a study of Nielseniq (2023) **In a world increasingly concerned with the environment and personal well-being, the beverage industry is undergoing a significant transformation. Consumers are no longer satisfied with beverage brands providing mere refreshment; they want them to align with their values and contribute to their overall health. This shift**

in consumer preferences has given rise to a convergence of sustainability, wellness, and beverage brands. In a study of Physiology and Behavior (April 2023) The research participants perceived the most common barriers to healthy eating among both adolescents and their parents were the lack of interest, knowledge and skills around healthy eating and vegetable. According to the research study Journal Nutritional Disorders and Therapy, the Results of the food consumption surveys in the Philippines conducted by the Food and Nutrition Research Institute-Department of Science and Technology (FNRI-DOST) showed that the average consumption of green, leafy, and yellow vegetables and vitamin C-rich fruits is low in the Filipino diet. According to Food Research International (2021) The global carbonated beverage market is large, and consumers like the oral irritation (ex. burning or prickling) associated with carbonated beverages.

This study used chayote to create innovative beverage. Chayote is one of the unused fruit in the Philippines compare to other fruits. It is cultivated as a vegetable but technically it is a fruit. It is only and commonly utilized in making and cooking salads, tinola, and ginisa other than that chayote is not consumed. Chayote, scientifically known as Sechium edule, is a type of squash that belongs to the Cucurbitaceae or gourd family. This plant can be found year-round and its peak season is from September to November. Chayote can boost overall health. It is also known to be a general digestive health and a liver booster.

This research further studied about Chayote nutritional facts and created a healthy and sustainable beverage that likely demanded by people. Chayote has a high water content. According to the United States Department of Agriculture (USDA), a 100 grams serving of chayote contains over 94 grams of water. Hence, it will be beneficial to extract the juice/water of chayote to make it a beverage particularly the carbonated drink. Carbonated drink is considered as a healthy alternative to sugary soft drinks. It is created using sustainable ways promoting: no poverty, zero hunger, good health and well-being, responsible consumption and production, and climate action. By sourcing chayote fruit in local farmers, it helps minimizing the poverty in farming livelihood. By means of its nutritional values it can help address malnutrition. It can also encourage and empower farmers and sellers of chayote leading to a more stable food supply. It also contribute to better health and well-being. This study also fosters responsible consumption and production by utilizing eco-friendly packaging and re-purposing leftovers from the production process such as peels and seeds that can be compost for reducing waste. Also, locally sourcing of ingredients will definitely reducing carbon footprint.

STATEMENT OF THE PROBLEM

The objective of this study was to develop a carbonated drink using chayote fruit. It was underutilized in beverage production thus the researchers came up with the idea of introducing the healthy benefits of chayote through innovative beverage as well as rising its consumer demands.

The challenges of the researchers were on how to present its development to meet the consumer demands. Also to addressed issues related to consumer acceptance and product development (aroma, taste, flavor, color).

1. to **develop a** Chayote Carbonated Drink in terms of:
1.1 appropriate percentage per ingredients;
1.2 technology support;
1.3 regulation; and
1.4 financial.
2. to determine the **sensory evaluation** of the Chayote Carbonated Drink and if there are **significant differences** between the three formulations in terms of terms of:

2.1 appearance
2.2 aroma
2.3 mouthfeel
2.4 flavor
2.5 taste and
2.6 after taste

3. to determine the **consumer acceptability** of Chayote Carbonated Drink in terms of:
   3.1 appearance
   3.2 aroma
   3.3 flavor and
   3.4 taste
4. to determine the **food components** of the Chayote Carbonated Drink in terms of:
4.1 pH test; and
4.2 nutritional benefits

THEORETICAL FRAMEWORK

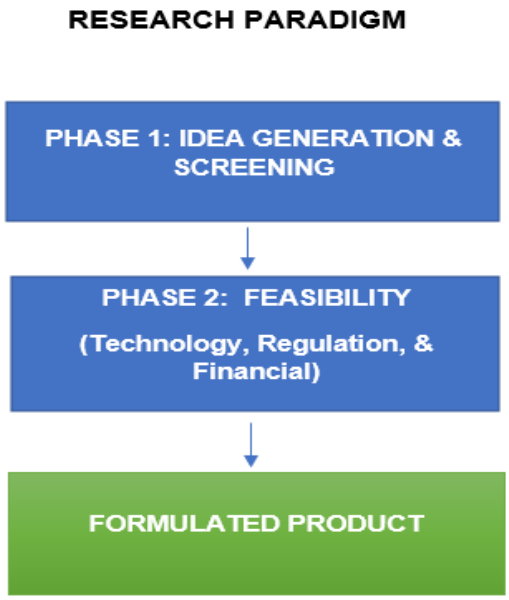

Figure 1. Modified Framework based of Aramouni and Deschenes (2017), Process of Product Development

The first phase of this modified theoretical framework was the idea generation which generated concepts based on consumer input. All of the participants contributed to generate ideas. Following idea generation, screening took place. This was the most critical step since it determined whether to spend time and money. The second phase was the feasibility. A product launching required sufficient regulatory compliance, the purchased of the required equipment, and understanding and awareness of the required costs. Consequently, the formulated product was introduced. The researchers intentionally excluded the test marketing phase to focus on the relevant concepts of the analysis.

METHODOLOGY

RESEARCH DESIGN

The researchers used an experimental design conducting three (3) formulations with different percentage of chayote and pineapple extract. It was thoroughly evaluated by ten (10) trained panelist using completely randomized design (CRD) and descriptive test to quantified the sensory differences between samples and determined which formulation produced the best sensory attributes and met consumer expectations in terms of individual preferences of sensory attributes and overall appeal. The samples had different codes to differentiate without bias. The control recipe were the water with an amount of 300 mL, juice of three (3) medium-sized pineapples, and 40 mL honey simple syrup made of pure honey and water (1:1).

Table 1. ***Chayote Carbonated Drink***

INGREDIENTS	CONTROL	219	289	231
Chayote Extract	-----	**350 mL**	150 mL	250 mL
Pineapple	**500 mL**	**150 mL**	**350 mL**	**250 mL**
Water	**300 mL**	300 mL	300 mL	300 mL
Honey Simple Syrup	40 mL	40 mL	40 mL	40 mL
Pure Honey	**1:1**	**250 mL**	**250 mL**	**250 mL**
Water	**1:1**	**250 mL**	**250 mL**	**250 mL**

Data Gathering Procedure and Process Flow

The researchers conducted an experiment of carbonated drink by locally sourcing the ingredients from the market of Bulihan, Silang, Cavite. The procedures for three (3) formulations were identical. To begin, the researchers carefully looked for a high quality and fresh chayote fruit and pineapple fruit. And also used clean and purified water. By making a honey simple syrup, the researchers used a 1:1 ratio of pure honey and water. After sourcing the raw materials, the researchers proceeded to mise en place. The fruits were washed properly as well as the tools and equipment to be used.

With the use of peeler, the researchers peeled the skin of chayote fruit and removed its seeds. Next, the researchers grated the chayote fruit and pressed it in the strainer to manually extract its liquid content. Transferred the extract into another bowl and set aside. For the pineapple, its leaves and skin were thoroughly removed using sharp knife. The researchers cut the whole pineapple into square cuts and extracted its juice using manual squeezer. Transferred the juice into clean bowl and set aside. However, using electric juicer made these steps more easier and faster. Subsequently, the researchers made a honey simple syrup. With the help of gas stove with low heat, the 1:1 ratio of pure honey and water were dissolve.

After obtaining the fruits' extracts and making honey simple syrup, the researchers proceeded to measure all formulations. First formulation was conducted followed by the second and the last. Those three (3) formulations were carbonated using soda machine with gas bomb. Put all the ingredients of specific formulation in the machine. Tightened the cap of the bottle and put in the air/gas bomb, afterwards covered the starter and rotated to start the carbonation, the researchers had shaken the bottle machine gently up and down three times, then opened the bottle cap and poured the carbonated drink in the glass or bottle. After opening the bottle, the fizz occured.

To determined the differences among the three (3) formulations, the 10 trained panelist evaluated the overall sensory attributes of the samples. The nine-point hedonic scale survey questionnaire was employed to 50 untrained respondents currently residing at Maduya, Carmona, Cavite to obtained and identified the significant consumer preferences and acceptability. Moreover, the researchers determineed the food component of Chayote Carbonated Drink in terms of pH test and nutritional benefits.

Production Process

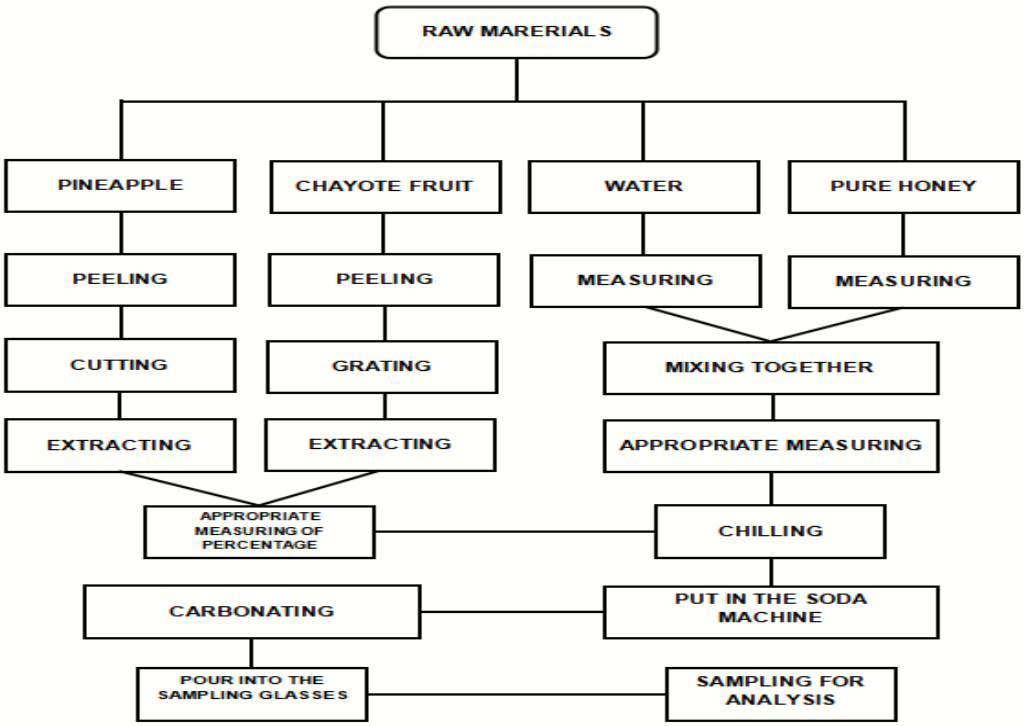

Figure 2. Process flow of Chayote Carbonated Drink

Methods of Evaluation

This study conducted sensory evaluation among the three (3) distinct formulations of Chayote Carbonated Drink to determined the most preferred formulation of the ten (10) trained panelists. The researchers used nine-point hedonic scale with descriptive test to identify the product acceptability. To differentiate the means among the three groups in terms of sensory evaluation and product acceptability, a statistical method referred to as analysis of variance (ANOVA) was employed. The evaluation of the chosen sample encompassed the judgement in these aspects: appearance (color and fizziness), odor (aroma), mouthfeel, flavor, taste, aftertaste, overall quality, and general acceptability. To ensure that the assessment answered without bias, the researchers used variant codes (numbers) to name the specific formula.

Consumer Acceptability

The chosen formulation was thoroughly evaluated with fifty (50) samples by fifty (50) untrained random residency of Maduya, Carmona, Cavite. The evaluation was assessed using nine-point hedonic scale survey questionnaire, it helped the researchers determined the most acceptable sensory preferences of the respondents in terms of appearance, aroma, flavor, taste, and overall quality. The serving size of the Chayote Carbonated Drink was 50 mL per glass.

PH Test

The researchers conducted the pH test using pH meter to assessed how acidic or alkaline the product is. Food's acidity or alkalinity is reflected in its pH, which affects safety, flavor, and texture. Food safety depends on pH because it inhibits dangerous microbes. To ensure safe

food preservation, it is essential to comprehend the distinction between foods that are acidified and those that are not.

Nutritional Value

The researchers prepared a sample of best formulation and submitted it to a licensed nutritionist and let them compute and evaluated the nutritional benefits of the product. And the result was the basis of the theoretical nutritional value of the product.

RESULTS AND DISCUSSION

Statement of the Problem 1

Appropriate Percentage Per Ingredients;

The researchers developed a carbonated drink made from fresh chayote extract and pineapple extract. The control sample is sparkling pinepple lemonade. Recipe from Trois Fois Par Jour website. It includes pineapple, sparkling water, and honey. The researchers made three (3) formulations with same ingredients but with distinct percentage of proposed ingredients. All of the formulations contains 300 mL of water and 40 mL of honey simple syrup. The first formulation contained 75% of chayote extract and 25% of pineapple extract. While the second formulation both of the ingredients contained 50%. For the third formulation, it contained 25% of chayote extract and 75% of pineapple extract.

Table 5. ***Appropriate percentage per ingredients.***

	CHAYOTE	PINEAPPLE
Variable 1	**75%**	**25%**
Variable 2	**25%**	**75%**
Variable 3	**50%**	**50%**

These formulations showed differences in sensory attributes. The researchers received a feedback of; formulation 1 is too tangy, formulation 2 is a balance of sweet and tangy, and the formulation 3 is the sweetest among the formulas.

Technology Support;

The methods for the three formulations were identical. When preparing the raw ingredients, the researchers took great care to select fresh and high-quality pineapple and chayote fruit. By creating honey simple syrup, the researchers used a 1:1 ratio of pure honey and purified water. Mixed it until both substance are totally blended. Using a peeler, the researcher removed the skin of chayote fruit. By using a knife, remove the seeds of chayote fruit. After that, manually extract the liquid substance of the chayote fruit by grating it and pressing it through a sieve. Then transfer the extracted content into another bowl and set aside. Using a sharp knife, carefully cut off the pineapple's leaves and skin. Next, the researchers sliced the pineapple into small pieces and by the help of a hand squeezer manually extracted the juice from the whole pineapple. Then transferred the pineapple juice into another bowl and set aside. However, using an electric juicer makes these process more easier and faster.

After obtaining all the fruit extraction, it must be chilled before carbonating. Prepare all the measurement then proceed to carbonate each formulations. Put all the liquid substance (water, chayote extract, pineapple juice, and honey simple syrup) of specific formulation into soda

machine. Tightened the cap of the soda machine and then insert the gas/air bomb into the starter. Rotate the starter to carbonate the drink, afterwards gently shake it up and down three (3) times and rest it for thirty seconds before opening the bottle to prevent fizz explosion. For bottling, pour the drink into 250 ml recyclable bottle. Tightened the cap and attached the sticker with logo and label, chilled it afterwards.

The development of chayote carbonated drink underwent numerous challenges by experimenting which control recipe was suitable to chayote fruit. It involved many trials and errors before achieving the best formulations and recipe. Throughout the development process of chayote carbonated drink, the researchers remain committed to the objective of this research which to introduced the best alternative for sugary soft drinks that was demanded by many consumers. It is a new flavor of carbonated drink that distinguished itself from others by both exceptional taste and its nutritional benefits.

Regulations

Codex Stan (Codex Alimentarius) plays a crucial role in ensuring global food safety and public health by establishing internationally recognized standards and guidelines for food production and quality. These standards provide a foundation for governments, industries, and researchers to ensure that food products are safe, nutritious, and suitable for human consumption. In this context, adherence to Codex Stan is essential for producing beverages, such as carbonated drinks, that meet the necessary safety, quality, and health requirements. By following these standards, food producers and researchers can contribute to the protection of public health, ensuring that ingredients and production processes are both safe and effective for consumers worldwide.

Table 6. ***Quality Assurance***

CODEX STAN 192-1995	**ACTUAL**
The carbonated beverages shall be prepared from drinking water, carbon dioxide.	All formulations were prepared from drinking water. The researchers utilized gas bomb to produce carbon dioxide.
All ingredients used in the preparation of carbonated beverages shall be clean, pure and fit for human consumption.	The researchers used fresh and high quality chayote, pineapple, honey, and water to guarantee cleanliness, safety, and suitability for human digestion.

Financial

The following tables were the financial costing of each formulations:

Table 7. ***Cost of direct materials of formulation 1***

INGREDIENTS	**BRAND**	**USED PORTION**	**COST AS PURCHASED**
Chayote fruit		350 ml	70
Pineapple fruit		150 ml	70
Pure Honey	Honeybee	40 ml	9.07
Water		300 ml	5.25
		TOTAL	**154.32**

Yield: 3 Bottles (280 ml each)

Price per yield: 51.44

Table 8. *Cost of direct materials of Formulation 2*

INGREDIENTS	BRAND	USED PORTION	COST AS PURCHASED
Chayote fruit	-	150 ml	30
Pineapple fruit	-	350 ml	140
Pure Honey	Honeybee	40 ml	9.07
Water		300 ml	5.25
		TOTAL	**184.32**

Total Yield**:** 3 Bottles (280 ml each)

Price per yield: Php 61.44

Table 9. *Cost of direct materials of Formulation 3*

INGREDIENTS	BRAND	USED PORTION	COST AS PURCHASED
Chayote fruit	-	250 ml	45
Pineapple fruit	-	250 ml	120
Pure honey	Honeybee	40 ml	9.07
Water		300 ml	5.25
		TOTAL	**179.32**

Total Yield: 3 Bottles (280 ml each)

Price per yield**:** 59.77

Statement of the Problem 2

Table 10. *Summary Results of Appearance - Color*

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	7.2	0.92	1.24	3.35	0.31	Accept H0
V2	10	7.7	1.16				
V3	10	8	1.33				

**alpha at 0.05*

Color. According to Sylvia (2016) the color of chayote fruit is yellowish or pale green. While according to NatashasKitchen.com the color of pineapple is yellow with a touch of green. The V1 had a score of (M=7.2, SD=0.92), while the V2 had a score of (M=7.7, SD=1.16), and the V3 had it results of (M=8, SD=1.33). The analysis of variance showed that there is no statistically significant differences between means of Appearance - Color with F=1.24 < df=3.35 and P=0.31 > 0.05. Hence the null hypothesis was accepted.

Table 11. ***Summary Results of Appearance - Bubbles***

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	6.6	1.65	0.15	3.35	0.86	Accept H0
V2	10	6.8	2.10				
V3	10	7.1	2.33				

**alpha at 0.05*

Bubbles. According to Choi (2022) the bubbles of carbon dioxide, or CO2, are what give soda its fizz. This colorless, odorless gas is added to carbonated beverages at high pressures throughout the manufacturing process until the gas and liquid are supersaturated. The V1 had a score of (M=6.6, SD=1.65), while the V2 had a score of (M=6.8, SD=2.10), and the V3 had it results of (M=7.1, SD=2.33). The analysis of variance showed that there is no statistically significant differences between means of Appearance - Bubbles with F=0.15 < df=3.35 and P=0.86 > 0.05. Hence the null hypothesis was accepted.

Table 12. ***Summary Results of Aroma***

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	6.7	2.21	0.91	3.35	0.41	Accept H0
V2	10	7.2	1.23				
V3	10	7.7	1.34				

*alpha at 0.05

Aroma. According to Weber (2021) chayote brings fresh and herbaceous scent to both savory and sweet dishes. On the other hand according to Scentopia-Singapore, pineapple's aroma is a combination of sweet and tangy notes. The V1 had a score of (M=6.7, SD=2.21), while the V2 had a score of (M=7.2, SD=1.23), and the V3 had it results of (M=7.7, SD=1.34). The analysis of variance showed that there is no statistically significant differences between means of Aroma with F=0.91 < df=3.35 and P=0.41 > 0.05. Hence the null hypothesis was accepted.

Table 13. *Summary Results of Mouthfeel*

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	7.1	1.85	1.71	3.35	0.20	Accept H0
V2	10	7.5	1.18				
V3	10	8.2	0.79				

*alpha at 0.05

Mouthfeel. According to Simons et al. (2019) the mouthfeel of carbonation drink refers to heat, burning, cooling, tingling, and numbling. It contributes to the enjoyment of drinking carbonated drinks. The V1 had a score of (M=7.1, SD=1.85), while the V2 had a score of (M=7.5, SD=1.18), and the V3 had it results of (M=8.2, SD=0.79). The analysis of variance

showed that there is no statistically significant differences between means of Mouthfeel with F=1.71 < df=3.35 and P=0.20 > 0.05. Hence the null hypothesis was accepted.

Table 14. ***Summary Results of Flavor***

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	6.4	1.96	1.21	3.35	0.31	Accept H0
V2	10	7	2.05				
V3	10	7.7	1.57				

*alpha at 0.05

Flavor. According to Zhu & YU (2020) pineapple flavors are fruity, winy, vanilla-like, vegetal, beany, sweet, and acidic tones. On the other hand the flavor of chayote fruit according to FoodPrint (2024) is a mild flavor that strikes a balance between apple and cucumber with a fresh crispiness reminiscent to jicama. The V1 had a score of (M=6.4, SD=1.96), while the V2 had a score of (M=7, SD=2.05), and the V3 had it results of (M=7.7, SD=1.57). The analysis of variance showed that there is no statistically significant differences between means of Flavor with F=1.21 < df=3.35 and P=0.31 > 0.05. Hence the null hypothesis was accepted.

Table 15. *Summary Results of Taste*

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	6.9	1.52	2.05	3.35	0.15	Accept H0
V2	10	7.2	1.62				
V3	10	8.1	0.88				

*alpha at 0.05

Taste. According to Neyssa (2019) chayote has a mild taste. On the other hand according to Natashas Kitchen, pineapple tastes like sweet and tangy with a hint of tropical flair. The V1 had a score of (M=6.9, SD=1.52), while the V2 had a score of (M=7.2, SD=1.62), and the V3 had it results of (M=8.1, SD=0.88). The analysis of variance showed that there is no statistically significant differences between means of Taste with F=2.05 < df=3.35 and P=0.15 > 0.05. Hence the null hypothesis was accepted.

Table 16. ***Summary Results of Aftertaste***

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	7.2	1.55	1.16	3.35	0.33	Accept H0
V2	10	7.1	1.20				
V3	10	8	1.56				

*alpha at 0.05

Aftertaste. According to Sherly (2024) after eating pineapple, you may experience an unpleasant or bitter aftertaste. Bromelain, an enzyme found in pineapple, is the cause of it. It breaks down proteins in your mouth. While according to Gray (2024) chayote is mildly flavored, clean, and refreshing fruit. The V1 had a score of (M=7.2, SD=1.55), while the V2 had a score of (M=7.1, SD=1.20), and the V3 had it results of (M=8, SD=1.56). The analysis of variance showed that there is no statistically significant differences between means of Aftertaste with F=1.16 < df=3.35 and P=0.33 > 0.05. Hence the null hypothesis was accepted.

Table 17. ***Summary Results of Most Preferred Formulation***

Formulation	n - No of Samples	Mean Scores (M)	Standard Deviation (SD)	F-Test	Critical Values	*P-Value	Decision
V1	10	7	1.49	2.71	3.35	0.08	Accept H0
V2	10	7.3	1.34				
V3	10	8.3	1.06				

*alpha at 0.05

Most Preferred Formulation. According to Barker et al. (2021) customers enjoy the burning or prickling sensation that carbonated beverages cause in their mouths, which contributes to the large global market for carbonated drinks. Also research has shown that despite being seen as an oral irritation, consumers find the carbonation feeling to be enjoyable and desirable. The V1 had a score of (M=7, SD=1.49), while the V2 had a score of (M=7.3, SD=1.34), and the V3 had it results of (M=8.3, SD=1.06). The analysis of variance showed that the score of variable 3 which interpreted as like very much is the best and most preferred formulation among others and it will be used in conducting nutritionist, pH test, and consumer acceptability.

Statement of the Problem 3

Table 18. ***Summary Results of*** **Consumer Acceptability**

Parameters	Mean Score	Interpretation
Appearance	8.38	Like very much
Aroma	8.5	Like very much
Flavor	8.54	Like very much
Taste	8.48	Like very much
Overall Acceptability	8.56	Like very much

Appearance. A visually appealing product can draw attention and create a positive first impression, increasing its likelihood of being chosen. The appearance of the Chayote Carbonated Drink received a high mean score of 8.38, indicating that the consumers very much like its visual appeal. The drink likely presents an attractive color, clarity, and carbonation level, which appeals to the customers' aesthetic preferences. A score of 8.38 suggests that the product's visual characteristics, such as color, clarity, and presentation, are highly satisfactory and positively contribute to the overall consumer experience.

Aroma. The aroma of a product plays a vital role in shaping consumer experience and acceptance. The aroma of the Chayote Carbonated Drink received an excellent score of 8.5,

demonstrating a strong preference among consumers for its scent. The fragrance likely presents a fresh and pleasant characteristic that enhances the drinking experience. With a mean score of 8.5, the drink's aroma was well-received, indicating that it has a pleasant and appealing scent that likely complements its flavor and adds to the overall enjoyment of the product.

Flavor. A product with a well-balanced and pleasant flavor profile is more likely to be accepted and appreciated by consumers. The flavor of the Chayote Carbonated Drink earned the highest score of 8.54, signifying that consumers greatly enjoy its taste. The drink likely offers a refreshing and distinctive flavor that appeals to a wide audience. A score of 8.54 reflects a very favorable response to the flavor, indicating that the drink's taste is well-balanced, enjoyable, and aligns with consumer preferences for a unique yet refreshing carbonated beverage.

Taste. The taste is one of the most significant factors influencing consumer preference The taste of the Chayote Carbonated Drink scored 8.48, indicating that it is highly liked by consumers. The combination of carbonation and the natural taste of chayote likely provides a satisfying and enjoyable drinking experience. The score of 8.48 suggests that the drink's taste is well-rounded and appealing, with the carbonated texture complementing the flavor profile of the chayote, making it refreshing and enjoyable for the consumers.

Overall Acceptability. Overall acceptability reflects the overall satisfaction consumers have with the product, taking into account all sensory aspects, from appearance to taste. Overall, the Chayote Carbonated Drink received a mean score of 8.56, the highest among all parameters, reflecting strong consumer acceptance and overall satisfaction with the product. The overall acceptability score of 8.56 indicates that the product is well-received in all aspects, from appearance to flavor, contributing to its high consumer approval. This score suggests the drink meets or exceeds expectations, making it a popular choice among consumers.

Statement of the Problem 4

4.1 pH Test

Table 19. *Result of the pH Test*

ATTEMPT	TEMPERATURE	PH RESULT
1st Reading	82.1 F	4.05
2nd Reading	82.2 F	4.08
3rd Reading	82.2 F	4.07
AVERAGE		**4.06**

Strict adherence to pH standards is essential for ensuring safety and quality in food production and necessary for regulatory compliance. Foods with a pH of 4.6 or below are considered high-acid foods. However, foods with a pH higher than 4.6, known as low-acid foods, are dangerous because they can encourage the growth of dangerous bacteria like Clostridium botulinum. The FDA specifies particular pH values for several food categories. To adhere to food safety regulations and avoid foodborne illnesses, the pH of both acidified and low-acid food needs to be monitored and managed (Rachael, 2024).

The pH test results for the Chayote Carbonated Drink show an average pH of 4.06, which falls within the range of acidic foods. Foods with a pH below 4.6 are classified as high-acid foods, and the Chayote Carbonated Drink meets this criterion. A pH of 4.06 indicates that the product is sufficiently acidic, which helps prevent the growth of harmful bacteria. Generally, foods with a pH level above 4.6 can allow dangerous bacteria, like Clostridium botulinum, to grow. Since the Chayote Carbonated Drink has a pH well below 4.6, it is considered safe in terms of

microbial stability and less likely to support the growth of such harmful bacteria. This pH level is also important for ensuring that the Chayote Carbonated Drink remains stable during storage and throughout its shelf life. Additionally, the drink's acidic nature helps to preserve its flavor profile and provides the refreshing, crisp taste associated with carbonated beverages. Strict adherence to pH standards, as indicated by the FDA for food safety and regulatory compliance, is critical in maintaining the product's safety and ensuring consumer health. The results suggested that the Chayote Carbonated Drink meets the necessary safety standards for a high-acid beverage.

Nutritional Benefits

Conducting nutritional testing is essential to provide consumers with accurate information about the health benefits of a product and to ensure it meets dietary standards. For the Chayote Carbonated Drink, this testing helps to highlight the nutritional value of the product, guiding consumers in making informed choices. Three different formulations were developed, and after sensory evaluations with 10 panelists, the most preferred formulation was selected. This formulation, which includes water, pineapple extract, simple honey syrup, and chayote extract. The 280 ml serving size for the Chayote Carbonated Drink was selected to align with standard beverage serving recommendations and consumer expectations, was then submitted to a licensed nutritionist for an in-depth analysis of its nutritional facts.

The nutritional analysis of Chayote Carbonated Drink revealed key macronutrients, vitamins, and minerals. Additonally, the result provided general benefits and also highlighted contradiction. Given its rich nutritional profile, the Chayote Carbonated Drink is an excellent beverage option for adolescents, young adult girls, and lactating mothers, as it supports their nutritional needs, including iron and folate intake. However, it may not be suitable for individuals with diabetes or those following a low-sugar diet due to the presence of honey syrup. Additionally, people with allergies to pineapple or chayote should avoid the product. Overall, the nutritional testing confirms that the Chayote Carbonated Drink provides a healthy and refreshing beverage option, while also emphasizing the need for individuals with specific dietary concerns to be mindful of its ingredients.

ESTIMATED ENERGY AND NUTRIENT CONTENT

FOOD ITEM	MACRONUTRIENTS									
	Energy (kcal)	CHO (g)	Fiber (g)	Sugars (g)	Protein (g)	Fat (g)	SFA (g)	MUFA (g)	PUFA (g)	Chol (mg)
Chayote fruit	17.97	3.98	0.47	1.95	0.39	0.08	0.02	0.01	0.03	0.00
Pinapple, extract, juice	41.41	10.05	0.16	7.80	0.28	0.09	0.01	0.01	0.03	0.00
Honey	32.25	8.01	0.03	7.98	0.01	0.01	0.00	0.00	0.00	0.00
TOTAL	91.63	22.05	0.65	17.73	0.68	0.18	0.02	0.02	0.06	0.00

MINERALS								VITAMINS			
Ca (mg)	P (mg)	Fe (mg)	Na (mg)	K (mg)	Zn (mg)	Cu (mg)	Mg (mg)	Vit A (ugRE)	Vit D (ug)	Vit E (ug)	Vit B1 (mg)
13.28	8.59	0.23	57.81	6.25	0.00	0.11	10.60	0.00	0.00	0.11	0.02
10.16	6.25	0.24	1.56	101.56	0.09	0.05	9.38	0.00	0.00	0.00	0.05
3.63	0.75	0.40	0.63	5.07	0.02	0.00	0.20	0.00	0.00	0.00	0.00
27.06	15.59	0.88	60.00	112.88	0.11	0.17	20.17	0.00	0.00	0.11	0.06

VITAMINS					
Vit B2 (mg)	Vit B3 (mg)	Vit B6 (mg)	Folate (ug)	Vit B12 (ug)	Vit C(mg)
0.02	0.31	0.07	82.17	0.00	2.34
0.02	0.16	0.08	14.06	0.00	34.22
0.00	0.00	0.00	0.20	0.00	0.00
0.03	0.47	0.15	96.43	0.00	36.56

Serving Size		1 bottle (280 mL)
No. of Servings Per Pack		1
Amount Per Serving		**%REI/RNI***
Calories (kcal)	91.6	3.6
Calories from Fat (kcal)	1.6	
Total fat (g)	0.18	
Saturated fat (g)	0.02	
Cholesterol (mg)	0	
Total Carbohydrates (g)	22.1	
Dietary Fiber (g)	0.7	3.3
Sugars (g)	17.7	
Protein (g)	0.7	1
Sodium (mg)	60	12
Iron (mg)	0.9	7.3
Magnesium (mg)	20.2	8.4
Vitamin B6 (mg)	0.2	11.4
Folate (mcg)	96.4	24.1
Ascorbic Acid (mg)	36.6	52.2
*Percent Recommended Energy Intake and Recommended Nutrient Intake are based on PDRI reference for adult male aged 19-29 years old		

NUTRITION FINDINGS

Benefits

- Contains good amounts of Iron, Magnesium, Vitamin B6, Folate and Ascorbic Acid
- Folate in one serving is of adequate amount. May be a great drink for adolescent and young adult girls, and for lactating mothers.

Contraindications

- Has very high sugar content. May not be advisable for people with elevated blood sugar levels.

Figure 3. Nutritional Value of Chayote Carbonate Drink

CONCLUSION

The researches successfully developed a new flavor of carbonated drink with three (3) distinct formulations made of chayote extract and pineapple juice. The researchers used various of fruits to find what best fit to the proposed product, chayote fruit. After many trials and errors, pineapple was selected for its flavor and color compatibility. Along with these two fruits, the researchers also utilized honey simple syrup to enhance the flavor of the carbonated beverage.

The researchers conducted sensory evaluation for appearance, aroma, mouthfeel, flavor, taste, and aftertaste. The formulation number three (3) received the highest score for most preferred variable by 10 trained panelists. This formulation contained 50% of chayote extract and 50% of pineapple extract that made the outcome balanced and suitable for consumers preference.

To assess consumer acceptability, the researchers conducted a test with fifty (50) untrained respondents, each sampling the product. The evaluation focused on appearance, aroma, flavor, and taste. The Chayote Carbonated Drink received an overall acceptability score of 8.56, indicating that the respondents "liked it very much." This score suggests that the drink meets or exceeds consumer preferences across all evaluated aspects, from appearance to taste.

This study also undergone pH test to ensure the food safety and quality of the drink. With the help of pH meter, Chayote Carbonated Drink have an pH average of 4.06. This indicated that Chayote Carbonated Drink is mildly acidic especially it contained citric acid from pineapple extract. This result indicated that this product is less prone to microbial contamination and helps retain its carbonation, contributing to the overall quality, stability, and taste of this

beverage. The researchers also passed the product to licensed nutritionist to evaluate the essential nutrients of chayote carbonated drink and supports consumer health. As a result, chayote carbonated drink is rich in Vitamin B6, Folate, and Ascorbic Acid. It is also a great drink for adolescent, young adult girls, and for lactating mothers. However, it is not advisable for people with elevated blood sugar levels due to high sugar content.

The results helped the researchers to attract segment of respondents who demanded beverage which aligned to their values and contribute to their overall health. This product also supported five (5) sustainable development goals; SDG 1, 2, 3, 12, and 13.

RECOMMENDATION

In order to determine how long consumers may keep this product, this study advises future researchers to evaluate the chayote carbonated drink's shelf life. Future researchers can also experiment the degree/level of mouthfeel and carbonation.

Chayote carbonated drink can expand its product line by creating more concentration or as a mixer for craft cocktails. Also, it is possible to add a touch of spices and herbal flavors to enhance its overall profile.

Future studies can use the leftover chayote from extraction to make crackers, pickles, fries, or patties in order to reduce the amount of food waste throughout the product's development. Additionally, leftover pineapple from extraction can be used to make jams.

It is recommended to remain using recyclable bottles to foster sustainable practices. Also sourcing locally can help chayote and pineapple farmers. It can also attract eco-friendly consumers.

The CODEX STAN and ASEAN standard methods for carbonated beverage can be further studied to guarantee the product's food quality and safety.

This study advises future researchers to utilize alternative sweeteners to reduce the sugar content such as non-sweet sugars, fruit-based sweeteners, and other low-calorie sweeteners. It can attract a large segment of health-conscious buyers.

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HIGH-PERFORMANCE OF TREATED CLAY FOR THE CONGO RED REMOVAL: ADSORPTION ISOTHERM AND KINETIC STUDY

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ABSTRACT

The release of organic pollutants such as dyes, constitutes a major challenge facing the world. These pollutants have a harmful effect on human health and the environment. In this context, the removal of dyes has attracted the attention of many researchers. Adsorption has proved to be a highly effective process for treating contaminated water. In fact, the effectiveness of removing pollutants depends on the properties of adsorbents. Numerous adsorbents, such as natural clay, have been used in the adsorption process. In order, to increase the application range of natural clay use, it is necessary to improve its physicochemical properties.

This study aims to examine the adsorption of anionic dye on the treated clay. The treated clay was characterized using XRD, FTIR, SEM-EDX, and pH_{pzc}. Batch adsorption experiments were carried out to determine the optimum conditions for the parameters: pH, adsorbent dose, contact time, and initial concentration.

Keywords: Clay, water pollution, adsorption, environmental science, adsorption isotherms.

SIN, SACRIFICE, SALVATION, AND THE HIDDEN CHRIST IN THE RIG VEDA: A COMPARATIVE EXPLORATION

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ABSTRACT

The Rig Veda, one of the oldest sacred texts, presents sacrifice (yajña) as an essential act maintaining cosmic order (ṛta) and uniting humanity with the divine. Rituals to Agni and Indra ensure abundance and spirituality, and the Purusha Sukta hymn details a cosmic sacrifice that resonates with similar motifs of divine self-offering. This central sacrificial principle of Vedic thought bears interesting parallels with later notions of Christ's sacrificial atonement principle in Christian tradition. Certain religious descriptions in the Vedas, such as of a "hidden" or "eternal" sacrifice and the enigmatic divine being (Purusha), are thought by some scholars to resemble certain forms of the messianic figure in biblical theology. Descriptions of Soma, the life-giving drink that imparts wisdom and transcendence, invite comparisons with Christian Eucharistic symbolism. This paper explores these theological intersections, examining how Vedic sacrifice foreshadows later understandings of salvation, both in Hindu and Christian thought.

Keywords: Rig Veda, yajña, Christ in Vedic scriptures, salvation, sacrifice, comparative theology

SOCIAL BOUNDARIES AS BORDERS: ADDRESSING POVERTY AND INEQUALITY

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Abstract

Borders are complex concepts that pertain to identity, politics, and society. They encompass various types, from physical and territorial boundaries to social, personal, and symbolic ones, particularly in international contexts. According to the US Census Bureau's 2013 American Community Survey, approximately 24.8 percent of Hispanics or Latinos in the United States live in poverty. This figure may be higher due to underreporting among undocumented individuals in this demographic. Comparatively, about 27.6 percent of Black Americans are reported to live in poverty, while only 11.1 percent of non-Hispanic whites are in the same situation. This data highlights the disproportionate likelihood of people of colour living in poverty in the United States. Undocumented Latino immigrants and other non-citizen groups face a significant barrier that is both literal and symbolic: the geographical border that delineates US territory. The enforcement of this border denies them legal status in the country, restricting their ability to physically enter, participate in civic activities, and access economic resources. This situation perpetuates cycles of poverty and adverse social outcomes within already disadvantaged immigrant communities. This paper explores the urgent societal impact of social boundaries as a form of border in US society across various classifications. It aims to address these societal issues. The methodology employed includes documentary analysis and a qualitative approach. The primary research question is: "How can social boundaries create conflicts within the social order, and how can these issues be mitigated?"

Keywords: Social Boundaries, Poverty, Inequality, Immigration, Cross-cultural Communication

ANALYSIS OF A REFORMULATED BLOCK HYBRID LINEAR MULTISTEP METHOD INTO RUNGE –KUTTA TYPE METHOD FOR FIRST ORDER INITIAL VALUE PROBLEM (IVP)

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Abstract

Problems arises from science and technology are expressed in differential equations. These differential equation are sometimes in ordinary differential equations. Reliability with high accuracy and stability are necessary for a numerical method for the solution of differential equations. This research paper presents the analysis of a reformulated block hybrid linear multistep method into Runge-Kutta type method (RKTM) for first order initial value problems (IVPs). In view of this, the block hybrid method derived is of uniform order 6 with error constants of $-\frac{263}{1935360}$, $-\frac{11}{120960}$, $-\frac{9}{71680}$, $-\frac{1}{15120}$ and $-\frac{9}{4480}$ while the Runge-Kutta type method reformulated maintain the order of the derived block hybrid linear multistep method which are of uniform order 6 but with error constants of $-\frac{263}{4232632320}$, $-\frac{11}{264539520}$, $-\frac{1}{17418240}, -\frac{1}{33067440}$ and $-\frac{1}{1088640}$. Testing for convergence of both the derived block hybrid linear multistep method and the Runge-Kutta type method shows that the two methods are consistent and are also zero stable.

Keywords: Block hybrid, Convergency, Linear multistep method, Order and error constants, Runge-Kutta type method.

Introduction

Science and engineering modelled their dynamics system in form of differential equations which require numerical methods for their effective solution (Rice *et al.,* 2023). Traditional explicit and implicit numerical approaches such as Runge-Kutta and linear multistep methods fail to simultaneously achieve accuracy and stability while keeping low computational costs especially for stiff differential equations (Parveen,and Ahmad, 2024).. Block hybrid linear multistep methods has being adopted to address these challenges but the method still have limitations in solving complex problems (Areo *et el.*,2024).

Classical fourth order Runge Kutta type method is of the form:

$$y_{n+1} = y_n + \frac{h}{6}\left(k_1 + 2k_2 + 2k_3 + k_4\right)$$

where:

$$k_1 = f\left(x_n, y_n\right)$$

$$k_2 = f\left(x_n + \frac{h}{2}, y_n + \frac{h}{2}k_1\right)$$

$$k_3 = f\left(x_n + \frac{h}{2}, y_n + \frac{h}{2}k_2\right)$$

$$k_4 = f\left(x_n + h, y_n + hk_3\right)$$

The general representation of linear multistep method have the form:

$$\sum_{j=0}^{k} \alpha_j y_{n+j} = h\sum_{j=0}^{k} \beta_j f_{n+j}$$

where:

y_{n+j} are the approximate solutions,

$f_{n+j} = f(x_{n+j}, y_{n+j})$,

h is the step size,

$\alpha_j \ and \ \beta_j$ are the method's coefficient

k is the step number which determine how many previous steps are used.

While the block hybrid linear multistep method has the general form:

$$Y = BY + hCF$$

where:

Y is the vector of function values at both step and off step points

B is the coefficient matrix for dependent variables

C is the coefficient matrix for function evaluations

F is the vector of function evaluation f(x, y).

However, conversion of block hybrid linear multistep methods into Runge-Kutta type method (RKTM) will address these challenges (Aliyu *et al.*, 2025).

The field of numerical methods requires an enhanced method which delivers high-order accuracy along with stability preserving capabilities (Sharma *et al.*, 2020). The main challenge involves in developing a scheme is uniform accuracy, minimal error constants, computational efficiency and faster convergence (Sharma *et al.*, 2020). A RKTM transformed from block hybrid linear multistep method will address these challenges through improved error constant, convergence rate and computational efficiency (Muhammad, 2020).

This research adds value to numerical analysis because it develops a new solution technique for first-order IVPs. This research investigates the reformulated method through extensive analysis and improvement to establish it as useful practical instrument applied in engineering practice and applied sciences. The research addresses only first-order IVPs by explaining the derivation process while conducting order assessments and stability examination. The

proposed approach should be expanded to solve higher-order problems and complex differential equations in future research.

METHODOLOGY

Derivation of the Method

The derivation of six – stage Runge – Kutta type method reformulated from three step block hybrid linear multistep method with two off-grids points is discussed in this section. First order three step block hybrid linear multistep method (TSBHLMM) with two off-grids point has been reformulated to first order Runge - Kutta Type method.

The general form of first order initial value problem (IVP) in ordinary differential equations (ODEs) is given as:

$$y'(t) = f(t, y), y(t_0) = y_0 \tag{4}$$

We use power series as the basis function given in the form:

$$y(t) = \sum_{i=0}^{n} \varphi_i t^i \tag{5}$$

Differentiating (3) we obtained:

$$y^1(t) = \sum_{i=0}^{n} i\varphi_i t^{i-1} \tag{6}$$

Using matrix inversion techniques to find the values of $\varphi_i's$ we obtain a continuous implicit scheme of the form:

$$y(t) = \alpha_0(t) y_n + h\left(\sum_{i=0}^{1} \beta_{n+\frac{2i+1}{2}} f_{n+\frac{2i+1}{2}} + \sum_{i=0}^{3} \beta_i f_{n+i} \right) \tag{7}$$

Interpolating (3) at $t = \{t_n\}$ and collocating (4) at $t = \left\{t_n, t_{n+\frac{1}{2}}, t_{n+1}, t_{n+\frac{3}{2}}, t_{n+2}, t_{n+3}\right\}$.

Which can be expressed in matrix form:

$$\begin{bmatrix} 1 & t_n & t_n^2 & t_n^3 & t_n^4 & t_n^5 & t_n^6 & t_n^7 \\ 0 & 1 & 2t_n & 3t_n^2 & 4t_n^3 & 5t_n^4 & 6t_n^5 & 7t_n^6 \\ 0 & 1 & 2t_{n+\frac{1}{2}} & 3\left(t_{n+\frac{1}{2}}\right)^2 & 4\left(t_{n+\frac{1}{2}}\right)^3 & 5\left(t_{n+\frac{1}{2}}\right)^4 & 6\left(t_{n+\frac{1}{2}}\right)^5 & 7\left(t_{n+\frac{1}{2}}\right)^6 \\ 0 & 1 & 2t_{n+1} & 3(t_{n+1})^2 & 4(t_{n+1})^3 & 5(t_{n+1})^4 & 6(t_{n+1})^5 & 7(t_{n+1})^6 \\ 0 & 1 & 2t_{n+\frac{3}{2}} & 3\left(t_{n+\frac{3}{2}}\right)^2 & 4\left(t_{n+\frac{3}{2}}\right)^3 & 5\left(t_{n+\frac{3}{2}}\right)^4 & 6\left(t_{n+\frac{3}{2}}\right)^5 & 7\left(t_{n+\frac{3}{2}}\right)^6 \\ 0 & 1 & 2t_{n+2} & 3(t_{n+2})^2 & 4(t_{n+2})^3 & 5(t_{n+2})^4 & 6(t_{n+2})^5 & 7(t_{n+2})^6 \\ 0 & 1 & 2t_{n+3} & 3(t_{n+3})^2 & 4(t_{n+3})^3 & 5(t_{n+3})^4 & 6(t_{n+3})^5 & 7(t_{n+3})^6 \end{bmatrix} \begin{bmatrix} \lambda_0 \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix} = \begin{bmatrix} y_n \\ hf_n \\ hf_{n+\frac{1}{2}} \\ hf_{n+1} \\ hf_{n+\frac{3}{2}} \\ hf_{n+2} \\ hf_{n+3} \end{bmatrix} \tag{8}$$

Making Use of Maple Mathematical software to obtain the values of $\lambda's$ in (8) that result in the continuous formula:

$$y(t) = \alpha_0 y_n + h\left[\beta_n f_n + \beta_{n+\frac{1}{2}} f_{n+\frac{1}{2}} + \beta_{n+1} f_{n+1} + \beta_{n+\frac{3}{2}} f_{n+\frac{3}{2}} + \beta_{n+2} f_{n+2} + \beta_{n+3} f_{n+3}\right] \quad (9)$$

Taking $t_1 = \frac{t - t_{n+2}}{h} \Rightarrow \frac{dt_1}{dt} = \frac{1}{h}$

(10)

We evaluate (7) at $t = t_{n+i}, \mathrm{i} = \frac{1}{2}, 1, \frac{3}{2}, 2 and 3$, we obtain a block hybrid linear multistep method as

$$\begin{bmatrix} y_{n+\frac{1}{2}} \\ y_{n+1} \\ y_{n+\frac{3}{2}} \\ y_{n+2} \\ y_{n+3} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} y_n \end{bmatrix} + h \begin{bmatrix} \frac{959}{5760} & \frac{35}{72} & -\frac{487}{1920} & \frac{49}{360} & -\frac{211}{5760} & \frac{1}{640} \\ \frac{169}{1080} & \frac{32}{45} & \frac{11}{120} & \frac{8}{135} & -\frac{7}{360} & \frac{1}{1080} \\ \frac{103}{640} & \frac{27}{40} & \frac{243}{640} & \frac{13}{40} & -\frac{27}{640} & \frac{1}{640} \\ \frac{7}{45} & \frac{32}{45} & \frac{4}{15} & \frac{32}{45} & \frac{7}{55} & 0 \\ \frac{11}{40} & 0 & \frac{81}{40} & -\frac{8}{5} & \frac{81}{40} & \frac{11}{40} \end{bmatrix} \begin{bmatrix} f_n \\ f_{n+\frac{1}{2}} \\ f_{n+1} \\ f_{n+\frac{3}{2}} \\ f_{n+2} \\ f_{n+3} \end{bmatrix} \quad (11)$$

Reformulation of Block Hybrid Linear Multistep Method (BHLMM) into Runge – Kutta Type Method (RKTM)

Proposed RKTM for first order differential equation

Aliyu *et al.*, (2025) defined an s-stage implicit Runge - Kutta methods for fist order ODEs in the form:

$$\left.\begin{aligned} y_{n+1} &= y_n + h\sum_{i=0}^{s} a_{ij} k_i \\ k_i &= f\left(x_i + \alpha_i h, y_n + h\sum_{i=0}^{s} a_{ij} k_i\right) \\ where i &= 1, 2, 3, \ldots, n \end{aligned}\right\} \quad (12)$$

The parameters α_j, k_j and a_{ij} defined the method. In Butcher array form, it can be written as

α	β
	W^T

(13)

Presenting (11) in the Butcher table we have

C	A						
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
$\frac{1}{2}$	$\frac{959}{5760}$	$\frac{35}{72}$	$-\frac{487}{1920}$	$\frac{49}{360}$	$-\frac{211}{5760}$	$\frac{1}{640}$	
1	$\frac{169}{1080}$	$\frac{32}{45}$	$\frac{11}{120}$	$\frac{8}{135}$	$-\frac{7}{360}$	$\frac{1}{1080}$	
$\frac{3}{2}$	$\frac{103}{640}$	$\frac{27}{40}$	$\frac{243}{640}$	$\frac{13}{40}$	$-\frac{27}{640}$	$\frac{1}{640}$	
2	$\frac{7}{45}$	$\frac{32}{45}$	$\frac{4}{15}$	$\frac{32}{45}$	$\frac{7}{55}$	0	
3	$\frac{11}{40}$	0	$\frac{81}{40}$	$-\frac{8}{5}$	$\frac{81}{40}$	$\frac{11}{40}$	
b=3	$\frac{11}{40}$	**0**	$\frac{81}{40}$	$-\frac{8}{5}$	$\frac{81}{40}$	$\frac{11}{40}$	

The Butcher array conditions for first order differential equation is stated as:

$$\left.\begin{aligned}&(\mathrm{i}).\sum_{j=1}^{s} a_{ij} = c_i \\ &(ii).\sum_{j=1}^{s} b_j = 1\end{aligned}\right\} \qquad (14)$$

Source:(Muhammad, 2020)

Since the butcher table (13) does not satisfied the conditions hence it was modified to satisfied the conditions (14).

Therefore six-stage implicit Ruge-Kutta type method is obtained as

$$\left.\begin{aligned}&y_{n+1} = y_n + h\left(\frac{11}{120}k_1 + \frac{27}{40}k_3 - \frac{8}{15}k_4 + \frac{27}{40}k_5 + \frac{11}{120}k_6\right)\\ &\textit{where}\\ &k_1 = f(x_n, y_n)\\ &k_2 = f\left(x_n + \frac{h}{6}, y_n + h\left(\frac{959}{17280}k_1 + \frac{35}{216}k_2 - \frac{487}{5760}k_3 + \frac{49}{1080}k_4 - \frac{211}{17280}k_5 + \frac{1}{1920}k_6\right)\right)\end{aligned}\right\} ($$

$$k_3 = f\left(x_n + \frac{h}{3}, y_n + h\left(\frac{169}{3240}k_1 + \frac{32}{135}k_2 + \frac{11}{360}k_3 + \frac{8}{405}k_4 - \frac{7}{1080}k_5 + \frac{1}{3240}k_6\right)\right)$$

$$k_4 = f\left(x_n + \frac{h}{2}, y_n + h\left(\frac{103}{1920}k_1 + \frac{9}{40}k_2 + \frac{81}{640}k_3 + \frac{13}{120}k_4 - \frac{9}{640}k_5 + \frac{1}{1920}k_6\right)\right)$$

$$k_5 = f\left(x_n + \frac{2h}{3}, y_n + h\left(\frac{7}{135}k_1 + \frac{32}{135}k_2 + \frac{4}{45}k_3 + \frac{32}{135}k_4 + \frac{7}{135}k_5\right)\right)$$

$$k_6 = f\left(x_n + h, y_n + h\left(\frac{11}{120}k_1 + 0k_2 + \frac{27}{40}k_3 - \frac{8}{15}k_4 + \frac{27}{40}k_5 + \frac{11}{120}k_6\right)\right)$$

RESULT AND DISCUSSION

Order and Error Constant of the TSBHLMM

We analyze the approximation of the order and error constant of the derived block method using the difference equation:

$$L[y(t),h]=\sum_{i=0}^{k}\left[\alpha_i y\left(t+ih\right)-h\beta y'\left(t+ih\right)\right]$$

(16)

We assume $y(t)$ to have as many higher derivatives we require, expanding the terms in (16) as a Taylor series about the point t we obtain the expansion

$$\left.\begin{aligned} &L[y(t),h]=C_0 y(t)+C_1 h y^{(1)}(t)+\ldots+C_q h^q y^{(q)}(t)+\ldots \\ &\text{where} \\ &C_0=\alpha_0+\alpha_1+\ldots+\alpha_k \\ &C_1=(\alpha_1+\alpha_2+\ldots+k\alpha_k)-(\beta_0+\beta_1+\ldots.+k^{(q-1)}\beta_k \; where q=2,3,\ldots,k \end{aligned}\right\}$$

(17)

The order and error constant is obtained by applying (13) and (14) in (11)

Table 3.1: Order and Error Constants of the TSBHLMM

Scheme	Order	Error Constant
$y_{n+\frac{1}{2}}$	6	$-\frac{263}{1935360}$
y_{n+1}	6	$-\frac{11}{120960}$
$y_{n+\frac{3}{2}}$	6	$-\frac{9}{71680}$
y_{n+2}	6	$-\frac{1}{15120}$
y_{n+3}	6	$-\frac{9}{4480}$

Table 3.1 shows that the block method (11) is of uniform order 6 with the respective error constants as shown in the table.

Order and Error Constant of the RKTM

Using the idea of Muhammad, (2020), we choose $k_i=f_{c_i}$, which implies that $k_1=f_{c1},k_2=f_{c2},k_3=f_{c3},k_4=f_{c4},k_5=f_{c_5},andk_6=f_{c6}$

$$\Rightarrow c_1=0,c_2=\frac{1}{6},c_3=\frac{1}{3},c_4=\frac{1}{2},c_5=\frac{2}{3},c_6=1$$

$$k_1=f_0=f_n,k_2=f_{\frac{1}{6}}=f_{n+\frac{1}{6}},k_3=f_{\frac{1}{3}}=f_{n+\frac{1}{3}},k_4=f_{\frac{1}{2}}=f_{n+\frac{1}{2}},k_5=f_{\frac{2}{3}}=f_{n+\frac{2}{3}},andk_6=f_1=f_{n+1}$$

Hence (15) becomes

$$\left.\begin{aligned} y_{n+1} &= y_n + h\left(\frac{11}{120} f_n + \frac{27}{40} f_{n+\frac{1}{3}} + \frac{8}{15} f_{n+\frac{1}{2}} + \frac{27}{40} f_{n+\frac{2}{3}} + \frac{11}{120} f_{n+1}\right) \\ y_{n+\frac{2}{3}} &= y_n + h\left(\frac{7}{135} f_n + \frac{32}{135} f_{n+\frac{1}{6}} + \frac{4}{45} f_{n+\frac{1}{3}} + \frac{32}{135} f_{n+\frac{1}{2}} + \frac{7}{135} f_{n+\frac{2}{3}}\right) \end{aligned}\right\},$$

$$y_{n+\frac{1}{2}} = y_n + h\left(\frac{103}{1920} f_n + \frac{9}{40} f_{n+\frac{1}{6}} + \frac{81}{640} f_{n+\frac{1}{3}} + \frac{13}{120} f_{n+\frac{1}{2}} - \frac{9}{640} f_{n+\frac{2}{3}} + \frac{1}{1920} f_{n+1}\right)$$

$$y_{n+\frac{1}{3}} = y_n + h\left(\frac{169}{3240} f_n + \frac{32}{135} f_{n+\frac{1}{6}} + \frac{11}{360} f_{n+\frac{1}{3}} + \frac{8}{405} f_{n+\frac{1}{2}} - \frac{7}{1080} f_{n+\frac{2}{3}} + \frac{1}{3240} f_{n+1}\right)$$

$$y_{n+\frac{1}{6}} = y_n + h\left(\frac{959}{17280} f_n + \frac{35}{216} f_{n+\frac{1}{6}} - \frac{487}{5760} f_{n+\frac{1}{3}} + \frac{49}{1080} f_{n+\frac{1}{2}} - \frac{211}{17280} f_{n+\frac{2}{3}} + \frac{1}{1920} f_{n+1}\right)$$

Taylor series expansion of

$$y_{n+1} = y(n+h) = y(n) + hy'(n) + \frac{(h)^2}{2!} y''(n) + \frac{(h)^3}{3!} y'''(n) + \frac{(h)^4}{4!} y^{iv}(n) + \ldots + \frac{(h)^s}{s!} y^s(n)$$

$$y_{n+\frac{2}{3}} = y(n+\frac{2}{3}h) = y(n) + \frac{2}{3}hy'(n) + \frac{(\frac{2}{3}h)^2}{2!} y''(n) + \frac{(\frac{2}{3}h)^3}{3!} y'''(n) + \frac{(\frac{2}{3}h)^4}{4!} y^{iv}(n) + \ldots + \frac{(\frac{2}{3}h)^s}{s!} y^s(n)$$

$$y_{n+\frac{1}{2}} = y(n+\frac{1}{2}h) = y(n) + \frac{1}{2}hy'(n) + \frac{(\frac{1}{2}h)^2}{2!} y''(n) + \frac{(\frac{1}{2}h)^3}{3!} y'''(n) + \frac{(\frac{1}{2}h)^4}{4!} y^{iv}(n) + \ldots + \frac{(\frac{1}{2}h)^s}{s!} y^s(n)$$

$$y_{n+\frac{1}{3}} = y(n+\frac{1}{3}h) = y(n) + \frac{1}{3}hy'(n) + \frac{(\frac{1}{3}h)^2}{2!} y''(n) + \frac{(\frac{1}{3}h)^3}{3!} y'''(n) + \frac{(\frac{1}{3}h)^4}{4!} y^{iv}(n) + \ldots + \frac{(\frac{1}{3}h)^s}{s!} y^s(n)$$

$$y_{n+\frac{1}{6}} = y(n+\frac{1}{6}h) = y(n) + \frac{1}{6}hy'(n) + \frac{(\frac{1}{6}h)^2}{2!} y''(n) + \frac{(\frac{1}{6}h)^3}{3!} y'''(n) + \frac{(\frac{1}{6}h)^4}{4!} y^{iv}(n) + \ldots + \frac{(\frac{1}{6}h)^s}{s!} y^s(n)$$

$$f_1 = f(n+h) = y'(n) + hy''(n) + \frac{(h)^2}{2!} y'''(n) + \frac{(h)^3}{3!} y^{iv}(n) + \frac{(h)^4}{4!} y^{v}(n) + \ldots + \frac{(h)^{s-1}}{(s-1)!} y^{s-1}(n)$$

$$f_{\frac{2}{3}} = f(n+\frac{2}{3}h) = y'(n) + \frac{2}{3}hy''(n) + \frac{(\frac{2}{3}h)^2}{2!}y'''(n) + \frac{(\frac{2}{3}h)^4}{3!}y^{iv}(n) + \frac{(\frac{2}{3}h)^5}{4!}y^{v}(n) + \ldots + \frac{(\frac{2}{3}h)^{s-1}}{(s-1)!}y^{s-1}(n)$$

$$f_{\frac{1}{2}} = f(n+\frac{1}{2}h) = y'(n) + \frac{1}{2}hy''(n) + \frac{(\frac{1}{2}h)^2}{2!}y'''(n) + \frac{(\frac{1}{2}h)^4}{3!}y^{iv}(n) + \frac{(\frac{1}{2}h)^5}{4!}y^{v}(n) + \ldots + \frac{(\frac{1}{2}h)^{s-1}}{(s-1)!}y^{s-1}(n)$$

$$f_{\frac{1}{3}} = f(n+\frac{1}{3}h) = y'(n) + \frac{1}{3}hy''(n) + \frac{(\frac{1}{3}h)^2}{2!}y'''(n) + \frac{(\frac{1}{3}h)^3}{3!}y^{iv}(n) + \frac{(\frac{1}{3}h)^4}{4!}y^{v}(n) + \ldots + \frac{(\frac{1}{3}h)^{s-1}}{(s-1)!}y^{s-1}(n)$$

$$f_{\frac{1}{6}} = f(n+\frac{1}{6}h) = y'(n) + \frac{1}{6}hy''(n) + \frac{(\frac{1}{6}h)^2}{2!}y'''(n) + \frac{(\frac{1}{6}h)^3}{3!}y^{iv}(n) + \frac{(\frac{1}{6}h)^4}{4!}y^{v}(n) + \ldots + \frac{(\frac{1}{6}h)^{s-1}}{(s-1)!}y^{s}(n)$$

Applying (16) and (17) to the new reformulated BHLMM from the RKTM gives

Table 3.2: The Order and Error Constant for the Proposed RKTM

Scheme	Order	Error Constants
y_{n+1}	6	$-\frac{263}{4232632320}$
$y_{n+\frac{2}{3}}$	6	$-\frac{11}{264539520}$
$y_{n+\frac{1}{2}}$	6	$-\frac{1}{17418240}$
$y_{n+\frac{1}{3}}$	6	$-\frac{1}{33067440}$
$y_{n+\frac{1}{6}}$	6	$-\frac{1}{1088640}$

Table 3.2 shows that the uniform 6 from the block hybrid linear multistep method was maintained when it was reformulated back to Runge – Kutta type method. The respective error constants are shown in the table

Zero stability of the BHLMM and the RKTM

If (11) is written in the normalized block form we have

$$A_0 Y_s = A_1 Y_{s-3} + h(B_0 F_{s-3} + B_1 F_s) \quad (19)$$

Where s represent the block number

$$Y_s = \left(y_{n+\frac{1}{2}}, y_{n+1}, y_{n+\frac{3}{2}}, y_{n+2}, y_{n+3}\right)^T \quad (20)$$

$$Y_{s-3} = \left(y_{n-\frac{5}{2}}, y_{n-2}, y_{n-\frac{3}{2}}, y_{n-1}, y_n\right)^T \quad (21)$$

$$F_s = \left(f_{n+\frac{1}{2}}, f_{n+1}, f_{n+\frac{3}{2}}, f_{n+2}, f_{n+3}\right)^T \quad (22)$$

$$F_{s-3} = \left(f_{n-\frac{5}{2}}, f_{n-2}, f_{n-\frac{3}{2}}, f_{n-1}, y_n\right)^T \quad (23)$$

Also, A_0, A_1, B_0 *and* B_1 are matrices in which their entries are given by the coefficient of the block method (11) and reformulated (18).

The zero stability of equation (11) and (18) can be obtained as

$$\rho(\lambda) = \left|\lambda A^{(1)} - A^{(0)}\right| \quad (24)$$

where

$$A^{(0)} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad A^{(1)} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\rho(\lambda) = \lambda^5(\lambda - 1) = 0\,. \quad \lambda_j = (0,0,0,0,0,1),\ j = 1,2,3,4,5 \text{ and } 6$$

Clearly the method (11) and (18) are zero stable which satisfies $\left|\lambda_j\right| \leq 1$

Consistency of TSBHLMM and RKTM

The methods (8) and (27) – (31) are said to be consistent if they have order greater than one with the first and second characteristics polynomial defined respectively by:

$$(i).\rho(r) = \sum_{j=0}^{k} \alpha_j z^j$$

$$(ii).\sigma(r) = \sum_{j=0}^{k} \beta_j z^j$$

where r is the principal root, which satisfy these conditions

$$\sum_{j=0}^{k} \alpha_j = 0$$

and

$$\rho'(1) = \sigma(1)$$

Table 3.3: Parameters for Obtaining Consistency of the BHLMM (8)

Scheme	**Order**	$\sum \boldsymbol{\alpha_j}$	$\boldsymbol{\rho'(1)}$	$\sigma(1)$
$\boldsymbol{y_{n+3}}$	**6**	**0**	**3**	**3**
$\boldsymbol{y_{n+2}}$	**6**	**0**	**2**	**2**
$\boldsymbol{y_{n+\frac{3}{2}}}$	**6**	**0**	$\frac{3}{2}$	$\frac{3}{2}$
$\boldsymbol{y_{n+1}}$	**6**	**0**	**1**	**1**
$\boldsymbol{y_{n+\frac{1}{2}}}$	**6**	**0**	$\frac{1}{2}$	$\frac{1}{2}$

The first order Runge-Kutta type method in ordinary differential equation (ODE) are said to be consistent if

$\phi(x, y(x), 0) \equiv f(x, y(x))$ holds.

Note: Consistency required that

$$\sum_{j=1}^{s} b_j = 1$$

Sources: (2022; Muhammad, 2020)

From the Butcher table resulted in (15) it shows that the conditions are satisfied for RKTM, derived. Hence the RKTM are consistent.

CONCLUSION

Three step block hybrid linear multistep method was successfully transformed into a Runge-Kutta type method and the uniform order was maintained which enhanced the numerical performance. The research analysis demonstrates that RKTM solution method present consistency and zero-stability properties with convergence characteristics which allows their application to first-order IVPs. The research adds to numerical method development by presenting strategies which enhance hybrid techniques used for differential equation solutions.

RECOMMENDATIONS

Recommendations for Further Studies

i. Researchers should study how to extend the new method to handle both higher-order differential equations alongside systems of IVPs because it could determine its full usefulness.
ii. Insights about RKTM effectiveness on complex differential problems can be acquired by studying its execution on stiff equations during analysis.
iii. The proposed method requires testing through its application to physical problems and engineering applications and financial challenges to prove practical usage.
iv. Evaluation of the reformulated approach requires additional comparison tests with Runge-Kutta methods as well as hybrid methods to demonstrate its relative benefits and drawbacks.
v. The optimization of computational algorithms together with parallel computing research would boost its performance speed for solving significant problems.

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THE PROSPECTS AND CHALLENGES OF THE PEDAGOGICAL APPLICATION OF GENERATIVE AI: A SURVEY FOR EDUCATIONAL MANAGEMENT

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Abstract

The emergence of generative artificial intelligence (AI) technologies has open up a wide range of opportunities, while generating significant debate in education. Generative AI is a subset of artificial intelligence that utilizes machine learning models to create innovative content, such as text, images or music based on structure or pattern learned from existing data. However, the study of West & Allen (2018) noted that the integration of Generative AI into education has raised certain concerns. This paper is a mixed review on the prospects and challenges of the pedagogical application of Generative AI. The paper discussed the application of Generative AI, the benefits and the challenges of implementing Generative AI in education. In order to simplify the process of gathering useful data for the paper write-up, questions were formulated and appropriately administered to respondents using online Google form questionnaire instrument. In conclusion, the paper inferred that Generative AI has remarkably impacted education, but there is a need for proper evaluation of the information generated by AI technologies. Finally, recommendations were made.

Keywords: Pedagogical Application, Generative AI, Educational Management.

INTRODUCTION

The term 'Generative artificial intelligence' (GenAI) refers to computational technologies that utilize machine learning models to perform various tasks, such as answering questions, summarizing texts, writing essays, creating captions, and generating stories, based on patterns and structures that are "trained" on massive amounts of text data, such as books, articles, websites, and social media posts. The technology behind GenAI uses large language models (LLMs) to produce natural language texts based on given input, such as prompt, keyword or query. LLMs can also learn from their own outputs and are able to improve over time. Generative AI is growingly revolutionizing the way humans work and communicate with each other in various sphere of life including the educational community. GenAI tools such as Gemini and ChatGPT are Generative Language Models, while Stagle Diffusion, Dall-E 3, and Sora are Generative Image and Video Models. Notably, ChatGPT is highly creative in human-like writing capabilities and content creation; offering accessible and personalized learning experiences for different categories of students, promoting the way teacher teach and learners learn. However, the integration of generative AI comes with both constructive and disruptive potentials.

RELATED LITERATURE

Chen et al. 2023 reveals that the development of GenAI is traced back to the 1960s. Sursala et al. (2023) noted that GenAI is a class of AI models that function by learning patterns from training datasets whose contents are generated based on those patterns. The recent introduction of GenAI has evoked much debate in various fields of life, and most especially within educational community. In terms of academic research, Dwivedi et al.(2023) noted that GenAI could help in the generation of new ideas (innovation goal) and in the improvement of writing (communication goal) and the generation of new ideas (innovation goal). The study of Jarvenpaa & Klein, (2024) signified that GenAI has the potential that promotes the process of knowledge development as it contributes to the identifying focal ideas, selection of theoretical products, and establishment of theory-building apparatus. Benbya et al. (2024) stated that GenAI can be used to discover insights that are temporary not cleared to researchers, encouraging the exploration of new knowledge and serving as stimuli for novel ideas. According to Benbya et al. (2024), GenAI's inability to grasp subjective experiences and reliance on past data may lead to misinformation and stifle innovation in knowledge development. More so, Bail (2024) recalls that the biases frequently exhibited by GenAI models reflecting the human-generated data they are trained on, perpetuating the prejudices and stereotypes present in the training data. However, Feuerriegel et al. (2024) stated that copyright violations is a significant limitation of GenAI models, as it can produce outputs that resemble existing works without the permission of the original authors. Additionally, Susarla et al. (2023) outlined the major challenges of GenAI tools, including interpretability, hallucination, and institutionalization biases.

Common Applications of Generative AI in Education

In education domain, the popular applications of Generative AI are under listed. Viz:-

- ❖ Students explore the use of Generative AI to:

1. Search for creative ideas: GenAI outcome generates brainstorming ideas that improves students' creativity in school tasks.

2. Clarify the meaning of complex concepts: GenAI outcomes aids further explanation of complex or abstract concepts for students.

3. Improve quality of written work: GenAI enhances auto-correction of spelling and grammar structure.

4. Increase study efficiency: GenAI increases the accuracy of study assignment based on input prompts.

❖ Teachers explore the use of Generative AI to:

1. Create new content for courses: GenAI create new content and study materials for teachers that could be used to educate their students, such as flashcards, study guides and discussion questions.

2. Design and organize course materials: GenAI's ability to create an engaging virtual learning environment for students improves lesson plans and provides appropriate learning styles to students to better understand of the course content.

3. Create personalized learning lessons: GenAI enhances personalize students' learning experiences based on their past performance and instant feedback leading to students' eagerness to learn and better academic achievements.

4. Support research work: Integrate GenAI helps teachers to quickly gather and summarize content from various sources including articles, books, and videos.

❖ School Managers explore the use of Generative AI to:

1. Plan and distribute resources: GenAI can essentially be used for resource planning tasks, ensure good school service quality

2. Automate administrative tasks: School administrators use GenAI to process students' applications, establish HR procedures, and manage facilities.

Benefits of Generative AI in Education

The integration of GenAI into education comes with numerous advantages. Viz:-:

1. Delivers customized learning experience: GenAI helps to captures past performance of students in order to re-strategize the method those best suites the achievement of their learning needs.

2. Automates various tasks: GenAI system helps to automate teachers' repetitive tasks such as marking of attendance, writing lesson notes, emails, and report summery. This enables teachers to concentrate on other works.

3. Enhances engaging and creative courses: Educators leverage the use of GenAI to create innovative ideas and course materials that enhances class engagement.

4. Improves retention and course completion: GenAI is used by School administrators to help identify at-risk students and at the same time personally intervene in their situations in order to improve their learning retention and aid their course completion.

Challenges of Generative AI in Education

There are so many huddles encountered in implementing GenAI in education. These include:-

1. Ethical and privacy concerns: The implementation of Generative AI in education is faced with concerns about safeguarding learners' information and maintaining educational fairness. Hence, the implementation should undergo rigorous procedures in order to ensure decisive outcome.

2. Need for Critical thinking skills:

Students 'over-reliance on the content generated by AI may diminish their ability to critically analyze information or have deep insight on certain subject matter.

3. Bias in AI outputs:
Certain inaccurate or discriminatory information may arise from the biases present in the trained data of some Generative AI models.

4. Academic misconduct: A very high number of students find it difficult to finish an assignment without the support of AI. However, it is very difficult for expert to detect academic malpractices enhanced with AI use.

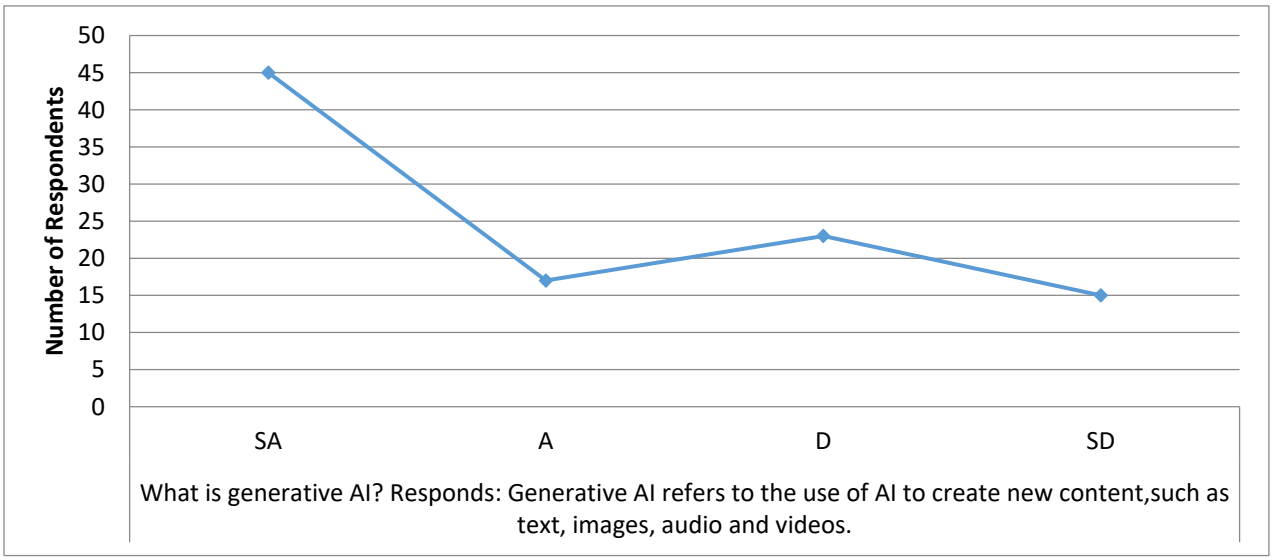
5. Limited digital infrastructure: Most institutions of learning are confronted with lack of digital infrastructure needed to empower generative AI models, while the cost of maintenance is relatively high.

MATERIALS AND METHODS

This paper adopted a mixed review approach on the prospects and challenges of GenAI in education sector. The common applications of Generative AI, the benefits and the challenges of GenAI in education were discussed. In order to collect some information considered useful for the paper discussion, drafted copies of questions were administered to respondents using online Google form questionnaire instrument. The responses gathered were subjected to Cronbach's alpha reliability analysis. The result of 0.854 gave a good reliability index of the instrument. The entire exercise took place within thirty-seven (37) days before completion.

RESULT AND DISCUSSION

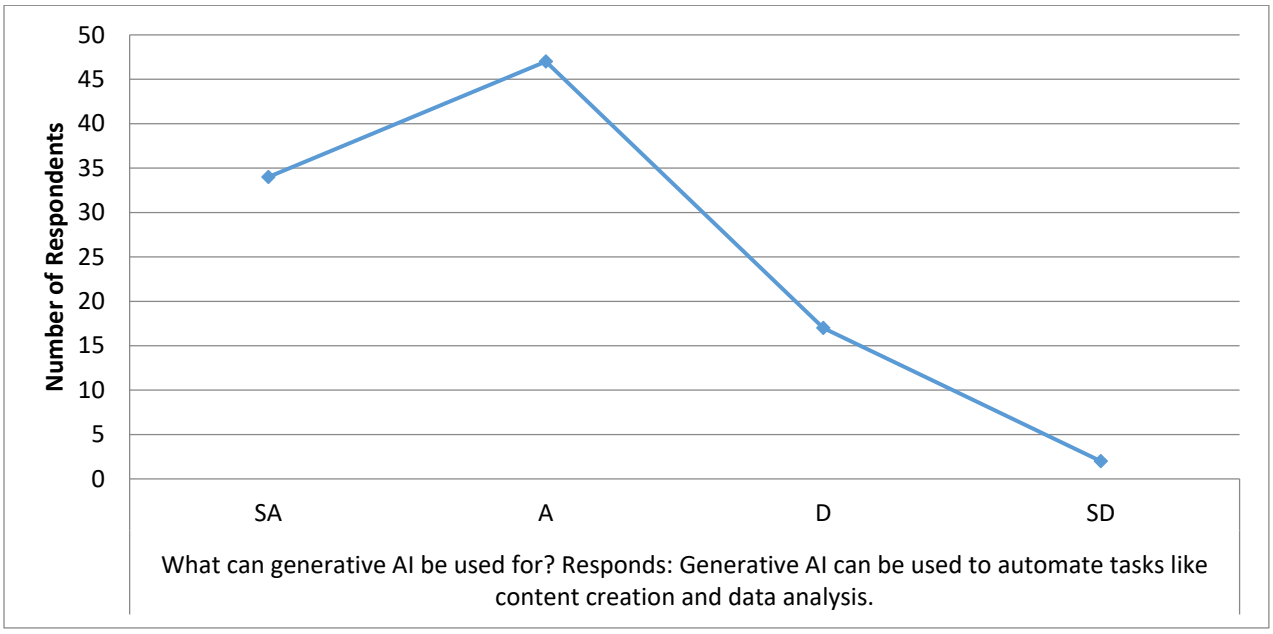
Fig.1: Chat Analysis



The graph plotted in figure 1 depicts that a very high number of the respondents understood the technology behind GenAI. According to their response, Generative AI or GenAI refers to the use of AI to create new content, like text, images, music, audio, and videos. The respondents

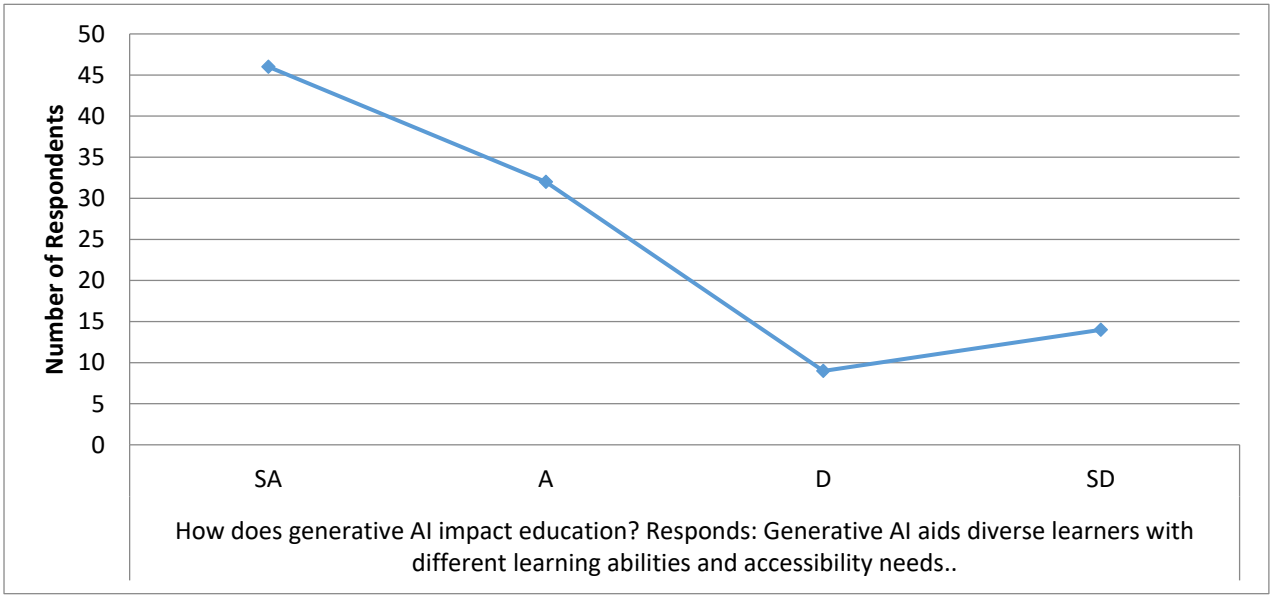
explained that GenAI is powered by foundation models that can perform series of multi-task, including summarization, classification, Q&A, and many more. In addition, the respondents mentioned that GenAI create new content by identifying patterns which are used for creating new variations. In other words, GenAI systems are trained on large datasets.

Fig.2: Chat Analysis



The graph plotted in figure 2 shows that most the of respondents agree with the statement that GenAI can be used to automate tasks like content creation and data analysis, thereby saving time and money. The respondents noted that GenAI allows users to focus on more strategic work, as GenAI automate repetitive or manual tasks creating a sort of relief on the part of its user.

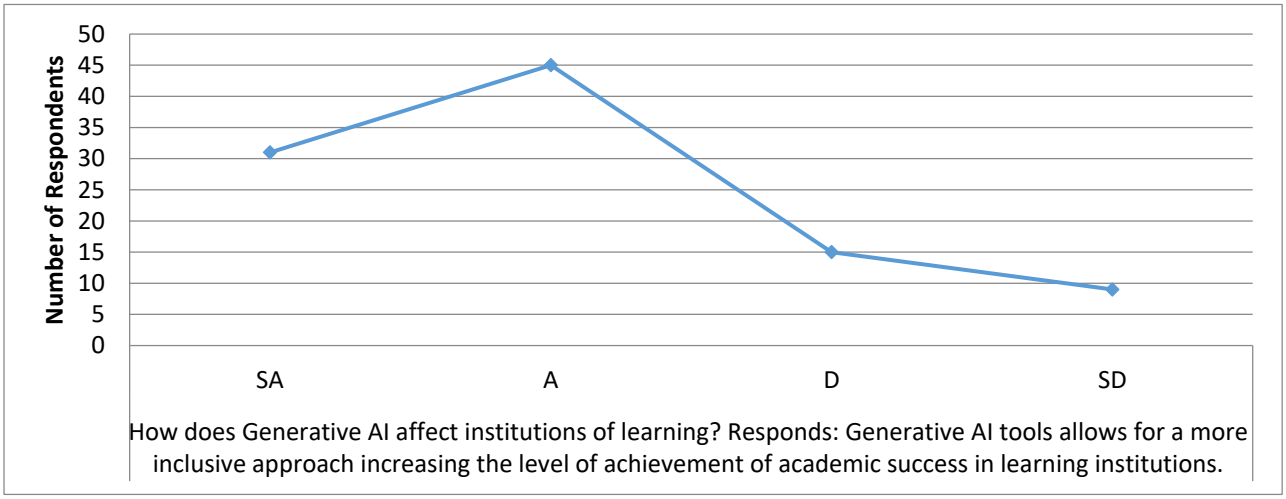
Fig.3: Chat Analysis



The graph plotted in figure 3 signifies that a greater amount of respondents concur that GenAI impact education as it aids diverse learners with different learning abilities and accessibility needs. The respondents explains that GenAI is growingly revolutionizing education by providing innovative teaching tools, personalized learning, and automated assessments. The

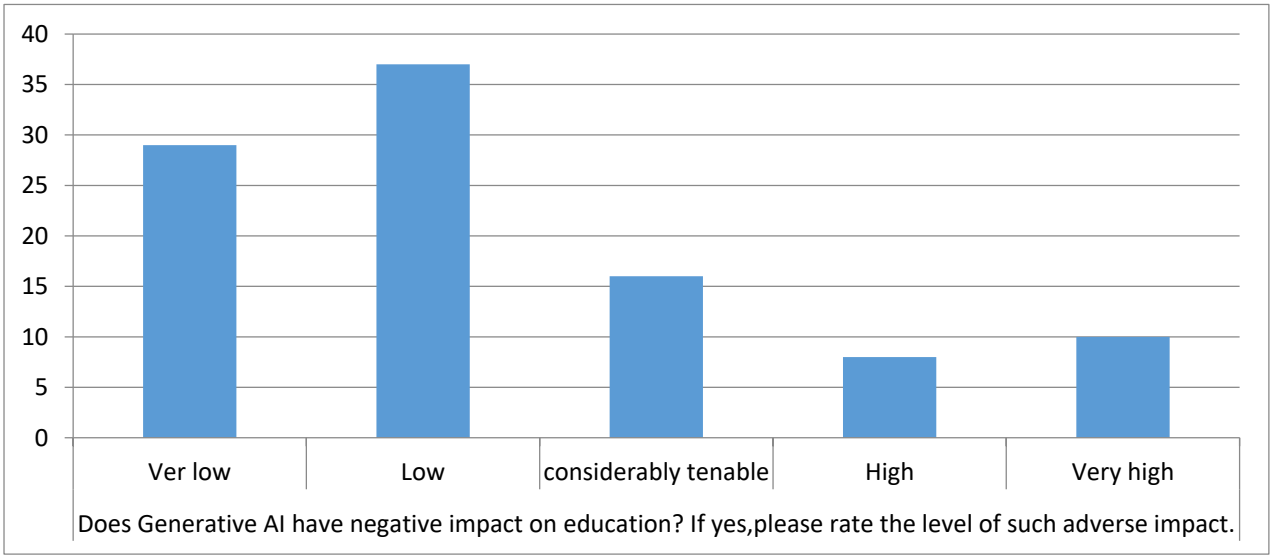
respondents added that GenAI helps to provide instant access to vast amounts of information. The respondents also emphasized that one of the significant benefits of GenAI in education is its ability to provide constructive and immediate feedback to students.

Fig.4: Chat Analysis



The graph plotted in figure 4 reveals that a huge number of respondents supported the statement that GenAI tools allows for a more inclusive approach thereby increasing the level of achieving academic success in various institution of learning. According to the respondents, students are able to engage themselves with material in a way that best suits their learning styles, improving academic outcomes.

Fig.5: Chat Analysis



The chat shown in figure 5 indicated that a few number of respondents supported that GenAI have negatively impacted education. The respondents inferred that although GenAI has opened up a world of possibilities, its implementation in education raises a lot of concerns about copyright violations, non-ethical use, data privacy, students' overreliance on the technology and reduction in intellectual growth.

CONCLUSION

The adoption of GenAI trends in education has shown positive signs, with various students, teachers, and school administrators applying it to their work. GenAI has positively impacted

education, generating numerous learning materials, facilitating easy accessibility to learning resources, enabling personalized learning experiences, and providing immediate feedback. The capability of improving academic outcomes drives more investment in GenAI solutions for education. However, it is also confronted with some challenges, including ethical and privacy concerns, need for critical thinking skills, bias in AI outputs, academic misconduct and limited digital infrastructure.

RECOMMENDATION

This paper recommends that school administrators should:

1. Discuss course policies and clearly communicate with students when and when not to use GenAI tools.

2. Consider students' accessibility to GenAI tools, especially those that students are required to interact with.

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GLOBAL HEALTH INTELLIGENCE SHARING: A VITAL TOOL FOR ACHIEVING SUSTAINABLE DEVELOPMENT GOAL 3 (SDG 3)

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ABSTRACT

Introduction and Pupose: Global health intelligence sharing is a crucial mechanism for addressing health challenges and advancing Sustainable Development Goal 3 (SDG 3), which aims to ensure healthy lives and promote well-being for all. This study examines the role of intelligence sharing in strengthening global health security, equity, and resilience.

Methods: A qualitative research approach was employed, including document analysis, literature review, and case study evaluation. The study explored existing mechanisms, contributions, challenges, and opportunities in global health intelligence sharing, with a focus on key initiatives such as the World Health Organization's Global Outbreak Alert and Response Network (GOARN) and the Global Initiative on Sharing All Influenza Data (GISAID).

Results: Findings highlight the impact of global health intelligence sharing in early disease detection, rapid response, and equitable resource distribution. However, several challenges limit its effectiveness, including data privacy concerns, technological disparities, geopolitical tensions, and fragmented governance structures. Despite these barriers, emerging opportunities such as advancements in digital technologies, regional collaborations, and open science initiatives provide potential solutions for strengthening global health intelligence systems.

Conclusion: A unified framework, enhanced regional capacity, and multi-sectoral partnerships are essential for leveraging global health intelligence sharing to achieve SDG 3. This study recommends increased investment in digital health infrastructure, fostering trust and cooperation among nations, and addressing data security concerns to promote equitable participation and collaboration. Strengthening global health intelligence systems will enable policymakers, practitioners, and stakeholders to drive sustainable improvements in health outcomes worldwide.

Keywords: Global Health, Intelligence Sharing, SDG 3, Public Health Security, Data Governance, Digital Health, Ethical Challenges.

CLASSICAL SOURCES: THEIR ROLE AND IMPORTANCE IN CONTRIBUTING TO THE STUDY OF HISTORY

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ABSTRACT

Through the analysis of these sources, the historian can extract valuable data about ancient civilizations and their mechanisms in various political, social and cultural fields, in addition to information about individuals and events they went through, which in turn contribute to enhancing our understanding of history and reconstructing the past accurately. In this paper, we will examine the importance of these sources in the valley and explore information about ancient history.

Keywords: Classical Sources- Herodotus- Ancient History- Greek and Roman

INTRODUCTION

The study of history is a constant endeavor to explore the past and understand its evolution over time. To achieve this goal, historians resort to various historical sources that help them reconstruct previous events, and among these sources are classical sources, which include manuscripts, inscriptions and antiquities from ancient civilizations such as Greece, Romans and Eastern civilizations, among the most important sources that cannot be dispensed with in the study of history.

In this study, we will explore more deeply how classical sources enrich the study of history and develop our understanding of the past. We will investigate the ways in which these sources form the inherent value of historical research methodology, enhancing our ability to draw authoritative conclusions about the events and figures that shape our history.

The study was divided into two axes with an introduction and a summary that dealt with the first axis: the definition of classical sources and their types, and dealt with an overview of the classical source and its origins (Greek, Roman, Eastern, etc.) and its types (manuscripts, inscriptions, antiquities, etc.). The second theme was entitled: Classical sources and their role in the study of history, as it dealt with the importance of classical sources in reconstructing the past Contribute to the understanding of ancient civilizations and their development and the possibility of extracting historical information from them.

CONCEPTUAL FRAMEWORK

The first axis: introducing classical sources and their types, including

First: Definition and Origin:

Classical sources are defined as writings and documents dating back to antiquity and medieval times in Western and Eastern civilizations, which form an important basis for historical research. These sources include the works of prominent historians such as Herodotus, Thucydides and Levy, along with the writings of philosophers such as Plato and Aristotle, and

writers such as Homer and Virgil. Classical sources also include governmental, political, legal, and other historical records from these periods.

Classical sources appeared in Greek cities, most notably in the city of Ionia, which is located on the western coast of Asia Minor on the Mediterranean Sea, and later appeared in southern Italy and the coastal cities located on the island of Sicily, and these sources date back to the period between the seventh and sixth centuries BC (Mosaddeq, 2023, p. 13).

Classical literature occupied great importance in the ancient Greek heritage, so poetic epics emerged for us that embody the most beautiful literary images, including, for example, the two famous epics Iliad and Odyssey, although the Iliad dealt with the Trojan War, which took place in 1250 BC, and the Odyssey glorified the adventures of the Greek hero Odysseus after his return to the homeland after the fall of Troy, but it represents the development of ancient oral poetry over 500 years, and these epics contributed to the embodiment of the principles of honor and courage, so many Stories of heroism in history (Mosaddeq, 2023, p. 14).

Then literature went a historical direction in the search for the scientific spirit and interest in historical data in the liberation of myths and genealogy, but the historical writing process remained not initiated until after contact with the Persians and fighting wars with them and then victory over them, as he was the first to initiate it Hecatus Melliti around 500 BC, as he was able to collect in his book geographical and historical data and relied on the methodology of criticism and investigation and the rejection of entertainment and enjoyment (S.M. Baura, Bla.T., pp. 100-112).

Herodotus is considered a primary and central source of classical historical studies, famous (circa 484 - 425 BC) He is considered the "father of history" and one of the most important ancient historians. With his work "History", Herodotus wrote down the first structured historical account of ancient events and civilizations in the Mediterranean and parts of the Middle East. This work laid the foundation for classical historical studies, and greatly influenced later historians and researchers. Herodotus is known for his narrator style and interest in cultural and social details, as well as his description of events Great historical such as the Persian Wars.

Herodotus excelled in scientific historical writing and led it to interest in the history of mankind and was interested in mentioning the great miraculous works and his attraction towards the epics was clear as he expressed his belief in the intervention of God in human affairs and was known for his narration of historical events down to the particles, but even focused on the marginal details that relate to the time and place of the event, so he considered his book (History of Herodotus) a mirror of his time (Baura, Pla.T., p. 81)

After him, Thukedides (471-401) BC, who was a contemporary of the war of annihilation between Athens and Sparta and lived until the fall of the Kingdom of Athens at the hands of the Spartans three years later, and during his living in exile, he invested the conditions of war in writing history, so he investigated his information from witnesses and supporters of the belligerents and saw documents, so he wrote a book in eight books, the first of which dealt with historical objectives and explained the causes of the war and called for a review of the rulings (Baura, Pla.T., p. 89).

Then there was a major turning point on the classical sources represented in the entry of Rome into a new era after 146 BC, which is the era of Greek friction or what is known as the Greco-Roman era after the Romans entered the country, so we have a sophisticated prose movement as an independent literary form in the second century BC and this contributed to the inspiration of the historian Polopius (198-117 BC) to write history, as he was arrested and lived as a hostage in Rome for six years, so many events about the power of Rome since before the war period The second Punic in 220 BC leading up to the conquest of Macedonia in 168 BC (Baura, Pla.T., p. 151).

We knew from the book of Herodotus in the middle of the fifth century BC a lot of accidents and landmarks, and from the book of Strabon first century BC a lot of historical and geographical information, and from the book of Bellini first century AD a lot of plants and natural manifestations, and from the book of Ptolemy second century AD a lot of news about the East and the Arabian Peninsula and its sections specifically has been the King Abdul Aziz House great efforts in preserving this heritage scattered in the classical texts as it succeeded in compiling And the translation of everything related to the Arabian Peninsula in a collection that came to light in 2017 consisted of seventeen parts.

The classical sources, in turn, are divided into two groups, the first group represented the travelers and the section represented the escorts of the military campaigns, so they chronicled the events of the areas they passed through, which are more like war reports that were later used as historical records that expressed the events of that period.

Although classical sources are the oldest source of history, we must take into account that these sources, like other sources, contain wheat and flesh, and therefore caution must be exercised when transferring and scrutinizing the recorded information.

However, they still represent those documents and writings dating back to antiquity and medieval times, and constitute an important basis for historical research. It includes the works of prominent historians, philosophers and writers from these periods, which provide us with a unique perspective on past events and societies.

Characteristics of classical sources

Classical sources have several important characteristics, most notably:

- Authenticity and antiquity: These sources date back to distant periods of time, making them authentic and reliable documents of the past (Carr, 1990, p. 11).
- Subtle details: Many of these sources are characterized by specific details and a rich narrative of events and characters (Carr, 1990, p. 53).
- Polyphony: These sources offer divergent perspectives on historical issues, enriching our understanding of the past (Carr, 1990, p. 78).
- Cultural significance: Classical sources reflect the cultural and civilizational dimensions of antiquity and the Middle Ages (Carr, 1990, p. 102).

The importance of studying classical sources in history

Classical sources are of great importance in the field of historical research for several reasons:

- Provide reliable information about the past: These sources form a direct gateway to past events and societies.
- Reconstructing the past: Studying these sources helps to reshape an accurate picture of historical events.
- Understanding civilizational contexts: These resources enable us to access the cultural and social dimensions of previous eras.
- Developing research methodology: The study of classical sources imposes critical approaches to dealing with historical documents (Carr, 1990, pp. 102-108).

Second Theme: Classical Sources and their Role in the Study of History

Classical sources contribute to the reconstruction of the past and contribute to the understanding of ancient civilizations, their development and the possibility of extracting historical information from them. Classical sources such as historical, philosophical and literary writings of antiquity provide us with a direct look at how people thought and acted in those eras. These personal perspectives in turn A task to understand the context and dynamics of historical events (Annan, 1983, Vol. 13, No. 4, p. 34).

Classical sources also contribute to revealing the intellectual and cultural development of humanity, documenting the development of philosophy, science and the arts through the ages and thus studying this development helps us understand how human ideas and practices have changed and evolved over time.It works to understand the roots and sources of many modern practices and institutions, as much of what we see today has its roots in ancient times, and therefore the study of classical sources helps us trace the origins and historical development of these practices and institutions (Sharaf et al., 2005, p. 63).

Classical sources form an essential part of humanity's cultural heritage, contributing to the enrichment of culture and human heritage and the development of dialogue and appreciation for this heritage.

In general, classical sources provide us with a window into the past that allows for a deeper and more diverse understanding of humanity's evolution and history. This deep understanding of the past helps us understand our present and plan for our future better.

Classical sources such as historical, literary and philosophical writings are original materials that researchers and scholars can analyze and interpret to obtain direct information about the era in which they were recorded. Thus helping to understand ancient societies and cultures: Analysis of classical sources helps in exploring and understanding the ways of living and thinking of ancient societies, and this is essential to understanding their history and context (Carr, 1990, 51).

After we have shown the importance represented by classical sources for the historical researcher and the value they contain of civilization, we will cite some of the examples that the classical sources provided us with in the field of history, for example, Herodotus' visit to Egypt, as he gave us a lot of information about this country in his book "Herodotus talks about Egypt", but when Dr. Ahmed Badawi presented this book, he referred to some of the lapses and fallacies in which Herodotus occurred, especially in the ninety-ninth part, noting that he did not stay in Egypt more than four months in the fifth century BC when the Persians were occupying it and claimed that he spoke with many Egyptians and he does not agree with the fact that Herodotus did not speak the language of the people of Egypt but this does not contradict the possibility of using the drowning who were residing in it or some of the guides who accompanied the people in exchange for certain wages and may have been deceived in the narrations that he was hearing or reached him, especially about the information related to the pyramids and the information was He assigns it to the soothsayers and then says the translator in other places, and this invites us to wonder about the possibility of making mistakes during the process of transmitting and recording historical information (Anonymous Author, 1966, p. 21). On the other hand, it gives us valuable information about the fact that Egypt is the gift of the Nile and describes the social nature of the inhabitants of the city and that they tend to eat the meat of bulls and calves and that they do not eat the meat of female cows because it symbolizes Isis, it is sacred to them and they call it Hathor (anonymous author, 1966, p. 131).

Elsewhere, when the Achaemenid king mentions Cambyses and that he signed a treaty with the king of the Arabs and stops mentioning his name (anonymous author, 1966, p. 153).

From other classical sources, Diodorus tells us about the Persian forces and mercenaries of Greece and the attack on Egypt during the reign of King Nakhtenbo I 380-362 BC with two hundred thousand Persian soldiers with twenty thousand Greek mercenaries with three hundred ships with three rows of oars (Mehran, 1980, vol. 3, p. 786).

When we look at these large numbers, we cannot trust their authenticity, and if the correspondence of the kings themselves has this exaggeration, how can we trust a writer like Diodor who lived in the first century BC?

As for the southern Arab countries, it was present and prolific in classical works, by virtue of the cultural and commercial link between them, some writings dealt with some references to the Kingdom of Sheba, including:

Herodotus mentioned in his History Herodotus mentioned the kingdom of Sheba in southern Arabia and pointed out that it was one of the ancient and commercially prosperous kingdoms. Herodotus even described the method of collecting incense: He stated that the inhabitants of southern Arabia collected incense in a superstitious way, such as firing flaming arrows to drive out dangerous snakes. This description may be exaggerated or confusing. Herodotus even estimated Yemen's population at one million, a far exaggerated figure compared to the realistic population estimates at the time.

In addition , Diodore of Sicily, in his book "The Historical Library", talked about the Kingdom of Sheba with its capital Marib, and mentioned some information about its civilization and commercial wealth.

Pliny the Elder, in his Natural History, gave a detailed description of the Kingdom of Sheba and referred to its capital, Marib, and its natural resources. He even gave estimates of the prices of incense and perfumes, stating that the prices of incense and perfumes were very exorbitant, which calls into question the realism of these estimates.

Theophrastus described guarding incense trees: He stated that incense trees in southern Arabia were surrounded by snakes and predatory birds to protect them. This description may be exaggerated or exaggerated.

Ptolemy: In his geography, he gives some geographical details about the location of the Kingdom of Sheba and its neighboring kingdoms in the Arabian Peninsula.

The Greek historian Artimidoor's mention of the names of kings in the kingdom of Ma'in in southern Arabia matches what is proved by archaeological inscriptions.

Pliny the Elder's reference to the conquests of the Sabaean kingdom of neighboring lands corresponds to local historical records.

Thus, a number of ancient classical historians and geographers referred to the Kingdom of Sheba as a civilization.

The ancient classical books abounded with many information about the Arabian Peninsula, as indicated by virtue of the cultural contact that was with the Arabs, and these references were compiled and translated as reported in the circuit series in 2017, and the most prominent of these references are Nord:Ptolemy's geographical description of the main sites and cities in the Arabian Peninsula closely corresponds to known geographical facts. Herodotus and Diodorus of Sicily's references to the location and borders of the Kingdom of Sheba correspond to what has been confirmed by recent archaeological discoveries.

Pliny the Elder's details about the unique natural products of Arabia correspond to modern knowledge. He touched on the presence of strange creatures in the Arabian Peninsula such as women with tails. These descriptions may be loaded with some fiction and legends. In general, despite some exaggerated or imaginary descriptions in these classical writings, they do not detract from their value as valuable sources of geographical, historical, and economic information about ancient Arabia (Hitti, 1937, p. 27, p. 33).

There are, then, many examples that point to the credibility of the geographical and historical information contained in classical writings on Arabia. There is no doubt that some ancient classical writings on Arabia may be marred by exaggerations or exaggerations in describing certain events and phenomena. Here are some examples:

These examples illustrate how ancient classical writings included some exaggerations and distortions in the description of Arabia. However, these sources remain valuable for understanding the ancient history and geography of the region, as long as they are read critically.

The bottom line

- Classical sources form an important basis for historical research thanks to their originality, fine detail, and multiplicity of perspectives. Studying these valuable sources helps us reconstruct a more accurate picture of the past, and recognize the civilizational and cultural contexts of previous eras. Thus, exploring classical sources is a cornerstone in understanding and interpreting history. With the development of historical studies and archaeological discoveries.
- The importance of classical sources in providing new insights into history and enriching contemporary studies with information and ideas that were not previously available has emerged. Therefore, these sources remain of interest to researchers and historians, as they are essential to understanding the past and linking it to the present.
- In addition, classical sources are of particular importance in the field of historical research due to their reliability and fine detail. It gives us first-hand testimonies from those who have lived through events, helping us reconstruct a more accurate picture of the past. It also enables us to have multiple perspectives on different historical issues.

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ADVANCEMENTS IN NEUROLOGICAL DISORDERS: ALZHEIMER'S, PARKINSON'S, AND BEYOND

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Abstract

Neurological disorders such as Alzheimer's disease (AD), Parkinson's disease (PD), multiple sclerosis (MS), and amyotrophic lateral sclerosis (ALS) present significant challenges to global healthcare due to their progressive nature and lack of definitive cures. Recent advancements in neurobiology, neuroimaging, biomarker research, and gene therapy have revolutionized the understanding and treatment of these disorders. Breakthroughs in precision medicine, stem cell therapy, deep brain stimulation (DBS), and neuroprotective strategies offer new hope for patients. In Alzheimer's disease, early detection through blood-based biomarkers and AI-driven diagnostic tools is improving clinical outcomes, while novel therapies such as monoclonal antibodies (e.g., Lecanemab, Aducanumab) target amyloid plaques to slow disease progression. Parkinson's disease management has evolved with personalized medicine, wearable monitoring, and gene-editing techniques like CRISPR, along with advanced dopamine replacement therapies and focused ultrasound (FUS) for tremor control. Moreover, research into the gut-brain axis is uncovering links between microbiome dysbiosis and neurodegeneration, opening new therapeutic avenues.This paper explores the latest innovations in the field of neurodegenerative disease treatment, regenerative medicine, and neurotechnologies, highlighting the shift towards early intervention, neuroprotection, and disease modification. The integration of artificial intelligence, big data analytics, and brain-computer interfaces (BCI) is also paving the way for the next generation of personalized neurological care.

Keywords: Neurodegenerative diseases, Alzheimer's disease, Parkinson's disease, precision medicine, neuroimaging, gene therapy, biomarkers, deep brain stimulation, AI in neurology, gut-brain axis, regenerative medicine, monoclonal antibodies, brain-computer interface.

Introduction

Neurological disorders, particularly neurodegenerative diseases, represent a significant and growing global health burden. These conditions affect millions of people worldwide, leading to progressive disability, loss of independence, and increased mortality. Among the most prevalent are Alzheimer's disease (AD) and Parkinson's disease (PD), which together account for a substantial proportion of neurodegenerative cases. Despite extensive research, there are currently no definitive cures for these disorders, making early detection, intervention, and disease management crucial in improving patient outcomes.

Alzheimer's disease primarily manifests as memory loss, cognitive decline, and behavioral changes, resulting from the accumulation of beta-amyloid plaques and tau tangles in the brain. In contrast, Parkinson's disease is characterized by motor dysfunction, tremors, rigidity, and bradykinesia, caused by the progressive degeneration of dopaminergic neurons in the substantia nigra. Other neurodegenerative conditions, such as multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), and Huntington's disease (HD), also contribute significantly to the rising burden of neurological diseases, each presenting unique pathophysiological mechanisms and clinical challenges.

Recent advancements in neurobiology, neuroimaging, gene therapy, and precision medicine have revolutionized the understanding and treatment of these disorders. The development of monoclonal antibodies, stem cell therapy, deep brain stimulation (DBS), and neuroprotective interventions has opened new avenues for modifying disease progression and improving quality of life. Additionally, research into the gut-brain axis has provided valuable insights into the role of microbiome dysbiosis in neurodegeneration, suggesting novel therapeutic targets.

The integration of artificial intelligence (AI) and machine learning (ML) in neurological research is further enhancing diagnostic accuracy, risk prediction, and treatment personalization. These cutting-edge technologies, combined with advancements in biomarker discovery, neuroinflammation modulation, and regenerative medicine, are shaping the future of neurodegenerative disease management.

This review explores the latest breakthroughs in neurodegenerative disease treatment, emphasizing the transition from symptomatic management to early intervention, neuroprotection, and disease modification. By highlighting emerging therapies, promising clinical trials, and future research directions, this paper aims to provide a comprehensive overview of the evolving landscape of neurodegenerative disorder treatment.

Alzheimer's Disease: Pathophysiology and Emerging Therapies

Pathophysiology and Biomarker Advances

Alzheimer's disease is characterized by progressive neuronal degeneration, primarily due to β-amyloid plaque deposition and tau protein aggregation. These pathological changes disrupt synaptic function and lead to widespread brain atrophy. Additionally, neuroinflammation, mitochondrial dysfunction, and oxidative stress contribute to disease progression (Hampel et al., 2021).

Recent biomarker research has significantly improved early-stage AD detection. Blood-based biomarkers, such as phosphorylated tau (p-tau181, p-tau217), can reflect disease pathology before clinical symptoms emerge. Cerebrospinal fluid (CSF) analysis and positron emission tomography (PET) scans have traditionally been used to detect amyloid and tau deposits, but blood-based markers offer a less invasive and more accessible diagnostic tool(Jack et al., 2019).

Furthermore, advanced neuroimaging techniques, including functional MRI (fMRI) and diffusion tensor imaging (DTI), allow for early visualization of neuronal connectivity changes in AD patients. AI-powered diagnostic algorithms are now being integrated into neuroimaging analysis, improving the ability to detect AD-related changes with high sensitivity and specificity (Schmidt et al., 2022).

Table 1: Key Biomarkers in Alzheimer's Disease Diagnosis

Biomarker	Type	Diagnostic Significance
β-Amyloid (Aβ42, Aβ40)	CSF & Blood	Indicates amyloid plaque deposition
Phosphorylated tau (p-tau181, p-tau217)	Blood	Reflects tau pathology and neurodegeneration
Total tau (t-tau)	CSF	Correlates with neuronal injury
Neurofilament Light Chain (NfL)	Blood	Marker of axonal damage and disease progression
Plasma Glial Fibrillary Acidic Protein (GFAP)	Blood	Associated with astrocytic activation and neuroinflammation

Monoclonal Antibody Therapy

Monoclonal antibodies (mAbs) have emerged as a promising therapeutic approach for Alzheimer's disease by targeting β-amyloid aggregates and reducing plaque burden. Lecanemab and Aducanumab, both of which received FDA approval, selectively bind to amyloid fibrils and facilitate their clearance through the immune system(van Dyck et al., 2023).

However, these therapies are most effective in early-stage patients, as they slow disease progression rather than reverse neurodegeneration. Clinical trials have demonstrated that Lecanemab can reduce cognitive decline by approximately 27% in early AD patients over 18 months (Cummings et al., 2023).

Newer antibody-based therapies are in development, focusing on tau protein aggregation. Donanemab, another experimental mAb, has shown potential in targeting tau tangles, which correlate more closely with disease severity than amyloid plaques. Combining anti-amyloid and anti-tau therapies could enhance treatment efficacy in future AD management (Lowe et al., 2023).

AI-Driven Diagnostic Tools

Artificial intelligence (AI) and machine learning (ML) are transforming Alzheimer's disease diagnosis and prognosis prediction. AI-driven models can analyze vast amounts of neuroimaging, biomarker, and genetic data to identify patterns indicative of early-stage AD.

Deep learning algorithms have been developed to analyze MRI and PET scans, detecting subtle changes in brain structure long before clinical symptoms manifest. These AI tools have demonstrated higher accuracy in differentiating AD from mild cognitive impairment (MCI) and other dementias compared to traditional diagnostic approaches (Schmidt et al., 2022).

Furthermore, natural language processing (NLP) is being applied to assess speech and language patterns in AD patients. Research suggests that linguistic changes occur early in AD, and AI-powered voice analysis tools may serve as a non-invasive screening method (Rentz et al., 2022).

Parkinson's Disease: Advances in Diagnosis and Treatment

Personalized Medicine and Dopamine Replacement Therapy

Parkinson's disease is primarily caused by the progressive degeneration of dopaminergic neurons in the substantia nigra, leading to motor dysfunction, rigidity, and bradykinesia. While levodopa remains the gold standard for dopamine replacement therapy, its long-term use is

associated with motor complications such as dyskinesia and "off" episodes (Kalia & Lang, 2021).

Personalized medicine approaches are now optimizing PD treatment based on genetic and metabolic profiling. Pharmacogenomics is being used to determine how individual patients metabolize dopaminergic drugs, allowing for tailored medication regimens. Additionally, novel extended-release formulations and continuous dopaminergic infusions, such as apomorphine pumps and subcutaneous levodopa delivery systems, are improving symptom control and reducing fluctuations (Oertel et al., 2022).

Deep Brain Stimulation and Focused Ultrasound Therapy

Deep brain stimulation (DBS) has revolutionized Parkinson's disease treatment by modulating abnormal neural circuits in the basal ganglia. The latest advancements in DBS involve adaptive stimulation systems that adjust in real-time based on neural activity, enhancing efficacy while minimizing side effects (Meidahl et al., 2017).

Additionally, focused ultrasound (FUS) is being explored as a non-invasive alternative to DBS for treating PD-related tremors. FUS can precisely target and ablate affected brain regions without the need for surgical implantation of electrodes.

Conclusion

The treatment landscape for neurodegenerative diseases has evolved significantly, with a growing emphasis on early diagnosis, precision medicine, and disease-modifying therapies. Traditional approaches, such as dopaminergic therapy for Parkinson's disease (PD) and cholinesterase inhibitors for Alzheimer's disease (AD), have been effective in symptom management but fail to alter disease progression. The advent of monoclonal antibodies, gene therapy, stem cell interventions, and neuroprotective strategies has opened new doors for targeted treatment approaches.

Artificial intelligence (AI) and machine learning (ML)-powered diagnostic tools are transforming early detection and prognosis prediction, offering a higher degree of accuracy and reliability. AI-based neuroimaging analysis and speech pattern assessments are showing promising results in detecting subtle cognitive and motor impairments before clinical symptoms become apparent. As a result, these tools are expected to play a vital role in preventative interventions and personalized treatment planning.

Despite these advancements, several challenges remain, including the high cost of novel therapies, limited accessibility, and the need for long-term efficacy data. The development of more affordable and scalable treatment options will be critical in ensuring that patients worldwide can benefit from these innovations. Additionally, neurodegenerative diseases are multifactorial, and a single treatment approach may not be universally effective. Future research should prioritize multimodal interventions that combine pharmacological, behavioral, and lifestyle-based approaches to provide holistic disease management.

Looking ahead, interdisciplinary collaboration among neurologists, geneticists, bioinformaticians, and AI experts will be crucial in accelerating progress. Large-scale clinical trials evaluating combination therapies, personalized medicine strategies, and neuroprotective agents will determine the long-term viability of these emerging treatments. Furthermore, the exploration of gut-brain interactions, neuroimmune modulation, and regenerative medicine may unlock novel pathways for therapeutic breakthroughs.

Ultimately, the future of neurological care lies in precision neurology, AI-driven diagnostics, and patient-centered treatment plans. By integrating cutting-edge research with clinical applications, we can move closer to not just managing neurodegenerative diseases but potentially halting or reversing their progression. The coming decade promises transformative

innovations that will reshape our understanding of brain health and neurodegeneration, offering hope for millions of patients worldwide.

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MATERIALS SCIENCE INNOVATIONS: GRAPHENE, SMART MATERIALS, AND BEYOND

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Abstract

Materials science has undergone a revolutionary transformation with the advent of advanced materials such as graphene and smart materials, paving the way for breakthroughs in electronics, healthcare, energy, and sustainability. Graphene, a single layer of carbon atoms arranged in a hexagonal lattice, exhibits exceptional electrical conductivity, mechanical strength, and thermal stability, making it a promising candidate for applications in flexible electronics, supercapacitors, and biomedical devices. Smart materials, including shape-memory alloys, self-healing polymers, and piezoelectric materials, have introduced new possibilities for responsive and adaptive technologies. Recent advancements in graphene-based nanocomposites have led to their integration into next-generation batteries, water filtration systems, and lightweight aerospace materials. Additionally, the emergence of 4D printing and bio-inspired materials has enabled the development of structures that can change shape or properties in response to external stimuli, opening doors for self-assembling medical implants and adaptive building materials. Furthermore, research in perovskites and topological insulators is enhancing energy efficiency in solar cells and quantum computing. As these materials transition from research to commercialization, challenges such as large-scale production, cost-effectiveness, and environmental sustainability must be addressed. This conference will explore the latest innovations, practical applications, and future prospects of graphene and smart materials, fostering interdisciplinary discussions to accelerate their adoption in real-world applications.

Keywords: Graphene, smart materials, nanotechnology, flexible electronics, self-healing polymers, shape-memory alloys, piezoelectric materials, 4D printing, bio-inspired materials, perovskites, topological insulators, energy storage, quantum computing, sustainable materials, materials science innovations.

Introduction

The field of materials science has witnessed an unprecedented transformation with the advent of advanced materials such as graphene and smart materials. These groundbreaking discoveries have set the stage for revolutionary applications across diverse industries, including electronics, healthcare, energy, aerospace, and sustainability. Graphene, a single layer of carbon atoms arranged in a hexagonal lattice, has garnered immense attention due to its exceptional electrical conductivity, mechanical strength, and thermal stability. At the same time, smart materials,

which encompass shape-memory alloys, self-healing polymers, and piezoelectric materials, have introduced dynamic and adaptive functionalities that were once considered science fiction.

The rapid advancements in graphene-based nanocomposites, 4D printing, and bio-inspired materials are redefining the boundaries of technology and engineering. These materials enable the creation of self-assembling medical implants, adaptive building structures, and next-generation energy solutions. Additionally, research on perovskites and topological insulators is unlocking new possibilities in solar energy efficiency and quantum computing. However, challenges such as large-scale production, cost-effectiveness, and environmental sustainability must be addressed to transition these materials from laboratory research to widespread commercialization.

Graphene: The Breakthrough Material

Graphene has been hailed as the "wonder material" of the 21st century due to its unique combination of properties. It is 200 times stronger than steel while being incredibly lightweight, making it an ideal candidate for structural and mechanical applications. Its unparalleled electrical conductivity enables electrons to move at speeds nearly 100 times faster than in silicon, paving the way for faster, more efficient electronic devices. Additionally, its superior thermal conductivity ensures efficient heat dissipation, making it a valuable asset in electronic cooling systems.

One of the most promising applications of graphene is in flexible and transparent electronics. Researchers are developing graphene-based transistors and circuits that have the potential to replace silicon in future semiconductor technologies. This breakthrough could lead to foldable smartphones, ultra-fast processors, and transparent touchscreens that revolutionize consumer electronics. In the field of energy storage, graphene-based electrodes are enhancing the efficiency of lithium-ion batteries and supercapacitors, enabling faster charging times and higher energy densities.

Beyond electronics and energy, graphene is making significant strides in healthcare and environmental applications. Graphene-based biosensors are being used for early disease detection, while its antibacterial properties are being explored for advanced medical implants. Additionally, graphene oxide membranes are proving to be highly effective in water filtration and desalination, offering a potential solution to global water scarcity. These diverse applications highlight the versatility and transformative potential of graphene across multiple industries.

Smart Materials: The Future of Adaptive Technology

Smart materials represent a new era of responsive and adaptive technology, capable of altering their physical properties in reaction to external stimuli such as heat, pressure, or electrical fields. Shape-memory alloys, one of the most widely studied smart materials, have the ability to return to their original shape when exposed to a specific temperature. This property is being utilized in aerospace engineering for self-repairing aircraft components, in biomedical implants such as stents that expand within arteries, and in robotics for the development of flexible and responsive actuators.

Self-healing polymers are another revolutionary innovation within smart materials. These materials can autonomously repair damage without external intervention, extending the lifespan of products and reducing maintenance costs. They are being incorporated into infrastructure materials, such as self-healing concrete for bridges and buildings, as well as in automotive coatings that repair minor scratches automatically. This advancement not only improves

durability but also contributes to sustainability by reducing material waste and energy consumption.

Piezoelectric materials, which generate electricity in response to mechanical stress, are paving the way for innovative energy-harvesting solutions. These materials are being integrated into wearable devices, where they convert body movements into usable energy, as well as in structural applications, where they harness vibrations from roads and buildings to generate power. As research progresses, smart materials will continue to drive advancements in industries ranging from medicine to transportation, offering solutions that are both efficient and sustainable.

Emerging Innovations: 4D Printing, Bio-Inspired Materials, and Beyond

While 3D printing has already revolutionized manufacturing, the introduction of 4D printing takes this technology a step further by enabling objects to change shape or properties over time in response to environmental factors. This innovation has significant implications for healthcare, where self-assembling medical implants can adapt to a patient's anatomy, and for construction, where adaptive materials can enhance the resilience of buildings in response to changing weather conditions. The ability of 4D-printed structures to self-adjust reduces maintenance requirements and enhances functionality in ways previously unimaginable.

Bio-inspired materials, modeled after natural structures, are also gaining traction in materials science. Inspired by the self-cleaning properties of lotus leaves, researchers have developed surfaces that repel water and dirt, leading to applications in self-cleaning glass and anti-fouling coatings. Artificial spider silk, which mimics the strength and flexibility of natural silk, is being explored for use in lightweight armor and high-performance textiles. Additionally, bone-like materials are being developed for regenerative medicine, allowing for improved bone grafts and prosthetics that integrate seamlessly with human tissues.

These emerging innovations highlight the power of nature-inspired engineering and smart fabrication techniques in shaping the future of materials science. As researchers continue to explore these frontiers, the possibilities for self-sustaining, energy-efficient, and adaptive materials are expanding at an unprecedented rate.

The Role of Perovskites and Topological Insulators in Energy and Computing

Perovskite materials have revolutionized the field of solar energy by offering higher efficiency and lower production costs compared to traditional silicon-based solar cells. Their unique crystal structure allows for better light absorption and charge transport, making them a promising candidate for next-generation photovoltaic technology. Researchers are working to enhance the stability of perovskite solar cells to enable their widespread adoption in renewable energy solutions. The flexibility of perovskites also allows for their integration into wearable solar panels and lightweight energy-harvesting devices.

Topological insulators, another emerging class of materials, are transforming the field of electronics and quantum computing. These materials exhibit a unique property where their surfaces conduct electricity while their interiors remain insulating. This characteristic enables more efficient and stable electronic circuits with minimal energy loss. In quantum computing, topological insulators are being explored for their ability to support quantum states that are less prone to errors, paving the way for the development of ultra-fast and secure computing technologies.

The advancements in perovskites and topological insulators signify a shift toward more efficient, sustainable, and powerful technologies. As research progresses, these materials will

play a crucial role in reshaping the landscape of energy generation and computation, driving innovation across multiple industries.

Challenges and Future Prospects

Despite the promising advancements in graphene, smart materials, and emerging technologies, several challenges remain in their widespread implementation. One of the primary hurdles is the large-scale production of these materials at an economically viable cost. The synthesis of high-quality graphene, for instance, is still expensive, limiting its commercial applications. Similarly, the complex fabrication processes involved in smart materials need to be optimized for mass production to make them more accessible across industries.

Environmental sustainability is another pressing concern. While many of these materials offer solutions to energy efficiency and waste reduction, their production processes can have environmental impacts that need to be mitigated. Researchers are actively exploring greener synthesis methods and sustainable raw materials to minimize the ecological footprint of these innovations. Additionally, regulatory challenges and safety concerns must be addressed, particularly in biomedical applications where biocompatibility and long-term effects require thorough evaluation.

Despite these challenges, the future of materials science is incredibly promising. Continued collaboration between researchers, engineers, and industries will be essential in overcoming these barriers and accelerating the commercialization of these advanced materials. As innovations in graphene, smart materials, and emerging technologies continue to evolve, they will shape the next generation of sustainable, high-performance, and intelligent materials that drive progress across all sectors of society.

Conclusion

Materials science stands at the forefront of technological innovation, transforming industries and redefining possibilities for the future. The rapid advancements in materials such as graphene, smart materials, perovskites, and topological insulators are paving the way for revolutionary applications in electronics, energy, healthcare, and environmental sustainability. As these materials transition from research laboratories to real-world applications, they hold the potential to solve some of the most pressing global challenges, from clean energy production to next-generation computing. However, the journey toward widespread adoption is not without challenges. Scalability, cost-effectiveness, and sustainability remain critical concerns that must be addressed before these materials can fully realize their transformative potential.

Graphene, often hailed as a "wonder material," has demonstrated remarkable properties, including exceptional electrical conductivity, mechanical strength, and flexibility. Its potential applications span across diverse fields, from ultra-fast flexible electronics to high-performance batteries and biomedical devices. Despite its promise, large-scale graphene production remains a significant bottleneck. Traditional methods of synthesis, such as chemical vapor deposition (CVD), are expensive and challenging to scale. Researchers are now exploring more cost-effective and sustainable production techniques, such as liquid-phase exfoliation and chemical reduction of graphene oxide. If these challenges can be overcome, graphene will likely become a fundamental component of future technologies, enabling the development of smarter, more efficient devices.

Smart materials, including shape-memory alloys, self-healing polymers, and piezoelectric materials, have introduced new possibilities for adaptive and responsive systems. These materials are revolutionizing industries by offering self-repairing structures, energy-efficient electronics, and advanced biomedical implants. Shape-memory alloys, for example, are being

used in medical devices such as stents and orthopedic implants that can change shape in response to body temperature. Similarly, self-healing polymers are being integrated into coatings and structural materials, reducing maintenance costs and extending the lifespan of products. However, widespread implementation of smart materials faces challenges related to durability, long-term stability, and integration into existing manufacturing processes. Continued research and development efforts are needed to enhance the reliability and cost-effectiveness of these materials, ensuring their seamless adoption in industrial and consumer applications.

Emerging technologies such as 4D printing and bio-inspired materials further illustrate the transformative potential of advanced materials. 4D printing, an evolution of 3D printing, allows printed structures to change shape or properties over time in response to external stimuli such as heat, moisture, or light. This innovation holds promise for self-assembling medical implants, adaptive aerospace components, and intelligent infrastructure. Similarly, bio-inspired materials, modeled after natural structures such as spider silk and lotus leaves, offer lightweight, strong, and sustainable solutions for a range of applications. The integration of these materials into mainstream industries could revolutionize product design and manufacturing, making materials more dynamic, responsive, and environmentally friendly.

Perovskites and topological insulators are also pushing the boundaries of energy and computing technologies. Perovskite solar cells have emerged as a promising alternative to conventional silicon-based solar panels, offering higher efficiency, lower manufacturing costs, and improved flexibility. However, issues related to stability and long-term performance must be addressed before they can be widely adopted. Similarly, topological insulators are unlocking new possibilities in quantum computing and energy-efficient electronics by enabling lossless electrical conduction. These materials have the potential to significantly enhance computational power while reducing energy consumption, paving the way for the next era of computing.

Despite these groundbreaking advancements, the transition from laboratory research to commercial application remains a formidable challenge. One of the most significant barriers is scalability—many of these materials are currently produced on a small scale and require further optimization for mass production. Additionally, the cost of production remains a major concern, particularly for developing economies that may struggle to access and integrate these high-tech materials into their industries. Governments and private enterprises must invest in research and development to create cost-effective production methods, ensuring that these innovations reach a global scale.

Another critical challenge is environmental sustainability. While many advanced materials contribute to sustainability—such as graphene in energy storage and perovskites in solar energy—their production processes can have unintended environmental impacts. Toxic byproducts, resource-intensive synthesis methods, and challenges in recycling these materials pose risks that must be addressed. Researchers are now exploring eco-friendly synthesis techniques and sustainable material alternatives to minimize the environmental footprint of these innovations. Ensuring a circular economy for advanced materials will be crucial in maintaining their long-term viability.

Moving forward, interdisciplinary collaboration will play a key role in unlocking the full potential of materials science. The convergence of materials science with artificial intelligence, biotechnology, and quantum physics is already driving new discoveries. AI-driven materials discovery is accelerating the identification of novel compounds with enhanced properties, while bioengineering is enabling the creation of living materials that can self-repair and adapt to their environments. These interdisciplinary efforts will be essential in overcoming current limitations and pushing the boundaries of what materials can achieve.

Final Thoughts

Materials science is entering a new era of discovery and innovation, with graphene, smart materials, 4D printing, bio-inspired materials, perovskites, and topological insulators leading the charge. These materials are not just theoretical breakthroughs—they are shaping the future of technology, enabling more sustainable energy solutions, next-generation computing, and smarter, more adaptive systems. However, the path to widespread adoption requires overcoming challenges related to scalability, cost, and environmental sustainability.

The next few decades will be crucial in determining how these materials evolve and integrate into society. Governments, industries, and researchers must work together to bridge the gap between laboratory discoveries and real-world applications. By addressing production challenges, promoting sustainable practices, and fostering interdisciplinary collaborations, we can unlock the full potential of these innovations and create a world where materials work in harmony with technology and the environment.

The possibilities in materials science are limitless. As we continue to explore new frontiers, the innovations of today will become the foundations of tomorrow, shaping a more advanced, efficient, and sustainable world.

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PRODUCTION OF WE43 MG MATRIX B 4 C ADDED FUNCTIONAL GRADED MATERIALS VIA POWDER METALLURGY METHOD AND INVESTIGATION OF THEIR MECHANICAL PROPERTIES

TOZ METALURJİSİ YÖNTEMİYLE ÜRETİLEN WE43/B_4C FONKSİYONEL DERECELENDİRİLMİŞ KOMPOZİTLERİN ÜRETİMİ VE MEKANİK ÖZELLİKLERİNİN İNCELENMESİ

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ABSTRACT

Introduction and Purpose: Magnesium alloys are preferred in current industrial areas due to their lightness, strength, and good biocompatibility properties. Among the Mg alloys, WE43 alloy, which contains rare earth elements, is widely used, especially in aerospace, biomedical, and defense areas. WE43 alloy has excellent mechanical properties, corrosion resistance, and thermal stability. However, the inadequacy of the hardness and wear resistance of pure magnesium alloys necessitates reinforcement with ceramic reinforcements to improve these properties. One of the effective methods of increasing the properties of magnesium alloys is reinforcement with boron carbide (B_4C) particles. B_4C reinforcement, which offers high hardness, thermal stability, and superior wear resistance, is widely used to improve the material's mechanical performance. Functionally Graded Materials (FGM) are innovative materials that provide advanced mechanical properties and thermal stability by gradually changing composition and structure. Powder metallurgy (PM) techniques are widely preferred in FGM production to control material composition and microstructure precisely.

Materials and Methods: In this study, WE43 magnesium alloy matrix and B_4C reinforced functional graded material (FGM) samples were produced using the powder metallurgy (PM) method. To examine the effects of ceramic reinforcement, B_4C particles were added to the WE43 matrix at 5%, 10%, and 15%. The mechanical alloying process ensured the homogeneous distribution of reinforcement particles. The prepared powder mixtures were compressed under controlled pressure by cold pressing and performed. Then, the samples were produced in the final form by hot pressing method at 525°C for 60 minutes to ensure density and microstructure homogeneity. A hot pressing process was carried out to increase the material's mechanical

strength and improve the interfacial bonding. The produced samples were analyzed by density, microstructure characterization, and mechanical tests and evaluated by ASTM standards.

Results: The mechanical tests carried out within the study determined that the mechanical performance of the composite materials produced by adding B_4C reinforcement to the WE43 magnesium alloy matrix was significantly increased. The lowest hardness value was 67.3 HV (0.5) in the WE43 material without reinforcement, while the highest was 105.5 HV (0.5) in the FDM material.

Discussion and Conclusion: The findings show that B_4C reinforcement increases the hardness and mechanical strength of WE43 matrix composites, thus strengthening their potential for structural applications. The results suggest that such lightweight, high-strength, and wear-resistant materials can be considered alternatives to aluminum and other traditional alloys in aerospace, biomedical, and engineering applications.

Key Words: Powder Metallurgy, Mg Alloy, Mechanical Testing, Composite Materials,

GİRİŞ

Metal matrisli kompozitler, son dönemde teknoloji ve sanayi alanında özellikle uzay, havacılık ve taşımacılık alanlarında kendilerine geniş bir kullanım alanı bulmuşlardır. Bu geniş kullanım alanının en büyük nedeni çok iyi aşınma dayanımları ve iyi derece elektriksel ve termal özelliklerinin yanı sıra üstün mekanik özellikler göstermiştir [1]. Magnezyum alaşımları, hafiflik, kolay işlenebilirlik ve döküm, çok yüksek mekanik özellikleri sayesinde metal matrisli kompozitlerde (MMK) matris alaşımı olarak son dönem oldukça çok araştırılmaya ve kullanılmaya başlanmıştır. Magnezyum alaşımlarının sağladığı dayanım/yoğunluk performansları sayesinde uzay, havacılık ve biyomedikal alanına kadar bir çok alanda kendine yer bulmaktadır [2]. Magnezyum alaşımları, alüminyum alaşımlarından %37, çelik alaşımlarından ise %78 daha hafiftir fakat, yüksek sıcaklıkta mekanik özellikleri, düşük korozyon ve aşınma dayanımları kullanım alanlarında belli sınırlamalar oluşturmaktadır. Bu yüzden magnezyum alaşımlarına seramik partikül takviyesi ile üretilen magnezyum matrisli seramik partikül takviyeli kompozitler geliştirilerek, magneyum alaşımlarının kullanım alanlarında bu özellikleri geliştirilmesi amacıyla araştırmalar yapılmaya devam edip kullanım alanlarıda genişletilmiştir. [3] Ayrıca nadir topra elementleri içeren magnezyum WE serisi alaşımlarda çok iyi aşınma direnci, korozyon direnci, sürünme ve yüksek spesifik mekanik özellikler göstermektedir. WE magnezyum alaşımları ve SiC, B_4C, Al_2O_3 vb. seramik takviyeleri ile bu alaşımın aşınma dayanımı gibi sertliğe bağlı özellikleri iyi oranda arttırılabilmektedir [4].

MMK'lar birden fazla faz içeren malzemelerdir. Sürekli ve süreksiz faz içeren, matris ve takviye içeren bu kompozitler hem her bölgesinde homojen takviye oranına sahip hem de tek parça içerisinde farklı takviye oranlarına sahip fonksiyonel derecelendirilmiş kompozitler olarak üretilmektedir. Fonksiyonel derecelendirilmiş malzeme (FDM), genellikle numunenin bir tarafından diğer tarafına katmanlı olarak geçiş sağlayanmatris içerisinde takviye elemanı oranlarının değiştiği ve her katman da ayrı mekanik, fiziksel ve kimyasal özellikler gösterebilen malzemelerdir [5]. FDM döküm, santrifüj ve kaplama kompozit olarak farklı guruplarda üretimi gerçekleştirilebilmektedir. Kompozit malzemelerin üretimi için yaygın olarak kullanılan katı faz prosesi, Toz Metalürjisi (TM) , Sürtünme Karıştırma Prosesi (FSP) vb. yöntemlerdir. TM yöntemi ile üretilen FDM, farklı seramik partikül takviye oranlarına sahip kompozit malzeme türünü ifade etmektedir [6]. FGM'de takviye oranlarına bağlı değişen mekanik özellikleri belirlemek amacıyla üretimi, mekanik ve tribolojik özellikleri belirlemede tek bir formda gerçekleştirilmektedir [7].

Bu çalışmada WE43 alaşım matris içerisine B_4C takviye partikülleri her katmanda farklı olacak şekilde sırasıyla ağ. %5, 10, 15 B_4C takviye oranlarında toz metalurjisi yöntemi ile

üretilebilirliği araştırılmıştır. Mikroyapı karakterizasyonları ile üretimin sonuçları incelenmiştir. Her katmandaki mekanik özellikleri farkı hakkında bilgi sahibi olabilmek için katman katman mikroyapı üzerinden mikrosertlik değerleri incelenmiştir.

MATERYAL VE METOT

Deneysel çalışmalar kapsamında, kompozit malzemelerin üretimi için matris malzemesi olarak kullanılan ön alaşımlı WE43 tozu, Magnesium Elektron® Ltd. firmasından temin edilmiştir. WE43 tozunun kimyasal bileşimi, Tablo 1'de detaylı olarak sunulmaktadır. Çalışmada, metal matrisli kompozit numunelerin üretimi için, ön alaşımlı WE43 metal tozuna seramik partikül takviye elemanı olarak (B_4C) parçacıklarıyla kombin edilmiştir. Bu kombinasyon, metal matrisli kompozitlerin mekanik ve termal özelliklerini geliştirmek amacıyla literatürde yaygın olarak kullanılan bir yöntemdir. Böylece, hem matris malzemesinin hem de takviye elemanlarının etkileşiminden faydalanılarak daha yüksek performanslı kompozit materyaller elde edilmesi hedeflenmiştir.

Tablo1.WE43 tozu kimyasal kompozisyonu

Alaşım	Mg	Y	Zr	Nd	Gd
% ağ.	Kalan	3,7-4,3	0,4-1	2-2,5	0,1-1,9

Deneysel çalışmanın gerçekleştirileceği deney numunenin üretimi ve karakterizasyon olarak iki farklı aşamada gerçekleştirilecektir. WE43 matris tozları ile ağ. % 5, 10, 15 takviye olacak şekil B4C tozları ayrı ayrı tartılarak hazılanmıştır. Matris malzemesi WE43 ve takviye elemanı B_4C seramik partikül takviyesi ile yüksek enerjili ve atmosfer kontrollü üç boyutlu gezegen tipi bilyalı karıştırıcıda 1/5 Zr_2O_3 toz/bilye oranında 60 dakika 300 rpm hızda karıştırılmıştır. Her oranda karışım işlemleri gerçekleştirildikten sonra toz malzeme H13 sıcak iş takım çeliğinden elde edilmiş 40x40mm kalıp içerisine numunenin yüksekliği ve katmanların boyları belirlendikten sonra yükseklik ölçülerine göre tozlar sırayla kalıbın içerisini dolduracak şekilde dökülmüştür. Daha sonra, 525°C sıcaklık altında 10 MPa ön yük uygulanarak 60 dakika ön yük sonrası 350 MPa basınç altında sıcak presleme işlemi gerçekleştirilerek kompozit numune üretilmiştir.

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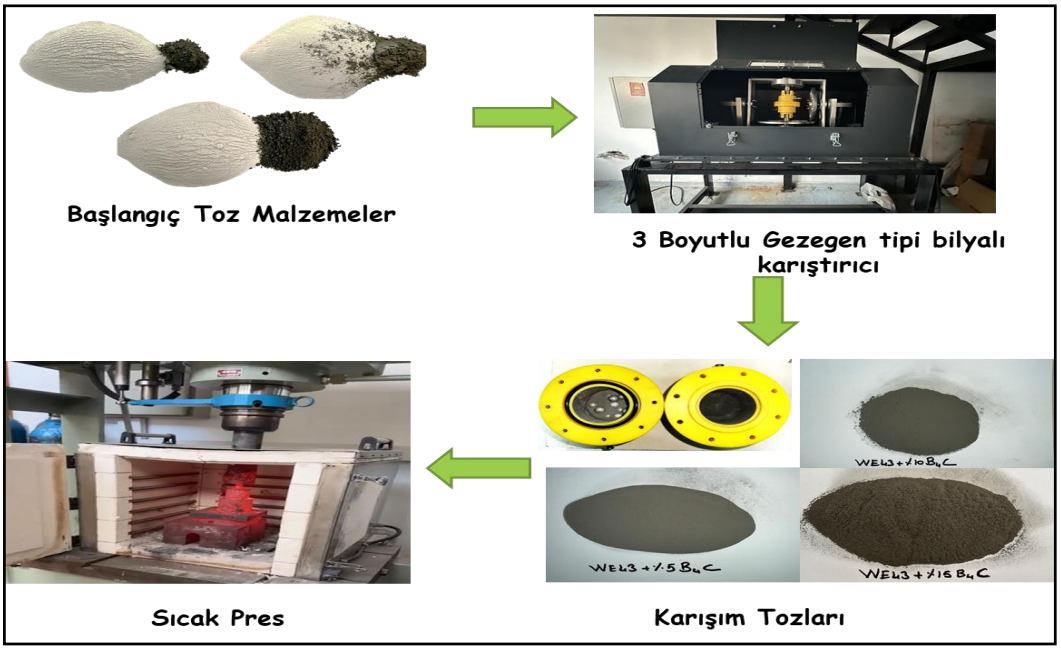


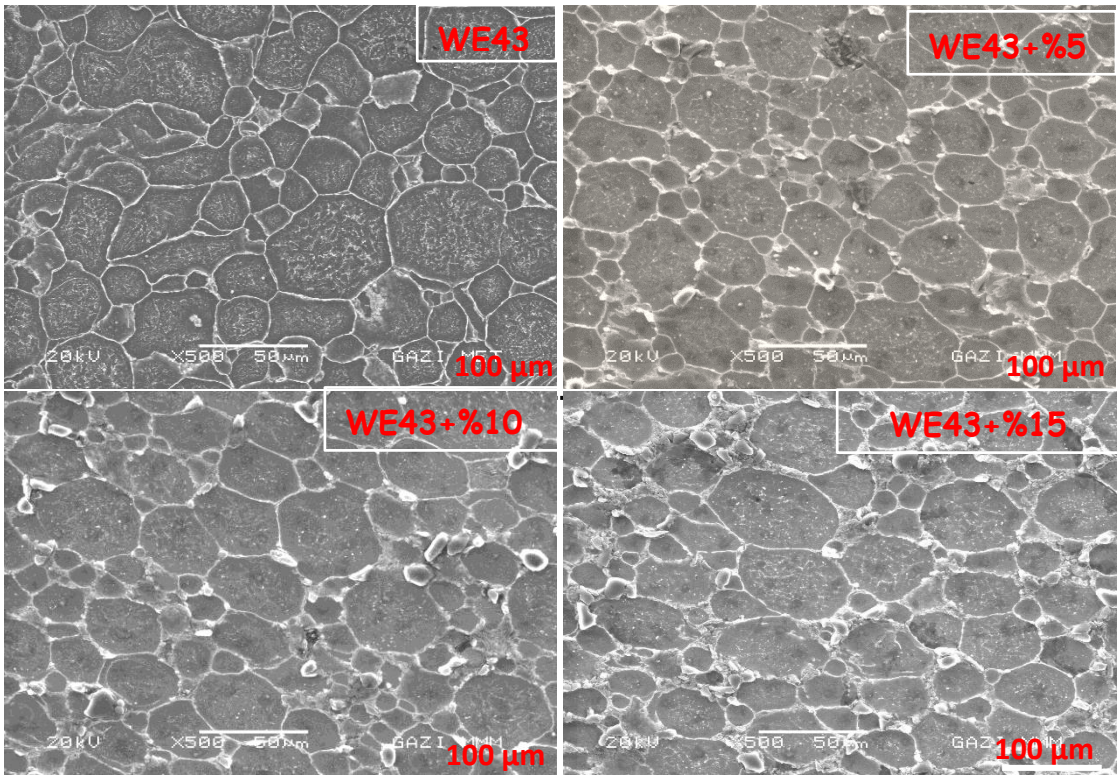
Şekil 1. İş akış şeması

Üretilen FDM kompozitler, mikroyapı analizleri için Gazi Üniversitesi, Metalurji ve Malzeme Mühendisliği Bölümü, Metalografi laboratuvarında zımparalama, parlatma ve dağlama metalografik ön işlemlerinden geçirildikten sonra, mikroyapı analizleri için Taramalı Elektron Mikroskobu (SEM) görüntüleri ve EDS analizleri yapılmıştır. Kompozit tabakalarındaki sertlik farklılıklarını ölçmek için vickes sertlik cihazında 500 gr yük altında 11 sn yükleme süresinde mikrosertlik analizleri gerçekleştirilmiştir.

DENEYSEL SONUÇLAR

Mikroyapı Analiz

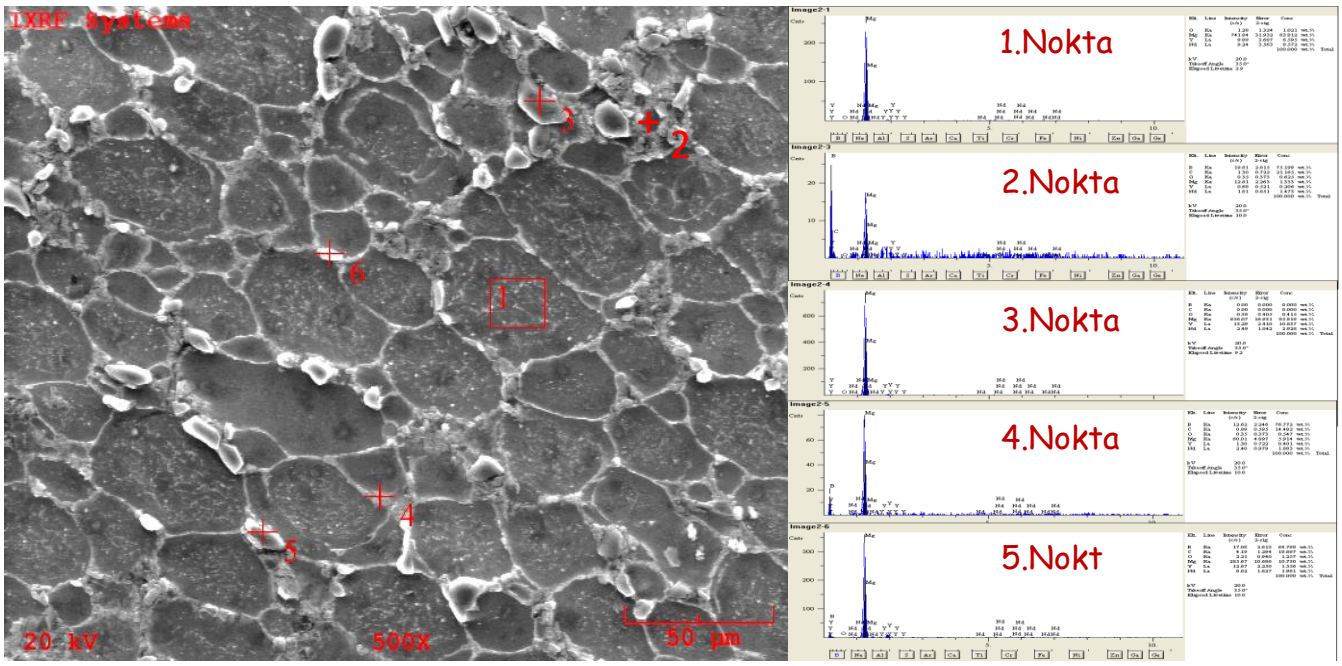
Üretimi gerçekleştirilen kompozit numunelerin sinterleme davranışlarının incelenmesi amacıyla taramalı mikroskopta mikro yapı analizleri gerçekleştirilmiştir. Şekil 2' te verilen tanelerarası boyun bölgelerinin tamamlanarak tanelerin birleştiği ve bulk bir matris yapısı haline geldiği belirlenmiştir. Saf WE43 bölgesi incelendiğinde tane sınırları beyaz renkte belli olmaktadır. Kompozit bölgeler incelendiğinde tane sınırlarında etrafı beyaz renkte merkezi gri renkte olacak şekilde B_4C seramik takviyeleri gözlemlenmiştir. Katman da B_4C oranı arttıkça, bu seramik partiküllerinin mikroyapı görüntüsünde sayılarının arttığı görülmüş olup, tanelerin etrafında gözenekleri belirten siyah bölgelerin bulunmaması WE43 matrisinin B_4C partiküllerini iyi bir şekilde ıslattığı ve fonksiyonel derecelendirilmiş kompozit parçanın başarı ile üretildiğini göstermiştir.



Şekil 2.WE43 matris içeren kompozit numunelerin SEM görüntüleri.

Şekil 3' te, fonksiyonel derecelendirilmiş malzemenin %15 B_4C takviyesi içeren mikroyapı görüntüsünden alınan EDS analizleri verilmiştir. Matris üzerinden alınan bölgesel EDS analizinde Mg, Y ve Nd elementlerinin bulunduğu B_4C bulunmadığı tespit edilirken tanelerin arasında bulunan farklı görünüme sahip partiküllerden alınan 2. 4. ve 5. noktalarda B ve C elementlerinin olduğu görülmüş olup bu yapıların B_4C partikülleri olduğu saptanmıştır. 3. Noktadan alınan daha farklı görünüme yapıdan alınan nokta analizinde ise bu yapınında WE43 matrisinin parçası olduğu belirlenmiştir. EDS analizinin alındığı görüntüde de Şekil 2. de verilen SEM analizlerinde olduğu gibi boyun verme işleminin tamamlanarak sinterlemenin

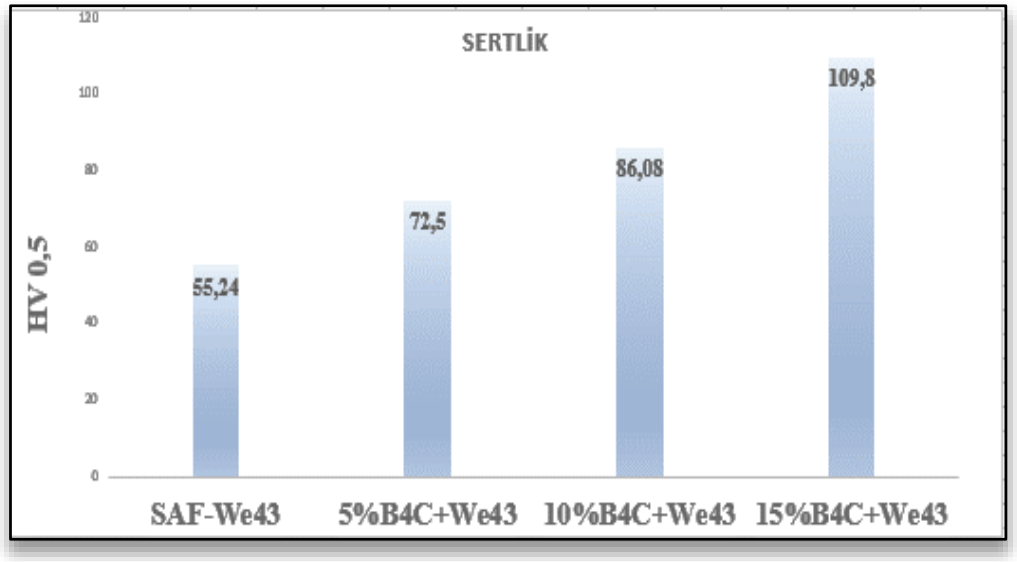
tamamlandığı ve B_4C tanelerinin WE43 matrisi ile iyi bir ıslatma özelliği göstererek matris ve tane arayüzeyinin iyi bir şekilde bağlandığı görülmüştür. Bu bağlanmada özellikle yüksek sıcaklıkta uygulanan basıncın etkisinin önemli olduğu düşünülmektedir.



Şekil 3.Sıcak presleme ile üretilmiş FDM kompozit %15B_4C katman EDS analizi

Sertlik Ölçümü

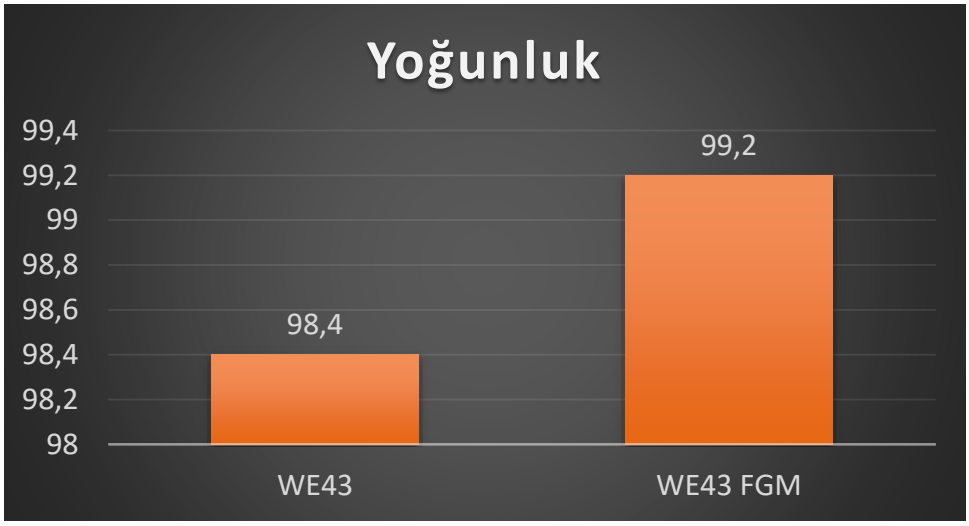
Deney numunenin Şekil 4' de sertlik değerleri katmanlar arası incelendiğinde 500 gram yük altında (HV 0.5) takviyesiz katmandaen düşükdeğer 55,24 HV ile saf WE43 alaşımına ait numunede belirlenirken, %5 B_4C takviyesi içeren bölgede sertlik değeri 72,5 HV , %10 B_4C takviyesi içeren bölgede ise 86,08 HV olduğu ve artan takviye oranı ile kompozit içerisindeki sertlik oranının arttığı belirlenmiştir. Seramik partikül takviye oranına bağlı olarak en yüksek %15takviye oranı içeren katmanda109,8 HV olarak tespit edilmiştir. Elde edilen bu verilerle aynı parça içerisinde farklı katmanlarda, farklı sertlik oranlarına sahip fonksiyonel derecelendirilmiş WE43 matrisli B_4C takviyeli kompozitin üretilebildiği görülmüştür. Bu fenomenin sebebinin matris içerisinde bulunan B_4C partiküllerinin matris bölgesine göre daha sert olması ve takviye oranı arttıkça matriste bir basma etkisi oluşturduğu ve matris üzerindeki bu gerilimin sertliği arttırdığı ön görülmektedir.



Şekil 4. FGM kompozit numunenin takviye oranına bağlı sertik grafiği.

Yoğunluk Ölçümü

Sıcak presleme yöntemiyle üretilen saf WE43+%5, %10, %15 katmanlı B_4C takviyeli numunenin yoğunluk ölçümleri, Arşimet prensibine göre gerçekleştirilmiştir. Elde edilen yoğunluk değerleri kıyaslandığında takviyesiz saf WE43 matris malzemesine göre takviyeli kompozit malzemenin yoğunluk değerinin arttığı sonuçlar elde edilmiştir. FGM kompozit numune ve WE43 numunelerin sinterlemelerinin yoğunları açısından da oldukça az gözeneklilik göstererek başarılı bir şekilde gerçekleştirildiği görülmüştür. Şekil 2'de verilen mikroyapı SEM görüntüleri de bu yoğunluk oranlarını desteklemektedir.



Şekil 5. Üretilmiş FGM numunenin yoğunluk grafiği.

SONUÇLAR

- SEM görüntüleri üzerinde yapılan incelemeler sonucunda, 3B karıştırıcı kullanılarak hazırlanan başlangıç kompozit tozlarının homojen bir şekilde karıştığı gözlemlenmiştir. Bu gözlem, tozların mikro yapısının düzgün dağılımını ve karışım süreçlerinin etkili bir şekilde gerçekleştirildiğini desteklemektedir.
- Yapılan çalışmada , en düşük sertlik değerinin takviyesiz WE43 numunesinde, en yüksek sertlik değerinin ise ağırlıkça %15 B4C içeren seramik takviyeli FGM kompozit

numunede elde edildiğini ortaya koymaktadır. Bu bulgu, seramik takviyelerin kompozitlerin sertlik özelliklerini önemli ölçüde artırdığını göstermektedir.

- Yoğunluk değerleri takviyesiz WE43'de 98.4% iken üretimi gerçekleştirilmiş katmanlı üretilmiş FDM kompozit numunede 99,2% olduğu belirlenmiştir.

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THE ROLE OF SIEM AND PAM INTEGRATION IN STRENGTHENING CYBERSECURITY

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Abstract

This paper examines the integration of Privileged Access Management (PAM) systems with Security Information and Event Management (SIEM) platforms and its significant impact on modern security operations. While PAM solutions are crucial in controlling and securing privileged access to critical systems and preventing unauthorized actions, SIEM systems centralize event data, offering real-time monitoring and analysis to detect potential security threats. However, when these systems operate independently, detecting insider threats and advanced attacks becomes much more difficult. This study focuses on how the integration of PAM with SIEM enhances threat detection and improves the overall incident response process. Various integration methods are discussed, such as forwarding PAM logs to SIEM systems and employing machine learning-based anomaly detection techniques. The paper highlights practical use cases where widely adopted PAM solutions are successfully integrated with leading SIEM platforms. Experimental findings show that such integrations accelerate threat detection and reduce false positive alert rates significantly. In conclusion, integrating PAM and SIEM not only strengthens security operations by improving the identification of both insider threats and external attacks but also automates essential security processes, thus providing better protection. Future research should focus on leveraging AI-driven dynamic threat detection and integrating Zero Trust Architecture for enhanced security frameworks.

Key Words: Cyber Security, Privileged Access Management, Security Information and Event Management

USING NATURAL DEEP EUTECTIC SOLVENTS IN FOOD APPLICATIONS

GIDA ALANINDA DOĞAL DERİN ÖTEKTİK ÇÖZÜCÜLERİN KULLANIMI

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ÖZET

'Yeşil kimya' ilkeleri, toksik kimyasallardan kaynaklanan kirliliği azaltma, endüstriyel süreçleri güvenli ve sürdürülebilir hale getirme ve tüketicilere 'temiz etiketli ürünler' sunabilme ihtiyacı nedeniyle gıda sektöründe giderek önem kazanmaktadır. Doğal Derin Ötektik Çözücüler (NADES), doğal ürünlerden biyoaktif bileşikleri çıkarmak için geleneksel organik çözücülere alternatif, çevre dostu bir teknik olarak ortaya çıkmıştır. Şekerler, organik asitler ve alkoller gibi doğal bileşenlerin karıştırılmasıyla oluşturulan bu çözücüler, düşük toksisite, biyolojik olarak parçalanabilirlik ve yüksek çözme yeteneği gibi avantajlar sunmaktadır. Doğal derin ötektik çözücüler, derin ötektik çözücülerin (DES) yeni bir türevidir. Doğal Derin Ötektik Çözücüler, karışımı oluşturan bileşenlerin şekerler, organik asitler, bazlar ve amino asitlerden meydana gelmesi nedeniyle "doğal" olarak kabul edilir. Doğal Derin Ötektik Çözücüler, bileşenlerine bağlı olarak hem hidrofilik hem de hidrofobik bileşikleri özütleyebilmektedir. Doğal Derin Ötektik Çözücüler, ısıtma, vakumlu buharlaştırma, dondurarak kurutma, ultrasonikasyon veya mikrodalga destekli sentez gibi çeşitli yöntemlerle bileşenlerin türüne ve istenen özelliklere bağlı olarak oda sıcaklığında berrak, çökelti oluşturmayan bir çözücü elde etmek amacıyla belli oranlarda karıştırılmasıyla hazırlanmaktadır. Günümüze kadar yapılan çalışmalar, bitkisel kaynaklardan fenolik bileşikler, karotenoidler, karbonhidratlar ve alkaloidler dahil çeşitli maddelerin ekstraksiyonunda etkinliklerini vurgulamaktadır. Doğal Derin Ötektik Çözücü uygulamaları, ekstraksiyon dışında gıda muhafazasını, analizini ve hatta tat arttırma özelliğini de kapsamaktadır. Özellikle, geleneksel çözücülere kıyasla raf ömrünü uzatarak ekstrakte edilen bileşikleri stabilize edebilirler. Bu derlemede, Doğal Derin Ötektik Çözücülerin hazırlanması, özellikleri, gıda alanında uygulamaları ve toksisitesi konuları ele alınmaktadır.

Anahtar Kelimeler: NADES, Yeşil kimya, Gıda.

ABSTRACT

The principles of "green chemistry" are becoming increasingly important in the food industry due to the need to reduce pollution from toxic chemicals, make industrial processes safe and sustainable, and provide consumers with "clean label products." Natural Deep Eutectic Solvents (NADES) have emerged as an environmentally friendly alternative technique to traditional organic solvents for extracting bioactive compounds from natural products. These solvents, created by mixing natural components such as sugars, organic acids, and alcohols, offer advantages like low toxicity, biodegradability, and high dissolving ability. Natural deep eutectic

solvents are a new derivative of deep eutectic solvents (DES). Natural Deep Eutectic Solvents are considered "natural" because the components of the mixture consist of sugars, organic acids, bases, and amino acids. Natural Deep Eutectic Solvents can extract both hydrophilic and hydrophobic compounds, depending on their components. Natural Deep Eutectic Solvents are prepared by mixing the components in certain ratios, depending on the type of components and desired properties, using various methods such as heating, vacuum evaporation, freeze drying, ultrasonication, or microwave-assisted synthesis, to obtain a clear, non-precipitating solvent at room temperature. Studies to date have highlighted their effectiveness in extracting various substances, including phenolic compounds, carotenoids, carbohydrates, and alkaloids from plant sources. Natural Deep Eutectic Solvent applications include food preservation, analysis, and even flavor enhancement, in addition to extraction. In particular, they can stabilize the extracted compounds by extending their shelf life compared to traditional solvents. This review covers the preparation, properties, applications in the food field, and toxicity of Natural Deep Eutectic Solvents.

Keywords: NADES, Green chemistry, Food.

GİRİŞ

Toksik kimyasallardan kaynaklanan kirliliğin azaltılması, endüstriyel süreçlerin daha güvenli ve sürdürülebilir hale getirilmesi, tüketicilerin ihtiyaç duyduğu ‘temiz etiketli ürünler’ sunulması gibi gereksinimler nedeniyle ‘yeşil kimya’ ilkeleri, tarımsal gıda sektöründe gittikçe önem kazanmaktadır. Bu bağlamda, sadece besin olarak değil, aynı zamanda antioksidan, antimikrobiyal, aroma verici ve renklendirici olarak işlevleri bulunan fitokimyasal içeren ürünlere giderek ilgi artmaktadır. Ek olarak, sürdürülebilirlik girişimleri, kimyasallar, ilaçlar, kozmetikler, gıdalar ve diğer yüksek katma değerli ürünler için bir biyolojik kaynak olan gıda atıklarını ve yan ürünlerini verimli bir şekilde değerlendirmek için büyük çaba harcanmaktadır. Bu nedenle gıda endüstrisi; atığı azaltma, yan ürünleri değerlendirme ve nutrasötik olarak kullanılabilen biyoaktif bileşikleri izole etme sorunuyla karşı karşıyadır (Mišan vd., 2020).

Doğal derin ötektik çözücüler (NADES) ilk olarak Choi vd. (2011) tarafından canlı hücrelerde bulunan, su ve lipitlerden farklı, ara polariteli bileşiklerin biyosentezi, taşınması ve depolanması için alternatif bir ortam olarak önemli rol oynayan sıvı sınıfı şeklinde tanımlanmıştır. Daha sonra, yeni ve gelişmiş yeşil çözücü sınıfı, dördüncü nesil iyonik sıvılar olarak kabul edilmiştir (Mišan vd., 2020).

NADES kavramı, doğada belirli metabolitlerin bolluğunun ve doğal ötektik karışımların varlığının gözlemlenmesinden doğmuştur. "Biyosentetik olarak ilkel metabolitler" (PRIM) ve hatta kersetin gibi bazı lipofilik bileşiklerin, birincil metabolik işlevlerinin ötesinde fizyolojik roller üstlenerek NADES bileşenleri olarak işlev görebileceği varsayılmaktadır. Bu çeşitli bileşenler, NADES'in geniş bir polarite aralığına ulaşmasını sağlayarak potansiyel uygulama alanlarını genişletmektedir (Liu vd., 2018).

NADES, düşük üretim maliyeti, basit sentez, geniş polarite aralığı, biyolojik parçalanabilirlik ve sürdürülebilirlik gibi avantajlara sahiptir. Özellikle düşük veya sıfır toksisitesi nedeniyle geleneksel çözücülerin yerine geçebilmektedir. Düşük buhar basıncı, nispeten geniş çözelti kombinasyonu, termal kararlılık veya yanmazlık gibi kimyasal özelliklere sahip olması en büyük avantajıdır. Ayrıca, NADES toksik olmaması, yüksek saflıkta olması ve atık içermemesi nedeniyle yeni bir yeşil çözücü türü olarak doğrudan gıda formülasyonlarına eklenebilmesi onu, diğer çözücülere göre avantajlı hale getirir (Wu vd., 2022).

Derin ötektik çözücülerin (DES) "doğal" türevi olan NADES, geleneksel çözücülere göre daha çevre dostudur. Şekerler, organik asitler ve amino asitler gibi birincil bitki metabolitlerinden oluşan NADES, iyonik, nötr ve amino asit bazlı tiplere ayrılır. Hem hidrofilik hem de lipofilik bileşikler için geniş bir polarite ve ekstraksiyon yeteneği yelpazesi sunar. İyonik sıvılar (IL'ler)

ve geleneksel çözücülerle karşılaştırıldığında; NADES kolay bulunabilmesi, düşük toksisiteli bileşenlerden oluşması, uçucu olmaması, geri dönüştürülebilir, düşük enerjili sentez gerektirmesi ve karşılaştırılabilir ekstraksiyon performansı sunması gibi avantajlara sahiptir (Tablo1). "Doğal" bileşimleri, yeşil teknoloji ilkeleriyle uyumlu olup bu özellik NADES'i gıda uygulamaları için uygun hale getirir (Hikmawanti vd., 2021).

NADES, yenilenebilirlikleri, biyolojik olarak parçalanabilirlikleri ve biyolojik uyumlulukları nedeniyle geleneksel çözücülere çevre dostu alternatifler olarak giderek daha fazla ilgi görmektedir. Doğal ürünlerden oluşmaları, organizmalar tarafından biyosentez ve metabolik parçalanmaya olanak tanır (Liu vd., 2018).

Tablo 1. IL, DES ve NADES çözeltilerinin özelliklerinin karşılaştırılması (Benvenutti vd., 2019; Hikmawanti vd., 2021)

Özellik	IL	DES	NADES
Bileşenler	İyonik Bağ:organik katyon ve organik veya inorganik anyon	Hidrojen Bağları: HBA, HBD ile karıştırılmış	Hidrojen Bağları: HBA, HBD ile karıştırılmış (doğada bulunan primer metabolitler)
Erime Noktası	100 °C'nin altı	100 °C'nin altı	100 °C'nin altı
Polarite Aralığı	Geniş	Geniş	Geniş
Çözünürlük	Yüksek	Yüksek	Yüksek
Stabilite	Stabil (sıvı)	Bazıları katılaşabilir	Bazıları katılaşabilir
Viskozite	Yüksek	Yüksek	Yüksek
Termolabilite	Isıya dayanıklı	Isıya dayanıksız	Isıya dayanıksız
Buhar basıncı	Düşük	İhmal edilebilir	İhmal edilebilir
Ayrılma	Kolay	Zor	Zor
Maliyet	Nispeten yüksek	Nispeten Düşük	Nispeten Düşük
Sentez olanağı	Düşük, talep edilen solvent kullanımı	Yüksek	Yüksek
Çözücü Hazırlanması	Zor	Kolay	Kolay
Toksisite	Yüksek	İyonik sıvılara göre düşük	Düşük
Biyolojik parçalanabilirlik	Orta	Yüksek	Yüksek
Çevre Dostu	Orta	Yüksek	Yüksek
Geri Dönüştürülebilirlik	Evet	Evet	Evet

DOĞAL DERİN ÖTEKTİK ÇÖZÜCÜLER VE ÖZELLİKLERİ

Derin ötektik çözücüler (DES), iyonik sıvıların bir alt sınıfıdır. DES, uygun molar oranlarda birleştirildiğinde her bir bileşenin erime noktasından daha düşük bir erime noktasına sahip olan iki veya üç bileşenin ötektik karışımıdır. Bu berrak sıvı karışımlarının bileşenleri, hidrojen bağı alıcıları (HBA) ve hidrojen bağı vericileridir (HBD). Kolin klorür, DES hazırlanmasında en yaygın kullanılan HBA'dır (Santana vd., 2019). Doğal derin ötektik çözücüler (NADES), DES'in yeni bir türevidir. NADES, ötektik karışımın bileşenleri şekerler, organik asitler ve bazlar ve amino asitler gibi birincil metabolit grupları (bitki tarafından hayatta kalmak için doğal olarak kullanılan) olduğundan "doğal" olarak kabul edilir. NADES: (1) iyonik sıvı NADES (asit ve bazdan yapılmış), (2) nötr NADES (sadece şekerlerden veya şeker ve polialkollerden yapılmış), (3) asitli nötr NADES (şeker/polialkol ve organik asitlerden yapılmış), (4) bazlı nötr NADES (şeker/polialkol ve organik bazlardan yapılmış) ve (5) amino asit bazlı NADES (amino asitler ve organik asitler/şekerlerden yapılmış) olarak gruplandırılabilir (Hikmawanti vd., 2021).

NADES'lerin etki mekanizması, farklı moleküllerdeki hidrojen bağlarına dayanır. Bu bağlar, çözücünün içinde karmaşık bir ağ oluşturur ve çözünürlüğü artırır. NADES'ler, özellikle bitkisel kaynaklı bileşiklerin (fenolik bileşikler, lignin, pektin gibi) ekstraksiyonunda etkilidir (Chen ve Lahaye, 2021). Literatürde NADES ile ekstraksiyonun etki mekanizması; hidrojen bağı yoluyla hedef bileşiklerle doğrudan etkileşim ile etkili şekilde çözme ve dolaylı olarak

hücre duvarında bozulmaya yol açma şeklinde belirtilmiştir (Hikmawanti vd., 2021). Ekstraksiyon verimi, NADES'in viskozitesi, iletkenliği, yoğunluğu ve polaritesi gibi özellikleri, bileşenlerinin özellikleri ve moleküller arası etkileşimleriyle yakından ilişkilidir. Su, hidrojen bağlarını zayıflatarak, erime noktalarını düşürerek ve çözücü özelliklerini değiştirerek NADES'in özelliklerini etkiler. Özellikle, az miktardaki su viskoziteyi önemli ölçüde azaltabilir, iletkenliği artırabilir. Bu durum, NADES'in su içeriğine duyarlılığını gösterir (Mišan vd., 2020). Viskozite, kritik bir faktör olup yüksek viskozite kütle transferini engeller. Sıcaklık, viskoziteyi azaltabilir. %10 ile %80 arasında değişen su ilavesi, hidrojen bağlarını bozar ve viskoziteyi modüle eder, ancak %50 molar fraksiyonunu aşmak sistemin standart bir çözelti gibi davranmasına neden olabilir (Cannavacciuolo vd., 2022). İletkenlik ve viskozite ters orantılı olup sıcaklık ve su içeriğinden etkilenir. Artan sıcaklık, kinetik enerjiyi yükselterek iletkenliği artırır, viskoziteyi azaltır. Su içeriği, başlangıçta iletkenliği artırır, ancak yüksek seviyelerde azaltabilir (Liu vd., 2018). Polarite, NADES'in ekstraksiyon yeteneklerini ve diğer çözücülerle karışabilirliğini etkileyen kritik bir özelliktir. NADES'lerin çoğu hidrofiliktir ve polariteleri sudan daha yüksekten metanole benzer değerlere kadar değişir. Organik asit bazlı NADES'ler en yüksek polariteyi gösterirken, amino asit ve şeker bazlı NADES'ler bunu takip eder. Şeker ve polialkol bazlı NADES'ler, en düşük polariteye sahiptir (Mišan vd., 2020). Polarite, metabolitleri çözmek için gereklidir. Kolin klorür gibi sabit bir HBA kullanırken, uygun HBD'ler seçilerek polarite kontrol edilebilir. HBD olarak organik asitler genellikle şekerlerden daha polar NADES'ler hazırlamaya yol açar. Su ilavesi de polariteyi etkiler (Cannavacciuolo vd., 2022).

Organik asit bazlı NADES'ler, serbest radikalleri temizleme yeteneklerinden dolayı güçlü antioksidan aktivite gösterir. Tersine, kolin klorür ve poliollerden oluşan NADES'ler düşük antioksidan aktivite sergiler. Antioksidan özelliklerini artırmak için, hidrojen bağı alıcıları ve hidrojen bağı vericileri olarak amino asitlerin ve organik asitlerin kullanılması önerilir. Ayrıca, kuaterner amonyum tuzları veya organik asitler içeren NADES'ler, özellikle Gram-negatif bakterilere karşı önemli antibakteriyel aktivite gösterir. Bu antibakteriyel etki, NADES bileşenlerinin bakteriyel hücre duvarlarıyla etkileşimine ve hücre hasarına bağlanmaktadır (Wu vd., 2022).

DOĞAL DERİN ÖTEKTİK ÇÖZÜCÜLERİN HAZIRLAMASI

NADES, ticari olarak temin edilebilen, genellikle sudan arındırılmış doğal bileşenlerin belirli oranlarda karıştırılmasıyla hazırlanır. Hazırlama yöntemleri, NADES'in viskozite, yoğunluk ve polarite gibi fizikokimyasal özelliklerini etkileyebilir. Temel amaç, oda sıcaklığında berrak, çökelti içermeyen bir çözücü elde etmektir. Yeni NADES'ler geliştirilirken, genellikle 1:1 molar oranla başlanır ve hidrojen bağı etkileşimlerine göre ayarlamalar yapılır. Hazırlama sürecindeki saflık değerlendirmesi, NADES'in etkinliğini ve güvenilirliğini sağlamak için kritik öneme sahiptir (Liu vd., 2018).

Bileşenlerin türüne ve istenen NADES özelliklerine bağlı olarak çeşitli hazırlama yöntemleri uygulanır (Liu vd., 2018). Buharlaştırma, ısıtma ve karıştırma, dondurarak kurutma, öğütme, ultrason destekli ısıtma ve mikrodalga ile ısıtma gibi çeşitli fiziksel yöntemler başlıca hazırlama teknikleridir. Bunlar arasında, özellikle termal olarak kararsız bileşenler için faydalı olan basitliği, maliyet etkinliği ve sıcaklık kontrolü nedeniyle ısıtma ve karıştırma en yaygınlarıdır. Ancak ısıtma tekniğinde, özellikle ester oluşumunun olduğu kolin klorür bazlı NADES'lerde safsızlıklara yol açabilir (Mišan vd., 2020). Isıtma tekniğinde, bileşenler belirli bir sıcaklık aralığında (50-100°C) karıştırılarak homojen, şeffaf bir sıvı elde edilir (Liu vd., 2018).

Vakumlu buharlaştırma, bileşenlerin suda çözülüp ardından santrifüj veya döner buharlaştırıcılar kullanılarak suyun uzaklaştırılmasıyla NADES elde edilmesini sağlar. Özellikle su hassasiyeti olan bileşenler için uygundur (Cannavacciuolo vd., 2022).

Dondurarak kurutma, bileşenlerin suda çözülüp dondurulduktan sonra suyun süblimleştirilmesiyle saf NADES elde edilmesini sağlar. Özellikle yüksek saflık istenen uygulamalarda kullanılır (Mišan vd., 2020). Ultrasonikasyon ve mikrodalga destekli sentezde, reaksiyon sürelerini önemli ölçüde kısaltmak için sırasıyla ultrasonik dalga ve mikrodalga enerjileri kullanılır. Mikrodalga destekli yöntem, moleküler çarpışmaları ve dielektrik ısıtmayı indükleyerek hızlı reaksiyon imkanı sağlarken, ultrasonikasyon kavitasyon yoluyla etkileşimi teşvik eder (Wu vd., 2022). Öğütme, daha yüksek saflık elde etmek için genellikle tercih edilir (Mišan vd., 2020).

NADES hazırlamanın kolaylığına rağmen, saflık değerlendirmeleri sıklıkla göz ardı edilir. Farklı sentez yöntemlerinin fizikokimyasal özellikler üzerindeki etkisi hakkında karşılaştırmalı veriler sınırlıdır. Aynı hazırlama teknikleri kullanılsa bile aynı NADES için çoğu kez farklı özellikler gözlemlenir (Mišan vd., 2020).

DOĞAL DERİN ÖTEKTİK ÇÖZÜCÜ UYGULAMALARI

NADES, ekstraksiyon, kromatografi, biyomedikal uygulamalar ve temel araştırmalar gibi çeşitli bilimsel alanlarda umut vadeden çok yönlü çözücüler olarak ortaya çıkmaktadır. Ekstraksiyonda, özellikle doğal ürünlerin çözünürlüğü için benzersiz yetenekler sunsada yüksek viskoziteleri nedeniyle analit difüzyonunu yavaşlatabilirler. Kromatografide, ayarlanabilir polariteleri ile doğal ürünlerin seçici ayrımını sağlayarak potansiyel mobil fazlar olarak kullanılabilirler. Biyomedikal uygulamalarda, toksik organik çözücülere biyouyumlu alternatifler olarak lipofilik bileşiklerin hidrofilik polimerlere iletimini kolaylaştırabilirler. Elektrokimyasal özellikleri sayesinde ekstraksiyon süreçlerinin izlenmesi, doğal ürünlerin tespiti ve gaz yakalama gibi çevresel sorunları çözmede kullanılabilirler. NADES'lerin ohm metrik izleme ile izlenebilmesi, özelliklerinin daha derinlemesine incelenmesine olanak tanır (Liu vd., 2018).

NADES, gıda endüstrisinde çeşitli uygulamalar bulmaktadır. Dondurulmuş gıdalarda protein denatürasyonu ve buz kristali oluşumunu önlemek için etkili kriyoprotektanlar olarak kullanılabilir. Gıda analizlerinde NADES, ağır metaller ve kontaminantların belirlenmesini ve uzaklaştırılmasını kolaylaştırır (Tablo 2) (Wu vd., 2022).

Tablo 2. Başlıca NADES Uygulamaları (Wu vd., 2022)

Uygulama		Gıda Matrisi	Kullanılan NADES
Tür	Hedef Bileşik		
Kriyoprotektan		Tavuk göğsü	Prolin: Glikoz (1:1), Üre: Glikoz: Kalsiyum klorür (3:6:1), Prolin: Sorbitol (1:1), Prolin: Glikoz (5:3),
Gıda analizi	Kurşun ve kadmiyum	Yenilebilir yağlar	Kolin klorür: Üre (1:2), Kolin klorür: Okzalik asit (1:2), Kolin klorür: Etilen glikol (1:2)
	Kobalt	Çay numuneleri	Kolin klorür: Fenol (1:1, 1:2, 1:3, 1:4)
	Pestisit kalıntıları	Meyve suları ve sebzeler	Kolin klorür: o-krezol (2:1), Kolin klorür: p-krezol (2:1), Kolin klorür: 4-klorofenol (2:1)
Ekstraksiyon	Fenolik bileşikler	Portakal kabuğu atığı	Kolin klorür: Etilen Glikol (1:2, 1:3, 1:4), Kolin klorür: Gliserol (1:2, 1:3, 1:4)
		Carya cathayensis	Kolin klorür-malik asit (1:1), Kolin klorür laktik asit (1:1)
		Tarım-gıda	Laktik asit: Glikoz (5:1), Sitrik asit: Glikoz (1:1) Fruktoz: Sitrik asit (1:1)
		Sapodilla posası	Kolin klorür: Malik asit (3:2), Kolin klorür:Gliserol (1:2), Kolin klorür: Laktik asit (1:1), Kolin klorür: Üre (1:2)

		Tahıl	Kolin klorür: Gliserol (1:2)
	Antosiyaninler	Üzüm posası	Kolin klorür: Sitrik asit (2:1), Prolin: Malik asit (1:1) Betain: Malik asit (1:1), Betain: Sitrik asit (1:1) Kolin klorür: Prolin:Malik asit (1:1:1)
		Jabuticaba	Kolin klorür: Propilenglikol (1:2), Betain:Sitrik asit (3:1) Kolin klorür: Malik asit (1:1), Sitrik asit: Glikoz (1:1) Kolin klorür: Sitrik asit (1:1)
		Böğürtlen	Kolin klorür: Asetik asit (1:2), Kolin klorür: Üre (1:2), Kolin klorür: Glikoz (1:2), Kolin klorür: Ksilitol (1:2) Kolin klorür: Laktik asit (1:2), Laktik asit: Sorbitol (1:2) Kolin klorür: Sitrik asit (1:2), Asetik asit: Sorbitol (1:2) Kolin klorür: Bütandiol (1:2), Malik asit: Ksilitol (1:2) Kolin klorür: Gliserol (1:2), Sitrik asit: Ksilitol (1:2)
	Pektin	Jabuticaba	Kolin klorür: Propilen glikol (1:2), Betain: Sitrik asit (3:1) Sitrik asit: Glikoz: Su (1:1:3)
	Çözünebilir şeker	Muz	Glikoz: Kolin klorür (2:3), Fruktoz: Kolin klorür (2:3), Malik asit: Kolin klorür (1:1), Malik asit: Fruktoz (1:1) Malik asit: b-alanin (1:1), Üre: Glikoz (1:1) Malik asit: Glikoz (1:1), Üre:Fruktoz (1:1)
	Beta karoten	Kabak	Kaprilik asit: Kaprik asit (2:1, 3:1, 4:1), Kaprilik asit: Laurik asit (3:1) Pelargonik asit: Laurik asit (3:1), Kaprik asit: Laurik asit (2:1) DL-mentol: Kaprik asit (2:1), DL-mentol: Kaprilik asit (1:1) Pelargonik asit: Kaprik asit: Laurik asit (3:1:1)
Tat artırıcı	Yeni tat arttırıcılar	Maillard tipi tat arttırıcılar	Kolin klorür: Sakkaroz: Su (4:1:4), Glikoz: Sakkaroz: Su (1:1:9), Kolin klorür: Üre: Su (1:2:1), Malik asit: Sakkaroz: Su (1:1:5), Betain: Sakkaroz: Su (2:1:9), Betain: Gliserol: Su (1:2:2)
Gıda filmleri	Biyoaktif bileşikler	*Luma chequen A. Gray berry*	Laktik asit: Gliserol (1:1, 1:2, 2:1), Kolin klorür: Sitrik asit (5:4), Tartarik asit: Gliserol (1:2, 1:3, 1:4), Kolin klorür: Gliserol (4:6), Laktik asit: Glikoz (8:1), Gliserol: Glikoz (8:1)

Ekstraksiyon Amaçlı Kullanımı

NADES, özellikle gıda sektöründe, geleneksel organik çözücülere alternatif olarak ilgi görmektedir. Temel uygulama alanı, bitkisel materyallerden değerli ikincil metabolitlerin verimli bir şekilde ekstraksiyonudur. Bu metabolitler, gıda kalitesi ve besin değeri için hayati önem taşıyan fenolik asitler, flavonoidler, alkaloidler, terpenoidler ve hatta proteinlerdir. Araştırıcılar, NADES'in "daha yeşil" doğasını vurgulayarak, metanol veya etanol kullanan

geleneksel yöntemlere kıyasla daha yüksek ekstraksiyon verimleri ve daha hızlı işlem süreleri elde etme yeteneklerini ortaya koymuşlardır. Artan verimliliği, NADES'in hedef bileşiğin özelliklerine uygun ve ayarlanabilen polaritesi gibi benzersiz özelliklerine atfedilmiştir. NADES'in çok yönlülüğü, belirli bileşik sınıflarına olan uygulamalarında kanıtlanmıştır. Çeşitli meyve, sebze ve baharatlardan belirli flavonoidlerin ekstraksiyonunu etkili kılmak için NADES bileşenleri optimize edilmiştir. NADES, vanilin gibi aroma bileşiklerinin ekstraksiyonunda etkili olduğu kanıtlamıştır. Vanilya kabuklarından etanole kıyasla daha üstün performans elde edilmiştir. NADES bazlı vanilya özlerinin doğrudan gıda ürünlerinde kullanılma potansiyeli, pratik önemlerinin altını çizmektedir (Mišan vd., 2020). Solvent olarak NADES, çeşitli gıda bileşiklerinin çözünürlüğünü ve stabilitesini artırarak, onları bozulmadan korur (Wu vd., 2022).

Asit ve şeker içeren NADES'lerle alkaloit analizinde örneğin Narcissus pseudonarcissus'tan galantamin, Peumus boldus'tan flavonoidler ve aporfin alkaloidleri ekstraksiyonunda başarılı olmuştur. Mentol/kafur ve mentol/timol bazlı uçucu NADES'lerle Chelidonium majus'tan izokinolin alkaloitleri için üstün verimler göstermiştir. İzoflavonoidler için genellikle suyla zenginleştirilmiş Ultrason Destekli Ekstraksiyon (UAE) ve Mikrodalga Destekli Ekstraksiyon (MAE) gibi tekniklerle birleştirilmiş kolin klorür/sitrik asit gibi NADES'ler, kudzu kökleri ve soya melası gibi kaynaklardan genistein, daidzein ve puerarin ekstraksiyonunda etkili olduğu kanıtlamış, geleneksel yöntemlere göre zaman, maliyet ve çevresel etki açısından avantajlar sunmuştur. Benzer şekilde, NADES'ler, özellikle MAE, UAE ve makrogözenekli reçineler ve flaş kromatografi gibi saflaştırma teknikleriyle birleştirildiğinde, siyah frenk üzümü, dut ve üzüm posası dahil olmak üzere çeşitli kaynaklardan antosiyanin ekstraksiyonunda geleneksel çözücülerden verim ve stabilite açısından daha iyi performans göstermiştir. Zerdeçaldan elde edilen kurkuminoidler için kolin klorür/propilen glikol ve kolin klorür/gliserol gibi NADES'ler, ekstraksiyon verimliliğini ve biyoerişebilirliği önemli ölçüde artırmıştır. Karotenoidler gibi hidrofobik bileşikler için NADES uygulaması daha az araştırılmış olsa da son çalışmalar yağ asitlerinden yapılan hidrofobik NADES'lerin (HDES) verimli ekstraksiyon için potansiyelini göstermektedir (González-Laredo vd., 2023).

NADES'in ekstraksiyon verimliliğini artırmak ve yeşil kimya prensiplerine uymak için genellikle ultrason destekli (USAE), mikrodalga destekli (MAE) ve basınçlı sıvı ekstraksiyonu (PLE) gibi tekniklerle birleştirilir. Bu kombinasyonlar, NADES'in geleneksel çözücülere kıyasla daha düşük toksisite ve iyileştirilmiş ekstraksiyon verimi gibi avantajlar sunar. Aynı zamanda maliyetleri, riskleri, ekstraksiyon süresini ve çevresel etkiyi en aza indirir (Tablo 3) (Cannavacciuolo vd., 2022).

Tablo 3. Farklı NADES karışımları ile farklı ekstraksiyon tekniklerinin karşılaştırılması (Cannavacciuolo vd, 2022).

Ekstraksiyon Yöntemi	Kullanılan NADES	Hedef Bileşikler	Ekstraksiyon Verimi (mg/g)
Isıtma ve karıştırma	Kolin klorür-Malik asit	Fenolik bileşikler	3.2
	Kolin klorür-Üre		2.7
	Kolin klorür-Fruktoz		1.80
Ultrason destekli ekstraksiyonu	Kolin klorür-Malik asit		2.5
	Kolin klorür: Gliserol		5.6
Mikrodalga destekli ekstraksiyon	Kolin klorür-Malik asit		3
	Kolin-klorür-Okzalik asit	Antosiyaninler	170
	Kolin klorür-Laktik asit		146.1
	Kolin klorür-Fruktoz		78.5
	Kolin klorür-Etilenglikol		93.7
Vakumlu buharlaştırma	Kolin klorür-Prolin		145.5
	Kolin klorür-Üre		101.4
	Sitrik asit-Maltoz		39.2
	Sitrik asit-Fruktoz		47.4

NADESler alkaloitler, fenolik bileşikler, İzoflavonoidler, antosiyaninler, kurkuminoidler ve karotenoidler gibi biyoaktif bileşiklerin ekstraksiyonunda geleneksel çözücülere çevre dostu ve etkili bir alternatif olarak ortaya çıkmıştır. NADES'ler, çeşitli bitki kaynaklarından bu bileşikleri çıkarmak ve stabilize etmek için başarıyla kullanılmıştır. Örneğin, alkaloitler için asitler ve şekerler içeren NADES, galantamin ekstraksiyonunda etkili olurken, prolin/oksalik asit ve kolin klorür/laktik asit, flavonoidler ve aporfin alkaloitleri için başarılı olmuştur. Fenolik bileşikler için kolin klorür bazlı NADES, çeşitli bitki kaynaklarından fenolikleri ekstrakte etmede etkili olduğunu kanıtlamıştır. İzoflavonoidler için. su ile zenginleştirilmiş ve Ultrason Destekli Ekstraksiyon (UAE) ve Mikrodalga Destekli Ekstraksiyon (MAE) gibi tekniklerle birleştirilmiş kolinklorür/sitrik asit gibi NADES'ler, genistein, daidzein ve puerarin ekstraksiyonunda etkili olmuştur. Antosiyaninler için, NADES'ler, özellikle MAE, UAE ve makrogözenekli reçineler ve flaş kromatografi gibi saflaştırma teknikleriyle birleştirildiğinde, geleneksel çözücülerden daha iyi performans göstermiştir. Kurkuminoidler için, kolin klorür/propilen glikol ve kolin klorür/gliserol gibi NADES'ler, ekstraksiyon verimliliğini ve biyoyararlanımı önemli ölçüde artırmıştır. Karotenoidler gibi hidrofobik bileşikler için NADES uygulaması daha az araştırılmış olsa da son çalışmalar yağ asitlerinden yapılan hidrofobik NADES'lerin (HDES) verimli ekstraksiyon için potansiyelini göstermektedir. NADES'ler, geleneksel yöntemlere göre zaman, maliyet ve çevresel etki açısından avantajlar sunarak biyoaktif bileşiklerin ekstraksiyonunda sürdürülebilir ve etkili bir alternatif olarak öne çıkmaktadır (González-Laredo vd.. 2023).

Doğal Derin Ötektik Çözücülerin (NADES) Jabuticaba (Benvenutti vd., 2019), elma posası (Chen ve Lahaye, 2021). greyfurt kabuğu (Elgharbawy vd., 2019) ve ejder meyvesi kabuğu (Tien vd., 2022) gibi çeşitli bitki yan ürünlerinden pektin ekstraksiyonu için yeşil alternatifler olarak umut verici uygulamalarını göstermektedir. Özellikle, kolin klorür-laktik asit kullananlar gibi NADES ön işlemleri. geleneksel mineral asit ekstraksiyonunun yerini alma potansiyeli göstererek pektin geri kazanımı için daha sürdürülebilir ve çevre dostu bir yaklaşım sunmaktadır (Chen ve Lahaye, 2021).

Gıda Analizinde Kullanımı

NADES, Gıda güvenliği ve kontaminant analizinde, sentetik fenolik bileşikler, bisfenoller, pestisitler, mikotoksinler ve ağır metaller gibi birçok maddenin tespiti ve ekstraksiyonu için NADES tabanlı yöntemler geliştirilmiştir (Cannavacciuolo vd., 2022). Araştırıcılar, pirinç unundan kadmiyum gidermek için NADES'i yıkama maddesi olarak başarıyla kullanmış, gıda matrisinin besin bütünlüğünden ödün vermeden ağır metal kontaminasyonunu azaltma yetenekleri gösterilmiştir. Ayrıca, çeşitli yenilebilir yağlarda ağır metallerin hassas tespiti için NADES bazlı mikroekstraksiyon teknikleri geliştirilmiştir. Bu yöntemler, geleneksel analitik prosedürlere kıyasla basitlik, hız ve azaltılmış çevresel etki sunmaktadır (Mišan vd., 2020).

NADES, hedef bileşiklerin ayrılmasını iyileştirerek sabit fazlar veya eluentler olarak kullanılabilir. Bununla birlikte, analitik numunelerde NADES'in müdahalesi, uzaklaştırma veya geri dönüşüm stratejilerini gerektirir. Sıvı-sıvı ekstraksiyonu, makrogözenekli reçineler kullanılarak katı faz ekstraksiyonu ve antiçözücü ilavesi gibi teknikler, hedef bileşikleri geri kazanmak ve NADES'i geri dönüştürmek için kullanılır. Suyla seyreltme, NADES yapılarını bozma, verimli bileşik geri kazanımı ve çözücü geri dönüşümü sağlamak için de etkilidir. Bu yöntemler, gıda analiz süreçlerinin sürdürülebilirliğini ve verimliliğini sağlar (Cannavacciuolo vd., 2022).

Tat Artırıcı Olarak Kullanımı

NADES, Maillard reaksiyonunu hızlandırarak ve tat düzenleyicilerinin üretimini etkileyerek yeşil bir lezzet arttırıcı olarak da işlev görür. Son olarak, NADES, gıda filmlerinde bir plastikleştirici olarak kullanılarak mekanik özelliklerini iyileştirir ve sürdürülebilir ambalajlamaya katkı sunarak kaplanmış gıdaların güvenliğini ve kalitesini artırır (Wu vd., 2022).

Kriyoprotektan Olarak Kullanımı

Protein denatürasyonu ve lipid oksidasyonu gibi reaksiyonlar et ürünlerinin dondurularak depolanması sırasında meydana gelir. Kriyoprotektanlar dondurma sırasında protein denatürasyonunu önler ve et ürünlerinin raf ömrünü uzatır. NADES, suyun termal davranışını değiştirme, kristalleşmeyi engelleme ve suyun camsı geçişine yol açma özelliklerine sahiptir. Bu nedenle bir kriyoprotektan olarak yüksek potansiyele sahiptir. Laktik asit bakterileri (LAB), her türlü gıda üretiminde sıklıkla kullanılan en tipik probiyotiktir. NADES, LAB hücrelerine nüfuz etmede, buz kristali oluşumunu ve protein agregasyonunu engellemede ve iki hücre içi enzimin aktivitesini sürdürmede etkilidir. Bu nedenle NADES, dondurulmuş depolama sırasında laktik asit bakterilerinin hayatta kalmasını önemli ölçüde iyileştirebilir. NADES ayrıca gıda temas arayüzleri için antifriz olarak da kullanılabilir. Kısaca, NADES'in dondurulmuş gıda endüstrisinde yeşil ve güvenli bir antifriz olarak büyük bir potansiyele sahip olduğunu göstermektedir (Wu vd., 2022).

Gıda Filmlerinde Kullanımı

NADES ayrıca gıda filmlerinde de kullanılır. Çoğu çalışma, NADES tarafından gıda yan ürünlerinden elde edilen fenolik bileşiklerin gıda filmlerinin mekanik ve işlevsel özellikleri üzerindeki etkilerine odaklanmış ve NADES'in bir plastikleştirici olarak filmlere dahil edilmesi incelenmiştir. Kitosan genellikle gıda kalitesini iyileştirmek için bir streç film gibi kullanılır ve film özellikleri esas olarak plastikleştiriciden etkilenir. Özellikle, NADES ile kaplanmış sentetik gıdalar, geleneksel dış ambalaj malzemeleri tarafından üretilen atıkların ortadan kaldırılmasına katkıda bulunur ve taze kaplanmış gıdaların ekonomik değerini artırır, güvenlik, ekonomi ve sürdürülebilirlik sağlar (Wu vd., 2022).

DOĞAL DERİN ÖTEKTİK ÇÖZÜCÜLERİN TOKSİSİTESİ

Çevresel açıdan kabul edilebilir çözücüler olan iyonik sıvılar (IL'ler), derin ötektik çözücüler (DES'ler) ve doğal derin ötektik çözücüler (NADES'ler), bileşen türleri ve oranlarına bağlı olarak değişen toksisiteleri ve biyolojik olarak parçalanabilirlikleri açısından dikkatle değerlendirilmektedir. IL'ler, düşük buhar basınçları ve yüksek kararlılıkları nedeniyle başlangıçta umut verici görünse de sentez süreçlerindeki yüksek sıcaklık gereksinimleri ve yenilenemeyen çözücüler kullanımı, su ve toprak kirliliği gibi çevresel endişelere yol açmaktadır. IL'lerin toksisitesi, özellikle katyon türüne ve alkil zinciri uzunluğuna bağlı olarak önemli ölçüde değişir; imidazoliyum bazlı IL'ler genellikle daha toksiktir ve daha uzun alkil zincirleri hem toksisiteyi hem de biyolojik olarak parçalanabilirliği artırır. Kolin klorür bazlı DES'ler, daha yüksek biyolojik olarak parçalanabilirlikleri ve daha düşük bakteriyel toksisiteleri nedeniyle daha yeşil alternatifler olarak kabul edilir. Ancak, sitotoksisiteleri, kolin klorür ile kullanılan hidrojen bağı donörüne (HBD) bağlı olarak değişebilir (Benvenutti vd., 2019). NADES'ler, tamamen doğal ve biyolojik olarak parçalanabilen bileşenlerden oluştuğu için en yüksek çevresel dostluk düzeyini sunar ve gıda, ilaç ve kozmetik gibi endüstrilerde güvenle kullanılabilir. Ancak, NADES'lerin tek tek bileşenleri genellikle güvenli kabul edilse de karışımları, özellikle hidrojen bağları ve yük delokalizasyonundan kaynaklanabilecek sinerjik etkiler nedeniyle artan toksisite gösterebilir. Fosfonyum bazlı NADES, kolin klorür bazlı NADES'e göre daha yüksek toksisite göstermektedir. Bu nedenle, NADES'lerin çevresel ve biyolojik etkilerini tam olarak anlamak için daha fazla araştırma yapılması gerekmektedir (Cannavacciuolo vd., 2022).

SONUÇ

Doğal Derin Ötektik Çözücüler (NADES), sürdürülebilir ve çevre dostu çözücüler olarak çeşitli bilimsel ve endüstriyel alanlarda büyük bir potansiyel sunmaktadır. Geleneksel organik

çözücülere kıyasla daha az toksik olmaları, biyolojik olarak parçalanabilirlikleri ve yenilenebilir kaynaklardan elde edilebilmeleri, NADES'leri özellikle gıda, ilaç ve kozmetik gibi hassas sektörler için cazip kılmaktadır. Araştırmalar, NADES'lerin ekstraksiyon, kromatografi, biyomedikal uygulamalar ve gıda analizleri gibi alanlarda etkili bir şekilde kullanılabileceğini göstermektedir. NADES'ler, özellikle bitkisel materyallerden değerli bileşiklerin ekstraksiyonunda yüksek verimlilik ve seçicilik sunmaktadır. Fenolik bileşikler, flavonoidler, alkaloidler ve terpenoidler gibi biyoaktif bileşiklerin NADES kullanılarak ekstraksiyonu, geleneksel çözücülere göre daha hızlı ve çevre dostu bir alternatif sunmaktadır. Gıda endüstrisinde, NADES'ler aroma bileşiklerinin ekstraksiyonu, gıda katkı maddelerinin çözünürlüğünün artırılması ve gıda güvenliği analizlerinde kullanılmaktadır. Ayrıca, NADES'lerin gıda filmlerinde plastikleştirici olarak kullanılması, sürdürülebilir ambalaj çözümleri için umut vadetmektedir.

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DEVELOPMENT OF THERAPEUTIC DEEP EUTECTIC SOLVENTS (THEDES), THEIR APPLICATION FIELDS AND FUTURE PERSPECTIVES

TERAPÖTİK DERİN ÖTEKTİK ÇÖZÜCÜLERİN (THEDES) GELİŞİMİ, UYGULAMA ALANLARI VE GELECEK PERSPEKTİFLERİ

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ÖZET

Terapötik Derin Ötektik Çözücüler (THEDES), geleneksel çözücülere bir alternatif olarak geliştirilen çevre dostu ve sürdürülebilir, en az bir bileşeni aktif farmasötik madde (API) içeren özel derin ötektik çözücülerdir. Terapötik Derin Ötektik Çözücüler, yeşil kimya prensiplerine uygun düşük toksisite, biyobozunurluk ve maliyet etkinliği gibi avantajlar sunan, biyoaktif bileşiklerin çözünürlüğünü, biyoyararlanımını ve stabilitesini artırma potansiyelinden dolayı büyük bir ilgi görmektedir. Son yıllarda yapılan çalışmalar, Terapötik Derin Ötektik Çözücü'lerin ilaç taşıma, transdermal ilaç salınımı, biyoaktif bileşiklerin korunması ve kontrollü ilaç salınımı gibi alanlarda yenilikçi çözümler sunduğunu ortaya koymaktadır. Bilimsel çalışmalar, Terapötik Derin Ötektik Çözücü'lerin farmasötik ve biyomedikal sistemlerde sürdürülebilir bir çözüm sunduğunu ve gelecekte daha geniş bir kullanım alanına sahip olabileceğini göstermektedir. Aynı zamanda, gıda sistemlerinde nutrasötik bileşenlerin çözünürlüğünü ve stabilitesini artırarak biyoaktif maddelerin raf ömrünü uzatmada da umut vadetmektedir. Ancak, düzenleyici süreçlerin netleşmesi ve endüstriyel ölçekli uygulamaların geliştirilmesi, bu çözücülerin ticari entegrasyonunu hızlandırmak için kritik öneme sahiptir. Terapötik Derin Ötektik Çözücü'lerin yeşil çözücüler alanında sunduğu yenilikçi potansiyel, ileri düzey araştırmalarla daha da derinleştirilerek yeni uygulama alanlarının keşfedilmesine olanak sağlayacağı öngörülmektedir. Bununla birlikte, Terapötik Derin Ötektik Çözücü'lerin endüstriyel ölçekte uygulanabilirliği, uzun vadeli stabilitesi, toksisite değerlendirmesi ve biyouyumluluğu gibi konular detaylı araştırılması gereken alanlar olarak öne çıkmaktadır. Bu derlemede, Terapötik Derin Ötektik Çözücü'lerin kimyasal yapısı, sentez yöntemleri, biyoaktif bileşikler üzerindeki etkileri ve potansiyel uygulama alanları ele alınmıştır.

Anahtar Kelimeler: Terapötik Derin Ötektik Çözücüler, THEDES, yeşil kimya, biyoaktif bileşikler, sürdürülebilir çözücüler

ABSTRACT

Therapeutic Deep Eutectic Solvents (THEDES) are environmentally friendly and sustainable special deep eutectic solvents developed as an alternative to conventional solvents, containing at least one active pharmaceutical ingredient (API) as a component. Therapeutic Deep Eutectic Solvents have attracted great interest due to their potential to enhance the solubility, bioavailability, and stability of bioactive compounds, as well as their advantages such as low toxicity, biodegradability, and cost-effectiveness in accordance with green chemistry principles. Recent studies have shown that Therapeutic Deep Eutectic Solvents offer innovative solutions in areas such as drug delivery, transdermal drug release, the protection of bioactive compounds, and controlled drug release. Scientific research indicates that Therapeutic Deep Eutectic Solvents provide a sustainable solution in pharmaceutical and biomedical systems and may have a broader range of applications in the future. At the same time, they hold promise in food systems by improving the solubility and stability of nutraceutical compounds, thereby extending the shelf life of bioactive substances. However, the clarification of regulatory processes and the development of industrial-scale applications are of critical importance to accelerate the commercial integration of these solvents. The innovative potential of Therapeutic Deep Eutectic Solvents in the field of green solvents is expected to be further deepened through advanced research, enabling the discovery of new application areas. Nevertheless, aspects such as industrial-scale applicability, long-term stability, toxicity assessment, and biocompatibility emerge as areas requiring detailed investigation. This review addresses the chemical structure, synthesis methods, effects on bioactive compounds, and potential application areas of Therapeutic Deep Eutectic Solvents.

Keywords: Therapeutic Deep Eutectic Solvents, THEDES, green chemistry, bioactive compounds, sustainable solvents

GİRİŞ

Son yıllarda yeşil kimya yaklaşımlarının benimsenmesiyle birlikte, geleneksel organik ve iyonik sıvılara alternatif olarak Derin Ötektik Çözücüler (Deep Eutectic Solvents, DES) geliştirilmiştir. DES'ler, belirli bir mol oranında bir araya getirilen iki veya daha fazla bileşenin birleştirilmesiyle oluşan (Smith vd., 2014; Silva vd., 2015), güçlü kovalent olmayan moleküller arası etkileşimler ile sistemin erime noktasında derin bir düşüşe yol açan çok bileşenli sıvılardır (Abdelquader vd., 2023). İyonik sıvılara (IL) benzer fizikokimyasal özelliklere sahip olmalarına rağmen, DES'ler daha az toksik, biyolojik olarak parçalanabilir ve düşük maliyetli olmaları nedeniyle çevre dostu bir uygulama olarak öne çıkmaktadır (Pereira vd., 2019; Gonçalves vd., 2023). DES'ler, hidrojen bağı alıcı (HBA) ve hidrojen bağı verici (HBD) bileşenlerinden oluşmaktadır. Bu bileşenlerin uygun oranlarda karıştırılması sonucu, bağlar arasındaki etkileşimler erime noktasını düşürerek ötektik karışım oluşturur (Yin vd., 2022). Doğal hammaddelerle sentezlenebilmeleri ve saflaştırma gerektirmemeleri, biyoaktif bileşiklerin ekstraksiyonu, kataliz, biyokataliz, elektrokimya ve karbondioksit yakalama gibi pek çok alanda uygulanabilirliği DES'leri cazip hale getirmiştir (Yin vd., 2022; Gonçalves vd., 2023). DES'lerin farmasötik alanda uygulamaları için Terapötik Derin Ötektik Çözücüler (Therapeutic Deep Eutectic Solvents, THEDES) kavramı geliştirilmiştir (Pereira vd., 2019).

DES bileşenleri olarak amino asitler, şekerler, polialkoller, organik asitler ve vitaminler kullanıldığında doğal derin ötektik çözücüler (NADES) olarak adlandırılır ve farmasötik sistemlerde biyouyumluluğu artırmak için THEDES'ler tercih edilir (Yin vd., 2022). THEDES, farmasötik formülasyonlarda ilaç biyoyararlanımını artırmada etkili bir sistemdir. Özellikle sudaki çözünürlüğü düşük olan ilaçların çözünürlüğünü artırma, cilt geçirgenliğini iyileştirme ve ilaçların kararlılığını sağlama gibi avantajlar sunmaktadır. THEDES'lerin hazırlanmasında kullanılan yöntemler arasında sıcaklık kontrollü karıştırma, öğütme, evaporasyon ve dondurarak kurutma gibi teknikler bulunmaktadır (Santos ve Duarte, 2021). Bu yöntemler,

sistemin homojenitesini ve farmasötik etkinliğini doğrudan etkilemektedir (Santana vd., 2019). THEDES'ler, sadece ilaç çözünürlüğünü artırmakla kalmayıp aynı zamanda biyoaktif bileşenlerin emilim hızını artırarak farmasötik etkinliği optimize edebilmektedir. Özellikle transdermal ilaç taşıyıcı sistemlerde THEDES'lerin kullanımı gittikçe popüler hale gelmektedir (Santos ve Duarte, 2021).

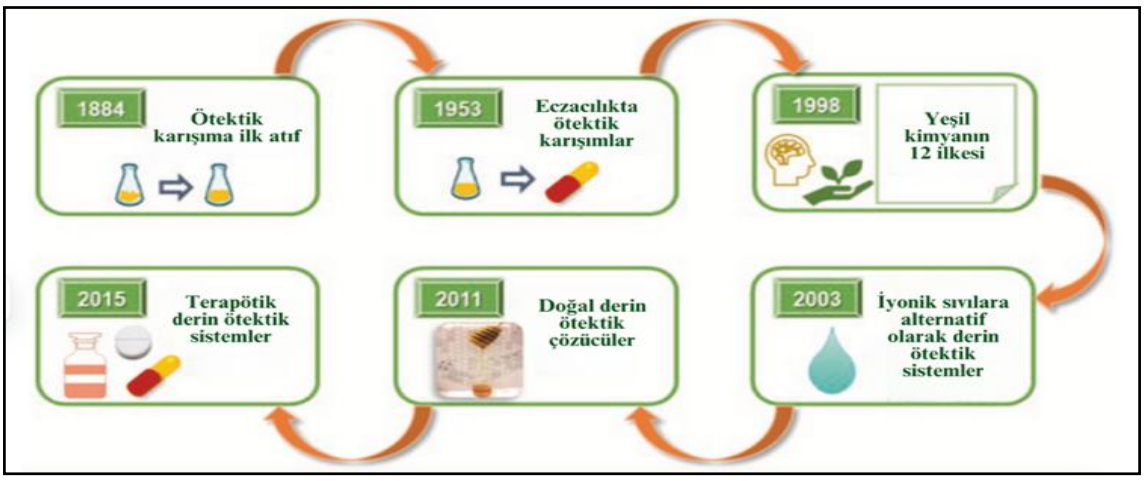
API bazlı derin ötektik çözücülerin geliştirilmesi, özellikle biyofarmasötik alanında ilaç çözünürlüğü ve geçirgenliği üzerinde büyük bir potansiyele sahip olup, bu çözücülerin farmasötik ve biyomedikal uygulamalardaki kullanımı giderek artmaktadır (Rahman vd., 2021). THEDES'lerin farmasötik etkinlik ve ilaç taşıma sistemlerindeki potansiyeli, hem yeşil kimya prensiplerine uygunluğu hem de ilaçların etkinliğini artırmadaki rolü nedeniyle oldukça dikkat çekmektedir (Bakr El-Nassan, 2024).

DES ve THEDES'ler, geleneksel organik çözücülere kıyasla düşük toksisite, biyobozunurluk haricinde, yeşil kimya prensiplerine de uygunluk göstermesi avantajlarıyla ilaç ve gıda alanında umut vadeden alternatifler arasında yer almaktadır. Ancak, THEDES'lerin kararlılığı, faz ayrışması, toksisite değerlendirmesi ve endüstriyel ölçekte uygulanabilirliği gibi konular halen araştırma gerektiren alanlardır (Pereira vd., 2019; Javed vd., 2024). Henüz THEDES türlerinin gıda sistemlerindeki kullanımı yaygınlaşmamış olup, bu alandaki çalışmalar sınırlıdır. Yakın gelecekte, bu çözücülerin gıda biliminde nutrasötiklerin çözündürülmesi ve biyoyararlanımın artırılması gibi çeşitli uygulamalarda önemli bir araştırma alanı haline gelmesi beklenmektedir.

Bu derlemede, THEDES'lerin biyoaktif bileşikler üzerindeki etkilerinin incelenmesi, farmasötik ve gıda bilimindeki uygulamalarına dair mevcut bilgilerin derlenmesi amaçlanmaktadır.

TERAPÖTİK DERİN ÖTEKTİK ÇÖZÜCÜLERİN (THEDES) ÖZELLİKLERİ

İlk olarak 1884 yılında literatürde ötektik karışımlara dair bir tanım yapılmış ve 1953 yılında farmasötik uygulamalarda kullanılma potansiyeli incelenmiştir. 1998 yılında Yeşil Kimya'nın 12 temel prensibinin belirlenmesi, çevre dostu çözücülere yönelik araştırmaları teşvik etmiş ve 2003 yılında DES'ler, iyonik sıvılara sürdürülebilir bir alternatif olarak önerilmiştir. 2011 yılında doğal derin ötektik çözücüler (NADES) keşfedilerek biyosistemlerdeki rolleri araştırılmış, 2015 itibarıyla ise terapötik derin ötektik sistemler (THEDES) geliştirilerek ilaç taşıma, biyoaktif bileşenlerin çözünürlüğünün artırılması ve farmasötik formülasyonlarda yenilikçi uygulamalar sağlanmıştır (Şekil 1). Bu gelişmeler, DES'lerin sürdürülebilir çözücüler olarak kullanımının yanı sıra farmasötik ve biyomedikal alanlarda artan önemini vurgulamaktadır (Santos ve Duarte, 2021).



Şekil 1. Terapötik derin ötektik çözücülerin gelişimi (Santos ve Duarte, 2021).

THEDES, en az bir bileşeni aktif farmasötik bileşen (API) olan özel derin ötektik çözücülerdir ve özellikle ilaç çözünürlüğünü, biyoyararlanımı ve farmasötik etkinliği artırma potansiyeli ile dikkat çekmektedir (Pereira vd., 2019). Geleneksel derin ötektik çözücülerden farklı olarak, THEDES'lerin yapısında farmasötik etkili bileşenler yer aldığından, bu çözücüler hem bir taşıyıcı hem de terapötik bir ajan olarak görev yapabilir (Gonçalves vd., 2023).

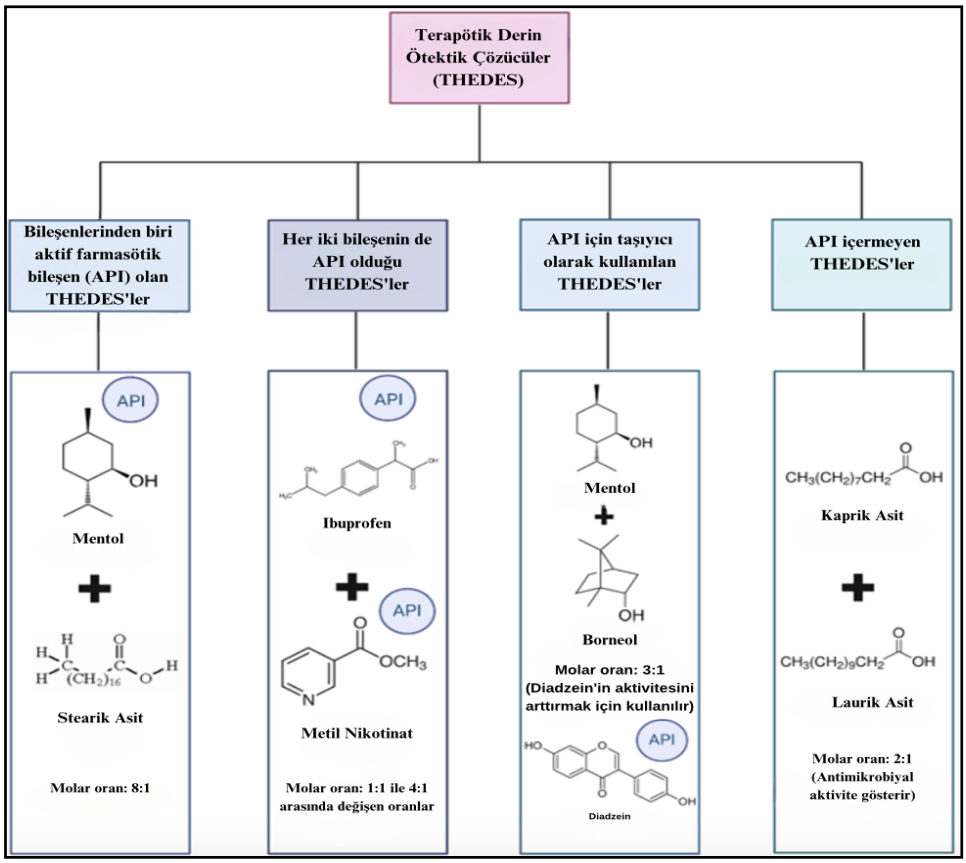
THEDES'ler, ilaç çözünürlüğü, biyoyararlanım ve geçirgenlik gibi farmasötik parametreleri iyileştirme potansiyeli sayesinde ilaç formülasyonlarında ve transdermal ilaç salınım sistemlerinde alternatif olarak kullanılmaktadır (Morrison vd., 2009; Gonçalves vd., 2023). Özellikle transdermal ilaç taşıyıcı sistemlerde THEDES'lerin kullanımı, cilt bariyerini aşmayı kolaylaştırarak ilaçların etkili bir şekilde taşınmasını sağlamaktadır (Aroso vd., 2016; Santos ve Duarte, 2021). Antibakteriyel ve antifungal özellikler taşıyan farmasötik bileşenlerle birleştirildiğinde, ilaçların terapötik etkilerini artırdığı da gösterilmiştir (Silva vd., 2018; Santos ve Duarte, 2021). Yapılan çalışmalar, terpen bazlı THEDES'lerin cilt geçirgenliğini artırmada etkili olduğunu ve farmasötik formülasyonların terapötik etkilerini iyileştirdiğini göstermektedir (Jain vd., 2002). Bu çözücü sistemler iyonik sıvılarla karşılaştırıldığında daha düşük toksisiteye, biyobozunurluğa ve çevre dostu bir yapıya sahip olmalarıyla da öne çıkmaktadır (Duarte vd., 2017).

TERAPÖTİK DERİN ÖTEKTİK ÇÖZÜCÜLERİN YAPISI VE HAZIRLANIŞI

THEDES sistemlerinde bileşen seçimi hâlâ deneme-yanılma sürecine dayanmaktadır (Bakr El-Nassan, 2024). THEDES formülasyonlarında kullanılan bileşenler, hedeflenen farmasötik uygulamalara bağlı olarak farklılık gösterebilir. Örneğin, API'nin cilt geçirgenliğini artırmak amacıyla mentol ve kafur gibi terpenler penetrasyon arttırıcı olarak kullanılırken, oleik asit ve laurik asit gibi yağ asitleri de aynı amaçla tercih edilmektedir (Rahman vd., 2021; Bakr El-Nassan, 2024). Bunun yanı sıra, kolin klorür, glikoller ve karboksilik asitler gibi suda çözünebilen bileşikler API'nin çözünürlüğünü artırma hedefiyle formülasyona dahil edilebilir (Rahman vd., 2021). THEDES'i ikinci bir bileşenle, özellikle bir polimerle birleştirme ve biyoaktif ötektik sistemleri sentezleme olasılığı, bu sistemlerin farmasötik ve biyomedikal uygulamalarında gelecekteki gelişmelerin ağını genişletecektir (Aroso vd., 2016). Yeni THEDES sistemlerinin tasarımı kolay değildir ve THEDES'i oluşturan moleküller arasında kurulan etkileşim ve ilişki türleri hakkında bilgi eksikliği, yeni sistemlerin geliştirilmesini engellemektedir. THEDES sistemlerinin hazırlanması, üretim sırasında hiçbir kayba neden olmadan ve sonraki saflaştırma adımlarına gerek kalmadan %100 saflıkta bir ürün eldesi sağlamaktadır (Duarte vd., 2017).

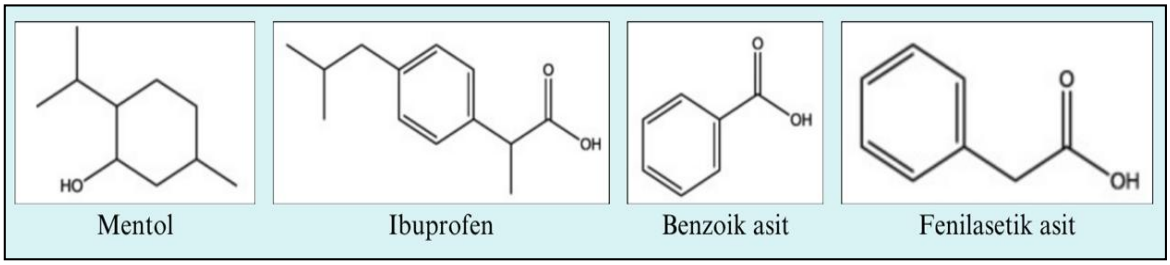
THEDES oluşturucu bileşenler arasında lidokain evrensel olarak yaygın görünmekte olup, birçok THEDES formülasyonunda kullanılmıştır. Bu durum, lidokain yapısında bulunan ve uygun HBD ile etkileşime girmeye elverişli iyi bir HBA adayı olan üçüncül amin fonksiyonel grubuna dayandırılmaktadır. Diğer HBA lokal anestezikler (LA) olan benzokain, prokain, tetrakain, mepivakain ve bupivakain de THEDES oluşumunda kullanılmıştır. Ancak bu bileşikler hakkında literatürde sınırlı sayıda çalışma bulunmaktadır (Abdelquader vd., 2023).

THEDES'ler, terapötik olarak aktif olan bir **derin ötektik çözücü (DES)** kategorisidir ve dört ana gruba ayrılmaktadır. İlk grup, THEDES terapötik olarak aktif bir molekül için taşıyıcı olarak işlev görmektedir. İkinci grup, DES'i oluşturan bileşenlerden biri, HBA veya HBD, aktif farmasötik bileşen olarak görev yapmaktadır. Üçüncü grup, hem HBA hem de HBD terapötik etkiye sahip olup birbirini tamamlayıcı farmakolojik aktivitelere sahiptir. Dördüncü grup ise DES'i oluşturan bireysel bileşenler terapötik aktivite göstermemekle birlikte, oluşturdukları DES terapötik özellik kazanmaktadır (Şekil 2) (Kalantri ve Vora, 2024).



Şekil 2. THEDES'in sınflandırılması (Kalantri ve Vora, 2024)

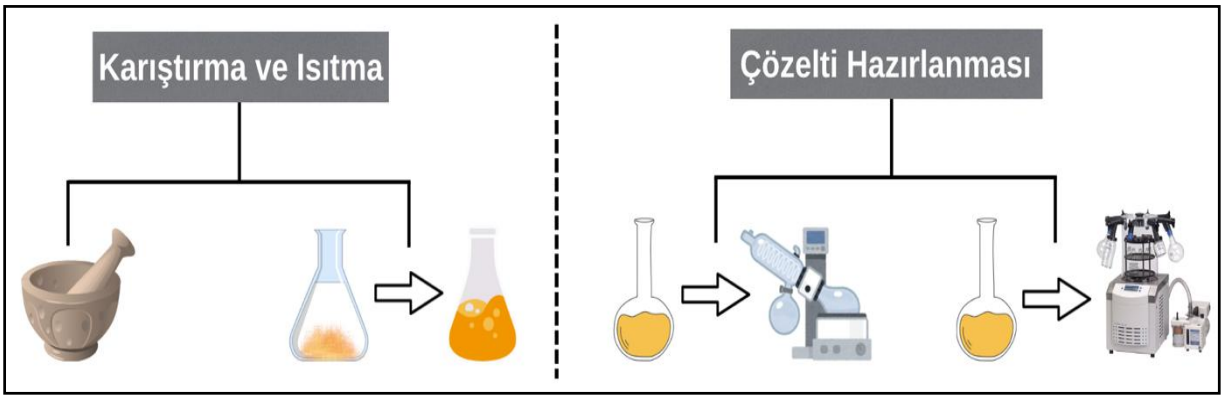
THEDES'lerin oluşumu, HBA ve HBD bileşenlerine göre belirli oranlarda farklılık gösterdiğinden (Silva vd., 2015), bu süreçte bileşenlerin fizikokimyasal özelliklerine göre farklı yöntemler uygulanır (Kalantri ve Vora, 2024). THEDES'lerin en yaygın HBA'ları asetilsalisilik asit, ibuprofen ve fenilasetik asit gibi çok çeşitli API'lerle birleşebilen kolin klorür (ChCl) ve mentoldür. Benzer şekilde üre ve gliserol de en yaygın bileşenler arasındadır. Bazen aynı bileşik, bir THEDES'te HBA olarak hareket ederken, başka bir THEDES'te HBD olarak hareket edebilir. Örneğin API, formülasyon için tuz formu kullanıldığında HBA olarak hareket edebilir, ancak aynı API saf formu kullanıldığında HBD olarak hareket edebilir (Rahman vd., 2021). Şekil 3'te THEDES hazırlanmasında kullanılan bazı bileşenlerin kimyasal yapısı gösterilmiştir.



Şekil 3. THEDES hazırlanmasında yaygın olarak kullanılan bileşenler (Duarte vd., 2017)

THEDES'ler, genellikle kontrollü sıcaklık-karıştırma, öğütme, vakum buharlaştırma ve dondurarak kurutma gibi yöntemlerle hazırlanır (Şekil 4). Hazırlama yöntemi sistemin homojenitesini, stabilitesini ve farmasötik etkinliğini doğrudan etkilemektedir (Santos ve Duarte, 2021). Örneğin, sıcaklık kontrollü karıştırma yöntemiyle hazırlanan THEDES sistemlerinde bileşenlerin belirli bir sıcaklık aralığında sürekli karıştırılmasıyla homojen bir karışım oluştururken, termal duyarlılığı yüksek bileşenler için dondurarak kurutma yöntemi veya vakum buharlaştırma gibi alternatif yöntemler tercih edilebilir (Santana vd., 2019; Bakr

El-Nassan, 2024). Kullanılan sıcaklık, her zaman karışımdaki bileşenlere bağlıdır. Örneğin, şekerler yüksek sıcaklıklarda uzun süre kararlı değildir (Santana vd., 2019).



Şekil 4. THEDES hazırlanmasında kullanılan bazı yöntemler (Santos ve Duarte, 2021)

Ötektik sistemlerin hazırlanması için tanımlanan yöntemlerden biri, sulu çözeltiden suyun buharlaştırılmasıdır. Bu yöntemde, bileşenler fazla miktarda su içinde çözülmekte ve ardından yaklaşık 50°C'de döner buharlaştırıcıda buharlaştırılmaktadır. Elde edilen sıvı, sabit ağırlığa ulaşana kadar silika jel ile birlikte desikatörde kurutulmaktadır (Santana vd., 2019). Kullanılan bir diğer yöntem ise dondurarak kurutmadır. Bu yöntemde, buharlaştırma yöntemine benzer şekilde her bir bileşenin sulu çözeltisi hazırlanmakta, ancak sonrasında elde edilen çözelti berrak ve viskoz bir sıvı oluşturmak üzere dondurarak kurutulmaktadır (Meneses vd., 2019).

Son yıllarda, THEDES'i de içeren derin ötektik çözücülerin hazırlanmasına yönelik farklı yeni yöntemler bildirilmiştir. Bunlardan mikrodalga destekli sentez yöntemi, bileşenlerin kapalı bir sistemde mikrodalga radyasyonuna ve kontrollü sıcaklığa maruz bırakılması esasına dayanmaktadır. Bu işlem sırasında dipol dönüşü meydana gelmekte ve moleküllerin çarpışması sonucunda dielektrik ısıtma gerçekleşmektedir. Böylece hazırlık süresi kısaltılmaktadır (Santos ve Duarte, 2021). Bir diğer yöntem olan ultrason uygulamasında, belirli bir kritik boyuta ulaştığında enerji açığa çıkaran kabarcıkların oluşumu ve çöküşü gerçekleşmekte, böylece HBD ve HBA arasındaki etkileşimler teşvik edilmektedir (Santana vd., 2019).

Hazırlama teknikleri içerisinde en yaygını, bileşenlerin kapalı bir cam kap içerisinde 40 ile 80°C arasında sürekli karıştırılmasıyla gerçekleştirilen **sıcaklık kontrollü karıştırma yöntemidir. B**u süreç, bileşenlerin erime noktalarına bağlı olarak 30 dakika ile 3 saat sürebilir (Rahman vd., 2021; Kalantri ve Vora, 2024). Vakumda buharlaştırma yöntemi, uçucu bileşen içeren sistemlerde kayıpları en aza indirirken, dondurarak kurutma özellikle ısıya duyarlı farmasötik bileşenlerin stabilitesini korumak için kullanılır (Santana vd., 2019). Formülasyondan sonra, THEDES formülasyonları için kullanılan kimyasallar (örneğin, kolin klorür ve mentol) oldukça higroskopik olduğundan, bir desikatörde muhafaza edilmeli veya -20°C'de bir dondurucuda saklanmalıdır (Rahman vd., 2021).

THEDES formülasyonunda bileşenlerin molar oranlarının değiştirilmesiyle sistemin çözünürlüğü, viskozitesi ve biyoyarayışlılığı gibi parametreler ayarlanabilir ve aynı bileşen farklı formülasyonlarda hem HBA hem de HBD olarak işlev görebilir (Rahman vd., 2021). Yapısal olarak, THEDES sistemlerinde en yaygın kullanılan bileşenlerden biri olan **kolin klorür,** hidrojen bağları aracılığıyla diğer bileşenlerle güçlü etkileşimler oluşturur ve özellikle fenilasetik asit (PAA) ile 1:1 oranında karışım oluşturduğunda, belirgin bir ötektik sistem meydana getirir. Kolin klorür ve hidrojen bağı verici bileşenler arasındaki bağ oluşturmayan etkileşimler arasında **anyon-pi, katyon-pi, hidrojen bağları, halojen bağları ve alkil-alkil etkileşimleri** bulunmaktadır ve bu etkileşimler THEDES sistemlerinin stabilitesinde önemli rol oynar (Saha vd., 2020). Tüm bu özellikler göz önüne alındığında, THEDES'lerin formülasyonu sırasında bileşenlerin kimyasal yapıları, etkileşim mekanizmaları ve hedeflenen farmasötik uygulamalar dikkate alınmalı, uygun sentez yöntemi seçilerek sistemin stabilitesi ve etkinliği

maksimize edilmelidir (Bakr El-Nassan, 2024; Kalantri ve Vora, 2024). Tablo 1'de THEDES bileşenlerinin farklı kombinasyonları verilmiştir.

Tablo 1. THEDES'lerin bileşimi, mol oranı ve hazırlanışı (Álvarez ve Zhang, 2019)

THEDES Bileşimi	Mol Oranı	THEDES Hazırlama Yöntemi
Mentol: Fenilasetik asit	2:1; 3:1	Karıştırma, 40°C'de ısıtma
Mentol: Benzoik asit	3:1	
Mentol: Asetilsalisilik asit	3:1	
Kolin Klorür: Asetilsalisilik asit	1:1	
Mentol: İbuprofen	3:1	Karıştırma, 40°C'de ısıtma
İbuprofen: L-Mentol İbuprofen: LD-Mentol	1:1	Eritilene kadar ısıtma
1,8-Oktanediol: Lidokain	1:1; 1:2; 1:3	Karıştırma, 80°C'de ısıtma
Kolin Klorür: Askorbik asit	2:1	Karıştırma, 40°C'de ısıtma
Mentol: Paeonol	6:4	Karıştırma, 40°C'de ısıtma

TERAPÖTİK DERİN ÖTEKTİK ÇÖZÜCÜLERİN KULLANIM ALANLARI

THEDES, farmasötik ve biyomedikal alanlarda ilaç çözünürlüğünü ve biyoyararlanımını artırmak, kontrollü ilaç salınımı sağlamak ve hedeflenmiş ilaç dağıtımını iyileştirmek amacıyla kullanılmaktadır. Antikanser, antibakteriyel ve yara iyileştirici ajanların etkinliğini artırarak kemoterapi, enfeksiyon tedavisi ve lokal anestezi uygulamalarında önemli rol oynarlar. Ayrıca diyabet, tüberküloz ve ateroskleroz gibi metabolik hastalıkların tedavisinde ilaç taşıyıcı sistemler olarak değerlendirilmekte ve biyouyumlu, çevre dostu alternatifler sunarak farmasötik araştırmalarda geniş bir potansiyel taşımaktadırlar (Tablo 2) (Kalantri ve Vora, 2024).

Tablo 2. THEDES bileşenlerinin farklı uygulamaları için literatürde bildirilen farklı sistemler (Santos ve Duarte, 2021)

THEDES	Uygulamaları
İbuprofen:terpenler (mentol, timol, menton, 1,8-sineol, d-limonen, p-simen)	İbuprofen ve çeşitli terpenler içeren ötektik karışımların hazırlanması ve karakterizasyonu; transdermal permeasyon artırıcılar olarak değerlendirilmesi
Lidokain:Prilokain (3:7); (4:6); (5:5); (6:4); (7:3)	Transmembran ilaç taşınımının artırılmasının değerlendirilmesi
Lidokain:Tetrakain (1:1) Lidokain:Kafur (1:1)	Anestezik uygulamalar için ötektik karışımların hazırlanması
Kolin klorür:Asetilsalisilik asit (1:1) Kolin klorür:Fenilasetik asit (1:1)	Çözücü ilavesi olmadan, aktif farmasötik bileşen (API) içeren THEDES'in hazırlanması
Kolin klorür:mandelik asit (1:2)	THEDES hazırlığı ve bunların jelatin lif zarlarına kapsüllenmesi
Kolin klorür:askorbik asit (1:1), (1:2), (2:1)	Doku mühendisliğinde olası uygulamalarla API (deksametazon) çözmek için THEDES hazırlanması
Kolin klorür:gliserol (1:2) Kolin klorür:etilen glikol (1:2)	DES ile Asetaminofen'in çözünürlük artırımı
Mentol:laurik asit (1:1); (1:2); (2:1); (4:1); (8:1) Mentol:miristik asit (1:1); (2:1); (4:1); (8:1); (10:1) Mentol:stearik asit (4:1); (8:1); (20:1)	Yara iyileştirici özelliklere sahip terpenler ve yağ asitleri içeren THEDES hazırlığı ve karakterizasyonu
Kaprik asit:laurik asit (2:1) Kaprik asit:stearik asit (4:1) Kaprik asit:miristik asit (3:1)	Antimikrobiyal etkinliği ve biyofilm ayırma özelliklerine sahip yağ asitleri içeren farklı DES'lerin hazırlanması
Miristik asit:limonene (1:1); (1:2); (2:1) Kaprik asit:limonene (1:1); (1:2); (2:1) Mentol:limonene (1:1); (1:2); (2:1) İbuprofen:limonene (1:1); (1:2); (2:1); (4:1); (8:1)	Limonen içeren THEDES hazırlanması ve antitümör etkinliklerinin değerlendirilmesi
Nimesulid:nikotinamid (1:2)	İlaç salınımı için kompres edilebilir dozaj formlarının doğrudan hazırlanması

Günümüze kadar üzerinde en çok çalışılan THEDES'ler, HBD olarak farklı steroidal olmayan

antiinflamatuvar ilaçlar (NSAID) içeren sistemlerdir. THEDES'ler ağırlıklı olarak transdermal yol ile ilaçların farmasötik performansını artırmak amacıyla kullanılmaktadır. Bununla birlikte, bazı çalışmalar, THEDES'lerin oral ve topikal yolla ilaç taşıma kapasitesini artırabileceğini göstermektedir (Pedro vd., 2021). Çeşitli terapötik kategorilere ve uygulama yollarına ait seçilmiş örnekler, HBA ve HBD gruplarının önerilen tanımlamaları ile birlikte Tablo 3'de sunulmuştur (Abdelquader vd., 2023).

Tablo 3. Rapor edilen THEDES örnekleri ve hidrojen bağlanma gruplarının önerilen tanımlamaları (Abdelquader vd., 2023).

Uygulama Yolu	**Önerilen Hidrojen Bağı Alıcısı**	**Önerilen Hidrojen Bağı Vericisi**	**Terapötik Faydası**
Transdermal	Fosfatidilkolin	Kannabidiol*	*Anti-romatizmal* kannabidiolün daha iyi birikimi
	Itrakonazol*	Fenol	*Anti-fungal* itrakonazolün daha iyi geçişi

Tablo 3. **(*devamı*)**

	Lidokain*	İbuprofen*, Ketoprofen*, Flurbiprofen*, Meloksikam*, Tenoksikam*, Asekolenak*	*Lokal anestezik* lidokain, listelenen *NSAID*'lerin deri emilimini artırma
Oral	Propranolol*	Laurik asit veya kaprik asit	*Anti-hipertansif* propranololün daha iyi geçişi
	Ranitidin	Üre, gliserol veya Aspirin*	*H_2-reseptör antagonisti* ranitidinin çözünürlüğünün artırılması
	Fenformin*	Gliserol	*Anti-diyabetik* fenforminin çözünürlüğünün artırılması
	Tiklopidin*		*Anti-koagülan* tiklopidinin çözünürlüğünün artırılması
	Tetrasiklin*		*Antibiyotik* tetrasiklinin çözünürlüğünün artırılması
	Etambutol*		*Anti-tüberküloz* etambutolün çözünürlüğünün artırılması
Diğer	**Topikal** Lidokain*	Sitrik asit	Lokal anestezik etkinin artırılması
	Diş Hekimliği Benzalkonyum klorür*	Akrilik asit	Diş kompozitlerinde antibakteriyel aktivitenin artırılması

***** *İlaçlar yıldız işaretiyle belirtilmiştir.*

Geleneksel çözücülere kıyasla, THEDES kullanımı, düşük çözünürlüğe sahip API çözünürlüğünü iyileştirme potansiyeline sahiptir. Örneğin, parasetamol, aspirin ve salisilik asit gibi bileşikler suda düşük çözünürlüğe sahiptir. Ancak üre ve kolin klorür karışımları gibi DES'ler, benzoik asit, danazol ve itrakonazol gibi düşük çözünürlüğe sahip bileşikleri çözebilme yeteneği göstermektedir (Morrison vd., 2009).

Tablo 4'te THEDES kullanılarak geliştirilen anti-tüberküloz ve anti-kanser etkili sistemler verilmiştir. Anti-tüberküloz etki gösteren sistemlerde özellikle pirazinamid, izoniazid ve süksinik asit gibi bileşenler kullanılırken, anti-kanser etkili sistemlerde kolin klorür, dietilstilbestrol ve ibuprofen gibi bileşiklerin farklı hidrojen bağlayıcılarla kombinasyonu öne çıkmaktadır (Oliveira vd., 2021).

Tablo 4. Anti-tüberküloz tedavisi için hazırlanan ve anti-kanser özellik gösteren THEDES sistemleri (Oliveira vd., 2021)

Anti-Tüberküloz Etki Gösteren	**Anti-Kanser Etki Gösteren**
Sitrik Asit:Etambutol:H_2O	Kolin Klorür: Gliserin
Kolin bikarbonat: geranik asit (1:2)	Kolin Klorür: Etilen glikol
Pirazinamid: Süksinik asit	Kolin Klorür: Üre
İzoniazid: Süksinik asit	
Pirazinamid: Nikotinik asit (2:1)	Kolin Klorür: Trietilen glikol
Pirazinamid: İzoniazid (5:1)	
Pirazinamid: Sakarin (4:1)	
	Kolin Klorür: Fruktoz
	Kolin Klorür: Glikoz
	N,N-Dietiletanol amonyum klorür: Trietilen glikol
	Piperidinil: Dietilstilbestrol
	Pirolidinil: Dietilstilbestrol
	Limonen: İbuprofen
	Perillil alkol: İbuprofen
	Mentol: İbuprofen
	Timol: İbuprofen

Stott vd. (1998) ilk olarak ibuprofenin, gelişmiş cilt geçirgenliğini desteklediği gösterilen farklı terpenlerle ötektik karışımlar oluşturduğunu bildirmişlerdir. Ayrıca DES'in model ilaçları çözebildiği, çözünürlüklerini, geçirgenliklerini ve emilimlerini artırabildiği belirlenmiştir (Silva vd., 2015). Bir THEDES'te, bir API hem HBA hem de HBD olarak kullanılabilir. Örneğin, aspirin, ChCl ile DES oluşturmak için hidrojen bağı vericisi olarak kullanılabilir, lidokain ve atropin ise karboksilik asit ile DES oluşturmak için hidrojen bağı alıcısı olarak kullanılabilir (García vd., 2023).

Duarte vd. (2017), ibuprofen, fenilasetik asit ve benzoik asit gibi farklı API'lerle komplekslenmiş mentol bazlı THEDES'ler geliştirmiş ve bunların izotonik bir çözeltideki çözünürlük ve geçirgenlik özelliklerini değerlendirmişlerdir. Fenilasetik asit içeren sistemler hariç, API'lerin THEDES formülasyonları içerisinde çözünürlüğünün 12 kata kadar, geçirgenliğinin ise 3 kata kadar arttığını tespit etmişlerdir. Benzer şekilde, García vd. (2023), THEDES formülasyonlarının katı dozaj formlarından sıvı sistemlere geçişini sağlayarak API'lerin biyoyararlanımını artırmada etkili olduğunu göstermişlerdir. Ancak, THEDES'lerin iki API'nin kombinasyonuyla oluşturulmasına yönelik çalışmalar oldukça sınırlıdır.).

THEDES'ler, özellikle antibiyotiklerin terapötik etkisini artırma ve antibakteriyel aktiviteyi güçlendirme potansiyeline sahip alternatif çözücüler olarak değerlendirilmektedir. Pereira vd. (2022), safranal, mentol ve linalool gibi antikanser özelliklere sahip terpenleri ibuprofen ve ketoprofen gibi steroid olmayan anti-inflamatuar ilaçlarla birleştirerek yeni THEDES formülasyonları geliştirmişlerdir. Ayrıca, limonen ile ibuprofen kombinasyonunun THEDES formunda ibuprofenin çözünürlüğünü artırdığını ve bunun antikanser aktivitelerle ilişkilendirildiğini bildirmişlerdir (Pereira vd., 2019).

Çeşitli çalışmalarda, farklı zincir uzunluklarına sahip mentol ve doymuş yağ asitleri bazlı hidrofobik THEDES'lerin biyomedikal uygulamaları incelenmiştir (Lomba vd., 2021). Menthol/ibuprofen (3:1) sisteminde, ibuprofenin çözünürlüğünün arttığı, ancak timol içeren THEDES'lerin çözünürlük üzerinde etkili olmadığı bildirilmiştir. Çalışmada yara iyileştirme için mentol ve stearik asit içeren bir THEDES formülasyonu geliştirilmiştir (Silva vd., 2019).

Son yıllarda, API-NADES bazlı formülasyonların, özellikle Çin bitkisel ilaçlarından türetilen bileşenler ile oluşturulmasının, hedeflenen özellikleri iyileştirmek açısından büyük bir potansiyel sunduğu belirtilmiştir. Bu formülasyonlar çözünürlük, biyoyararlanım, stabilite ve hedef bölgeye hızlı ilaç iletimi gibi avantajlar sağlayabilir (Xiao vd., 2022). Bazı durumlarda, THEDES formülasyonlarının API'lerin stabilitesini artırabildiği ve terapötik etkinliği kontrollü

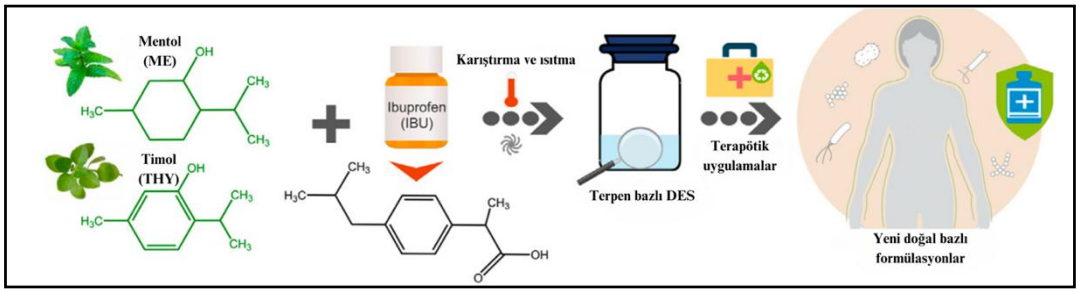
salınım yoluyla optimize edebileceği bildirilmiştir. Mano vd. (2017), kolin klorür-mandelik asit (1:2) bileşimiyle oluşturulan ve jelatin içinde kapsüllenen bir THEDES'in, fosfat tamponlu tuzlu suda hızlı çözünerek kontrollü bir salınım profili sunduğunu göstermiştir. Ayrıca, mandelik asidin hem Gram pozitif hem de Gram negatif bakteriler üzerindeki antibakteriyel aktivitesini koruduğu belirlenmiştir.

THEDES'lerin, ilaç endüstrisinin ötesinde biyomalzeme biliminde de potansiyel uygulamalara sahip olduğu vurgulanmaktadır. Bu çözücüler, ilaç taşıma sistemlerinde biyolojik malzeme geliştirilmesinde ve yenilikçi farmasötik formülasyonlarda önemli bir rol oynayarak, geleneksel çözücü sistemlerine kıyasla önemli avantajlar sunmaktadır (García vd., 2023).

Silva vd. (2019), mentol ve doymuş yağ asitlerine dayalı terapötik derin ötektik çözücülerin yara iyileşmesi üzerindeki potansiyel etkilerini incelerken; Mentol ve stearik asit (SA) bazlı THEDES sistemlerinin yara iyileşmesi ve antibakteriyel etkilerini incelemişlerdir. Mentol:SA (8:1) formülasyonu güçlü hidrojen bağları oluşturarak stabil bir yapı göstermiştir. Çalışmanın, mentol:SA bazlı THEDES'in yara örtülerinde kullanılma potansiyelinin vurgusuna dikkat çekmişlerdir.

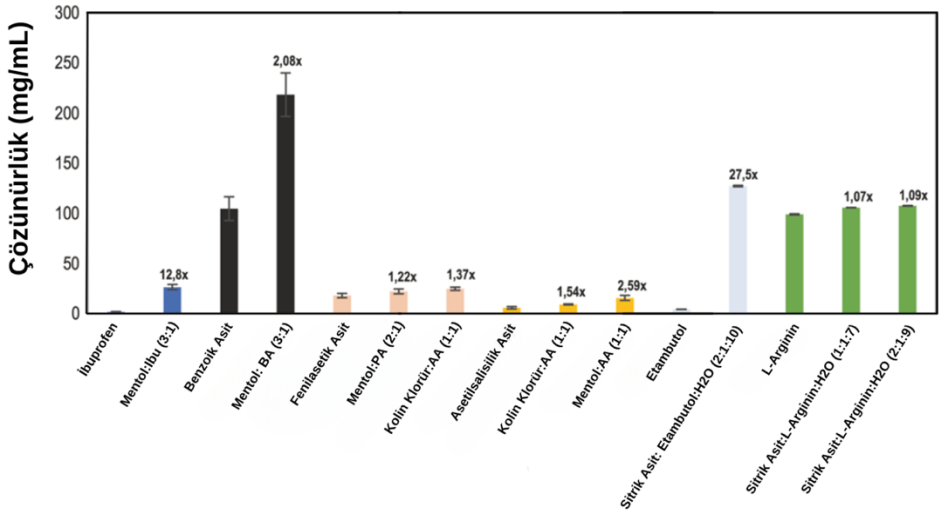
Supaweera vd. (2022), THEDES kullanarak *Curcuma longa* L. (zerdeçal) özlerinin mikroemülsiyon formülasyonları geliştirmişler ve bu formülasyonların anti-inflamatuar etkinliğini incelemişlerdir. Çalışmada, hidrofobik THEDES bazlı mikroemülsiyonlar (ME-23) kullanılarak bisdemetoksikurkumin, demetoksikurkumin, kurkumin ve aromatik-turmeron gibi biyoaktif bileşenlerin ekstraksiyon verimin arttığını tespit etmişlerdir. Ayrıca depolama testlerinde, THEDES bazlı mikroemülsiyonların kurkumin stabilitesini %90'ın üzerinde koruduğunu belirlemişlerdir.

Silva vd. (2021), THEDES kullanılarak doğal terpenler bazlı formülasyonlar geliştirmişler ve bunların **antimikrobiyal ve antikanser özellikleri**ni değerlendirmişlerdir. **Timol (THY) ve mentol (ME)** gibi monoterpenoidleri, **ibuprofen (IBU)** ile kombine ederek **farklı molar oranlarda THEDES formülasyonları** hazırlamışlardır (Şekil 5). Sonuçta, **terpen bazlı THEDES formülasyonlarının** biyomedikal alanda **antibakteriyel ve antikanser ajanlar olarak potansiyel taşıdığı** ortaya koyulmuştur. Mentol bazlı THEDES'lerde, API'lerin çözünme hızının büyük ölçüde artırıldığı gösterilmiştir. Terpenler ve özellikle mentole olan ilgi, çoğunlukla literatürde bildirilen geçirgenlik artırıcı etkinliğinden kaynaklanmaktadır (Jain vd., 2002).



Şekil 5. Terapötik uygulamalar için geliştirilen monoterpen bazlı DES'in şematik gösterimi (Silva vd., 2021)

Terapötik ajanlarla ötektik karışımların oluşumunu içeren bu çalışmalar, terapötik ajanın özelliklerinde yenilikler getirmiştir. Ümit verici sonuçlar, terapötik ötektik karışımlarla çözünürlük çalışmalarının araştırılmasına ve geliştirilmesine ve ötektik karışımların, zayıf çözünen ilaçları çözmek için bir araç olarak kullanılmasına imkan sağlamıştır (Şekil 6) (Santos ve Duarte, 2021).



Şekil 6. Terapötik derin ötektik çözücü sistemlerinde API'lerin çözünürlüğü artırmasıyla ilgili literatürde bulunan sonuçlar (Santos ve Duarte, 2021)

STABİLİZASYONUNDA THEDES'İN ROLÜ

THEDES'in kullanımı, biyoaktif bileşiklerin stabilizasyonu ve etkinliğinin korunması açısından önemli fırsatlar sunmaktadır. Özellikle ilaçlar, doğal özütler, enzimler ve proteinler gibi hassas biyoaktif moleküllerin stabilitesini artırmada THEDES dikkat çekicidir. Bu stabilizasyon yeteneği, biyoaktif bileşiklerin etkinliğini, raf ömrünü ve iletimini iyileştirmeye yönelik önemli etkiler yaratmaktadır. THEDES'in en belirgin avantajlarından biri ilaç stabilizasyonudur; ilaçlar THEDES formülasyonlarında kapsüllenerek, ışık, ısı, oksijen ve pH değişimleri gibi bozunma faktörlerinden korunabilir. Bu koruyucu ortam, ilacın etkinliğini uzun süre muhafaza ederek terapötik sonuçların iyileştirilmesine katkıda bulunur. Ayrıca, THEDES, bozulmaya eğilimli doğal özütlerin korunmasında da etkili olabilir. Bu çözücüler veya taşıyıcılar, aktif bileşenleri koruyarak oksidasyonu engeller ve özütlerin raf ömrünü uzatır. Bu stabilizasyon etkisi, özütlerin nutrasötik ve kozmesötik gibi uygulamalarda etkinliğini ve bütünlüğünü sürdürülebilir kılar (Javed vd., 2024).

İlaç stabilizasyonu ve doğal özütlerin korunmasının yanı sıra, THEDES enzimlerin ve proteinlerin stabilitesini koruyabilen önemli bir ortam sağlar. Bu biyomoleküllerin etkinliklerini sürdürebilmeleri için uygun stabilizasyon gerekmektedir. THEDES, enzimlerin ve proteinlerin yapılarını koruyarak denatürasyonu engeller ve depolama veya uygulama sırasında stabilitelerini muhafaza eder. Bu özellik özellikle biyokataliz, enzimatik reaksiyonlar veya enzim bazlı formülasyonların geliştirilmesinde değer taşır. Ayrıca, THEDES, biyoaktif bileşiklerin kontrollü salınımını sağlamak amacıyla nanopartiküller veya hidrojeller gibi sistemlere entegre edilebilir. Bu çözücüler, bileşenleri koruyarak erken salınım ve bozunmayı önler, böylece sürdürülebilir bir salınım profili oluşturur ve biyoaktif bileşiklerin stabilitesini ve terapötik etkinliğini artırır (Javed vd., 2024).

THEDES'İN ZORLUKLARI VE SINIRLAMALARI

THEDES'in ilaç dağıtım sistemi olarak kullanımıyla ilişkili birkaç sınırlama vardır ve çeşitli uygulamalarda potansiyelinden tam olarak yararlanmak için daha fazla araştırma ve geliştirme çalışmaları gereklidir. Bu sınırlamalar arasında, DES'lerdeki bazı API'lerin sınırlı çözünürlüğü yer alır ve bu da belirli formülasyonlardaki uygulamalarını kısıtlayabilir (Zhu vd., 2023). Ayrıca, THEDES'te özellikle stresli çevre koşulları altında, faz ayrımı veya zaman içinde aktif bileşiklerin bozunması gibi stabilite sorunları yaşanabilmektedir. THEDES genel olarak

güvenli kabul edilmekle birlikte, terapötik uygulamalar için tasarlanan formülasyonlarında kullanılan belirli bileşenlerin toksisitesi konusunda endişeler yaratmaktadır (Curreri vd., 2023). THEDES'in biyouyumluluğunun, biyolojik dokularla doğrudan temas içeren veya sistemik olarak uygulanan formülasyonlar için de kapsamlı bir şekilde değerlendirilmesi gerekir. THEDES tabanlı formülasyonlar için karmaşık ve zaman alıcı düzenleyici onay süreçleri, API'lerin bileşenler veya yardımcı maddelerle uyumluluğu ve THEDES'in daha yüksek üretim maliyeti, THEDES'in ilaç dağıtım sisteminde kullanımıyla ilişkili diğer sınırlamalardır (Javed vd., 2024).

SONUÇ

Terapötik Derin Ötektik Çözücüler (THEDES), farmasötik, biyomedikal ve gıda bilimi gibi çeşitli alanlarda sunduğu avantajlar sayesinde son yıllarda büyük ilgi görmektedir. Geleneksel çözücülere kıyasla düşük toksisite, biyobozunurluk ve yeşil kimya prensiplerine uyum gibi üstün özellikler, bu sistemleri sürdürülebilir ve çevre dostu bir alternatif haline getirmiştir. THEDES, ilaçların çözünürlüğünü artırma, biyoyararlanımı iyileştirme ve kontrollü salınım mekanizmaları geliştirme gibi kritik işlevlere sahip olup, özellikle transdermal ilaç taşıma ve oral farmasötik formülasyonlarda umut vaat etmektedir. Aynı zamanda, biyoaktif bileşiklerin stabilizasyonunu sağlayarak farmasötik etkinliği optimize etmekte ve nutrasötik bileşenlerin raf ömrünü uzatma potansiyeli sunmaktadır. Ancak, THEDES'in endüstriyel ölçekte uygulanabilirliği, uzun vadeli stabilitesi, toksisite değerlendirmesi ve biyouyumluluğu gibi konular halen tam aydınlatılamamıştır. Özellikle, formülasyon süreçlerinin standardizasyonu, bileşenlerin etkileşim mekanizmalarının daha iyi anlaşılması ve düzenleyici çerçevelerin netleşmesi, bu çözücülerin farmasötik endüstride yaygın kullanımını hızlandıracaktır. Farklı terapötik ajanlarla kombinasyonları ve biyomalzeme entegrasyonları gibi yenilikçi yaklaşımlar, THEDES sistemlerinin potansiyelini daha da artıracaktır. Gelecekte, THEDES'in hem bilimsel araştırmalarda hem de ticari uygulamalarda daha geniş bir yer bulması beklenmektedir. Gelecekte yapılacak olan araştırmalarla birlikte, bu çözücü sistemlerin farmasötik, biyomedikal, gıda ve çevre bilimlerinde daha etkin kullanımına yönelik stratejilerin geliştirilmesi, sürdürülebilir çözümler sunması açısından büyük önem taşımaktadır. Sonuç olarak, THEDES sistemleri, hem bilimsel araştırmalar hem de ticari uygulamalar açısından büyük bir potansiyel taşımakta olup, sürdürülebilir teknolojiler geliştirilmesine katkı sağlayacak önemli bir araştırma alanı olmaya devam edecektir.

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INVESTIGATION OF TEMPERATURE EFFECTS (CALCINATION) ON CRYSTAL STRUCTURES OF SULPHATE MINERALS USING CONFOCAL RAMAN SPECTROSCOPY (CRS)

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ABSTRACT

Gypsum ($CaSO_4 \cdot 2H_2O$) undergoes a series of phase transitions upon thermal treatment, transforming into bassanite ($2CaSO_4 \cdot H_2O$) and subsequently into different forms of anhydrite ($CaSO_4$). This transformation plays a crucial role in various industries, including construction, conservation, pharmaceuticals, and ceramics. In this study, high-purity natural gypsum samples, obtained from sedimentary especially evaporitic formations at the Ankara-Çankırı (Türkiye) border were subjected to calcination at temperatures ranging from 150°C to 850°C. Raman spectroscopic analysis was conducted using a Confocal Raman Spectrometer (CRS) with a 633 nm laser source to investigate structural modifications at different calcination stages. Results indicate that the primary Raman peak of gypsum at 1006 cm^{-1} exhibits a positive shift to 1022 cm^{-1} with increasing temperature, while secondary peaks also shift accordingly. Notably, a new peak at 607 cm^{-1} appears at 450°C, shifting to 609 cm^{-1} at higher temperatures. The spectral region between 1000–2000 cm^{-1} reaches maximum intensity at 350°C, followed by a decline at 850°C. Hydroxyl-related peaks in the 3200–3500 cm^{-1} range disappear completely after 30 minutes at 850°C, confirming the expected dehydration process. Additionally, a significant reduction in background noise was observed in spectra obtained from samples exposed to prolonged heating at 850°C, indicating enhanced structural stability. These findings provide a detailed spectroscopic insight into the gypsum-anhydrite transformation sequence, contributing to a better understanding of phase transitions and their industrial implications.

Keywords: Gypsum, Anhydrite, Calcination, Confocal Raman Spectroscopy, Phase Transition.

INTRODUCTION

Gypsum is a mineral with the chemical formula $CaSO_4 \cdot 2H_2O$, crystallizing in the monoclinic system and having a hardness of 1.5–2 on the Mohs scale (Klein et al., 1985). Through thermal treatment, it can transform into bassanite ($2CaSO_4 \cdot H_2O$) and anhydrite ($CaSO_4$) (Schmidt et al., 2011). This transformation system is utilized in industries such as geology, construction, conservation and restoration, industrial processing, and geotechnics and in fields like healthcare, pharmaceuticals, and art.

When gypsum is heated above 80°C, it loses part of its crystal water and transitions into bassanite, a more stable form. As the temperature increases further, this transformation continues into anhydrite forms. Each stage of this transformation results in products with distinct applications and uses. The transformation sequence can be listed as Gypsum – Bassanite – γ-Anhydrite – β-Anhydrite – α-Anhydrite (Borg et al., 1975). Different forms of anhydrite exhibit varying physical properties. γ-Anhydrite has relatively low density and is soluble; its porous structure makes it suitable for construction materials such as plaster and stucco. β-Anhydrite, on the other hand, is denser with fewer voids, making it more appropriate for ceramic production. α-Anhydrite is generally not used in industrial applications, as its formation requires extremely high temperatures. It is unstable and readily converts to other anhydrite forms when temperature conditions change (Lopez-Buendia et al., 2009).

The transition processes between these forms can be better understood using spectrometric techniques such as Confocal Raman Spectroscopy (CRS). A Confocal Raman Spectrometer (CRS) is an integrated analytical device consisting of a Raman spectrometer unit and an optical microscope. It excites the material of interest using a laser source and lenses. The excited material can reflect, absorb, or scatter the incident laser light. The detector in the Raman spectrometer captures the scattered light, generating spectra that enable material characterization. (Kadioglu et al., 2009; Giridhar et al., 2017). In this study, the Confocal Raman Spectrometer (CRS) at the Earth Sciences Application and Research Center (YEBIM) of Ankara University was used to better define the gypsum-anhydrite transformation series.

METHODOLOGY

High-purity natural gypsum minerals, selected from sedimentary (evaporitic) formations located at the Ankara-Çankırı (Türkiye) border, were subjected to calcination in a Protherm model muffle furnace at 150, 250, 350, 450, 550, 650, 750, and 850 degrees Celsius for 30 minutes each at the Earth Sciences Application and Research Center (YEBIM). Additionally, samples were collected at the 10th and 1440th minutes at 850 degrees Celsius. Following the calcination process, a Thermo Scientific model DXR branch Confocal Raman Spectrometer (CRS) was used to perform measurements utilizing a 633 nm wavelength laser source with an output power of 8 mW. Raman spectra were recorded separately within the Raman shift ranges of 50–3620 cm^{-1} and 50–1200 cm^{-1} (Gullu and Kadioglu, 2017). Laser focal points were selected using the 20x objective of the microscope unit.

RESULTS AND DISCUSSION

The primary peak of the gypsum mineral in the Raman spectrometer, initially observed at a Raman shift of 1006 cm^{-1} (Figure 1a), exhibited a positive shift up to 1022 cm^{-1} (Figure 1a-g) with increasing temperature. Secondary peaks at 672, 618, 496, and 413 cm^{-1} (Figure 1a) shifted respectively to 679, 635, 501, and 417 cm^{-1} (Figure 1k). Additionally, with the calcination process reaching 450°C, a new secondary peak emerged at 607 cm^{-1} (Figure 1e), further shifting to 609 cm^{-1} (Figure 1k) as the temperature increased. The peak at 1137 cm^{-1} exhibited a negative shift to 1133 cm^{-1} upon calcination at 450°C, accompanied by the formation of a new

peak at 1161 cm^{-1} (Figure 1e). At 550°C, another peak began to form at 1112 cm^{-1} (Figure 1f), becoming more pronounced at higher temperatures.

The high-intensity spectral region appearing within the 1000–2000 cm^{-1} range reached its maximum intensity at 350°C (Figure 1d). However, after 30 minutes at 850°C (Figure 1j), it was observed as a low-intensity peak, and after one day at 850°C (Figure 1k), it completely disappeared. The peaks at 3200, 3406, and >3500 cm^{-1}, which represent hydroxyl groups, gradually decreased in intensity as calcination progressed and completely vanished after 30 minutes at 850°C.

Apart from these changes, a significant reduction in background noise across the entire spectrum was observed following calcination at 850°C, leading to more pronounced peak definitions. Moreover, as the duration of exposure at 850°C increased, this reduction in spectral noise became even more evident. (Figure 1j and 1k)

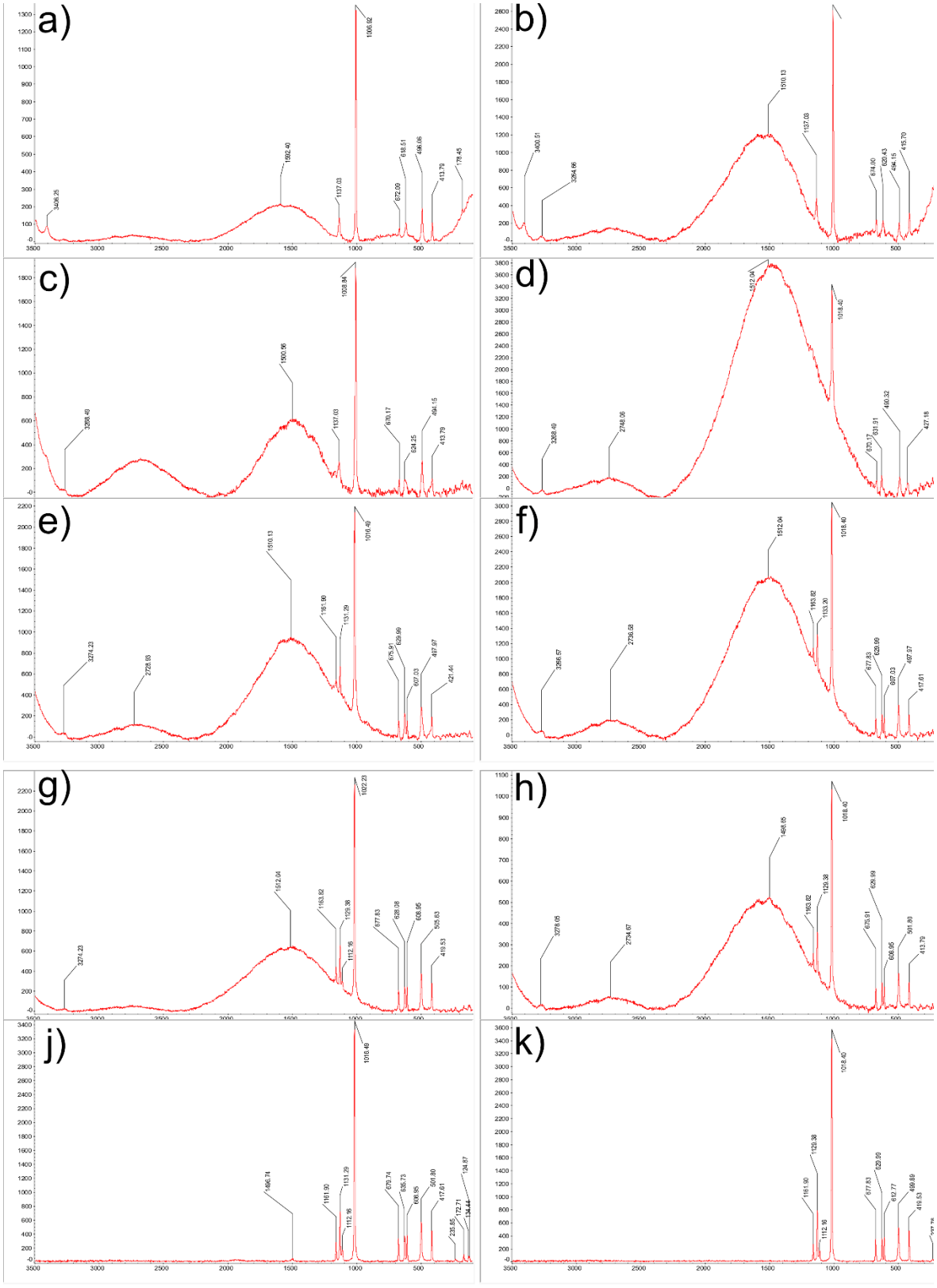

Figure 1. Raman spectrums of the calcinated samples. Starting from top left, a) Initial (pre-calcination), b)150°C, 30', c) 250°C, 30', d) 350°C, 30', e) 450°C, 30', f) 550°C, 30', g) 650°C, 30', h) 750°C, 30', j) 850°C, 30', k) 850°C, 1440'.

CONCLUSIONS

The positive shifts in the primary and secondary peaks of the gypsum mineral with increasing temperature are associated with the gypsum-anhydrite transformation and the removal of water

from the crystal structure. The intensified spectral region at 350°C, along with the high spectral fluctuations and the emergence of new peaks in subsequent temperature measurements, suggests that a phase transition may occurring within the 350–450°C range. The disappearance of the hydroxyl group peaks in the 3400–3600 cm^{-1} range with increasing temperature, indicating that the dehydration process is proceeding as expected. The overall spectral changes observed at 850°C further support the possibility of another phase transition occurring within this temperature range.

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DESIGN AND PERFORMANCE ANALYSIS OF VIBRATION TESTER FOR AUTOMOBILE HEADLIGHTS

OTOMOBİL FARLARI İÇİN TİTREŞİM TEST CİHAZININ TASARIM VE PERFORMANS ANALİZİ

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ÖZET

Bu çalışmada, araba farlarının trafik güvenliğindeki önemli rolü kapsamında, engebeli yollarda maruz kalınan titreşimlerin far montaj sistemlerine etkileri ele alınmıştır. Farların titreşim nedeniyle maruz kaldığı gevşeme, ışık açısında kayma ve bileşen deformasyonları, performans kayıplarına yol açmaktadır. Çalışmanın temel amacı, far sistemlerinin titreşim dayanıklılığını test etmek üzere özel olarak tasarlanmış bir titreşim simülasyon cihazının tasarımını, işleyişini ve performans analizini ortaya koymaktır. Cihaz, 1.10 kW gücündeki AC motor ve eksantrik kam mekanizması kullanılarak 10–100 Hz frekans ve 0.1–5 mm genlik aralığında kontrollü titreşim üretebilmektedir. Yaylı tabla sistemi ve dört UCP rulman, titreşimin homojen dağılımını sağlarken, kontrol paneli sayesinde gerçek zamanlı ayarlamalar yapılabilmektedir. Yapılan 5 saniyelik testlerde, CLL (şehir ışığı), DLL (gündüz farı), HI (uzun far) ve LOW (kısa far) lambalarının akım dalgalanmalarında (±0.2 A) ve ışık stabilitesinde anlamlı bir değişiklik gözlemlenmemiştir. Sonuçlar, sistemin endüstriyel uygulanabilirliğini, hızlı arıza tespiti ve enerji verimliliğini ortaya koysa da, 36 Hz üzerindeki 85 dB'i aşan gürültü seviyesinin iyileştirilmesi gerektiğini göstermektedir.

Anahtar Kelimeler: Titreşim simülasyonu; Araç farları; Dayanıklılık testi; Endüstriyel uygulanabilirlik; Gürültü kontrolü

ABSTRACT

This study examines the effects of vibrations on car headlight mounting systems, given their crucial role in traffic safety. Vibrations can lead to loosening, misalignment of the light angle, and component deformations, all of which result in performance losses. The primary objective

of this work is to present the design, operation, and performance analysis of a vibration simulation device specifically developed to test the durability of headlight systems under vibrational stress. The test device consisted of a 1.10 kW AC motor and an eccentric cam mechanism that generated controlled vibrations within a frequency range of 10–100 Hz and an amplitude range of 0.1–5 mm. A spring table system and four UCP bearings ensured the uniform distribution of vibrations, while a control panel allowed for real-time adjustments. During 5-second tests, no significant changes were observed in the current fluctuations (±0.2 A) or the light stability of the CLL (city light), DLL (daytime running light), HI (high beam), and LOW (low beam) lamps. Although the results confirm the system's industrial applicability, rapid fault detection capability, and energy efficiency, the noise level exceeding 85 dB at frequencies above 36 Hz indicates that improvements are necessary.

Key Words: Vibration simulation; Car headlights; Durability testing; Industrial applicability; Noise control

GİRİŞ

Araba farları, araçların gece sürüşünde ve kötü hava koşullarında yolun net bir şekilde görülmesini sağlarken, aynı zamanda trafikte diğer sürücülerin ve yayaların aracı fark etmesine yardımcı olarak güvenliği artıran bir bileşendir (Devarajan ve Kumaragurparan, 2024). Bu sistem, hem sürücünün kendi güvenliğini hem de çevresindeki insanların güvenliğini sağlamaktadır. Ancak farların uzun süreli etkili bir şekilde çalışabilmesi için stabil bir şekilde takılması gerekmektedir. Özellikle engebeli yollarda, sürekli titreşimlere maruz kalmak, far mekanizmasının zamanla gevşemesine neden olabilmektedir. Bu durum, farların ışık açısında sapmalara yol açarak yolun doğru bir şekilde aydınlatılmasını engellemekte ve karşıdan gelen sürücülerin gözünü kamaştırma gibi olumsuz etkiler oluşturmaktadır (Devarajan ve Kumaragurparan, 2024).

Ayrıca, titreşimler ve yanlış hizalamalar far mekanizmasında performans kayıplarına yol açabilmektedir. Far ampullerinin doğru yerleşimi ve stabilitesi bozulduğunda, ışığın dağılımı verimsiz hale gelir. Bu durum, sürüş sırasında görüş mesafesini kısaltarak tehlikeli durumların oluşmasına sebep olur. Aynı zamanda, bu tür mekanik sorunlar farların bileşenlerinde erken aşınmalara ve hasarlara neden olabilir. Farların iç bileşenlerindeki titreşim kaynaklı deformasyonlar, ampul ve reflektör gibi önemli parçaların işlevselliğini olumsuz etkileyerek farların ömrünü önemli ölçüde kısaltmaktadır.

Uzun vadede, bu tür sorunlar araç sahiplerini daha sık bakım yaptırmak veya far sistemlerini değiştirmek zorunda bırakmaktadır. Bu durum, hem zaman hem de maliyet açısından sürücüler için ek bir yük oluşturmaktadır. Bu tür problemlerin önlenmesi için, araç üreticilerinin ve sürücülerin titreşimlere karşı dayanıklı far tasarımlarına ve montaj mekanizmalarına öncelik vermesi önemlidir. Ayrıca, düzenli bakım ve kontrollerle farların doğru hizalanması sağlanarak performans düşüşlerinin önüne geçilebilir. Yüksek kaliteli far bileşenlerinin kullanılması ve profesyonelce yapılan montaj işlemleri, farların ömrünü uzatarak daha güvenli bir sürüş deneyimi sunar.

Titreşim test cihazları, otomotiv endüstrisinde uzun yıllardır kullanılmaktadır. Ancak, geleneksel test yöntemleri, genellikle manuel incelemelere dayanmakta ve gerçek zamanlı veri toplama kabiliyetinden yoksundur. Bu durum, arızaların erken tespitini zorlaştırmakta ve test süreçlerini uzatmaktadır.

Devarajan ve Kumaragurparan (2024), LED farların termal performansını iyileştirmek amacıyla farklı ısı emici kanat yapılarının etkisini araştırmıştır. Çalışma, 6 ila 12 W aralığındaki LED güçlerinde dört farklı kanat modelini incelemiş ve ısı emiliminde %73.6'ya varan iyileşmeler gözlemlenmiştir. Ayrıca, ISO 16750 standardına göre yapılan titreşim testlerinde, ısı emicilerin üç farklı senaryoda (Yolcu Aracı Motoru, Yolcu Aracı Yüksek Kütleler, ve Yolcu

Aracı Düşük Kütleler) titreşim karakteristiklerinin belirlenen standartlara uygun olduğu görülmüştür.

Chris ve ark. (2010), otomotiv aydınlatma sistemlerinde titreşim dayanıklılığı testleri sırasında arızaların tespitine yönelik mevcut manuel inceleme yöntemlerinin yetersizliklerini ele almışlardır. Geleneksel yöntemlerin, arızanın ilk oluşum anını belirleyemediği ve devam eden testlerin ek hasarlara yol açarak tasarım iyileştirme süreçlerini zorlaştırdığını vurgulamışlardır. Çalışmalarında, hızölçer ve mikrofon tabanlı iki izleme sistemi kullanmışlar ve titreşim ile akustik sinyal analizi yöntemlerini açıklaşmışlardır. Sonuç olarak, sağlıklı ve arızalı sistemler arasında belirgin farklılıklar olduğunu göstermişler ve bu yöntemlerin gerçek zamanlı, düşük maliyetli bir teşhis sistemi geliştirilmesi için umut vadettiğini ortaya koymuşlardır.

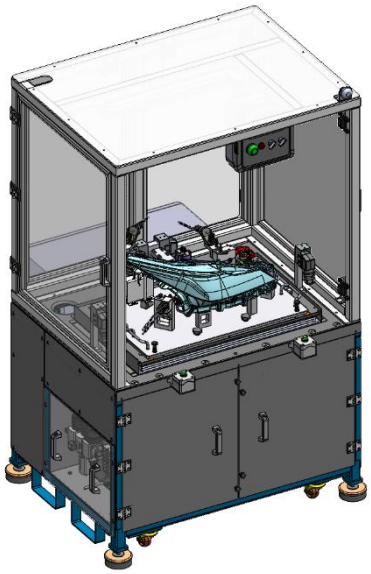
Siswanto ve ark. (2011), elektronik cihazların titreşim testleri için genel amaçlı bir test platformu geliştirmişlerdir. Çalışmalarında, cihazların yerleştirilip titreşim ile test edileceği bir tabla tasarımı incelemişlerdir. Üç farklı tasarım modeli, doğal frekansları ve mod şekilleri açısından analiz edilmiş ve en hafif ağırlığa ve en yüksek ilk doğal frekansa sahip model seçilmiştir. Bu titreşim tablasının 2500 Hz'e kadar titreşim frekanslarında rijit bir yapı sergilediği belirtilmiştir.

Hong ve arkadaşları (2021), elektronik bileşenlerin titreşim dayanıklılığı üzerine yaptıkları çalışmada, baskılı devre kartı (PCB) ve lehim bağlantılarının güvenilirliğini etkileyen faktörleri ele almışlardır. Özellikle otomotiv uygulamalarında karşılaşılan titreşim yüklerinin, lehim bağlantılarında farklı arıza modlarına yol açabileceğini vurgulamışlardır. Titreşim testlerinin sistematik bir şekilde yürütülmesi için PCB titreşim yanıtı, lehim bağlantılarının mekanik dayanıklılığı ve elektriksel arıza tespit yöntemleri üzerinde durulmuştur. İyi tasarlanmış bir titreşim test metodolojisinin, PCB düzeneği üzerindeki gerilmeleri doğru bir şekilde modelleyerek, bileşenlerin ömür tahminlerini ve güvenilirlik performansını iyileştirebileceğini belirtmişlerdir. Bu bağlamda, test parametrelerinin optimize edilmesinin, deneysel kurulumun ve çevresel koşulların arıza tespit süreçlerindeki rolü detaylı bir şekilde incelenmiştir.

Bu çalışma, araba farlarının titreşim karşısındaki performansını test etmek üzere tasarlanan bir titreşim simülasyon cihazının tasarımını, işleyişini ve performans analizini sunmayı amaçlamaktadır. Cihaz, gerçek yol koşullarını laboratuvar ortamında simüle ederek, far sistemlerinin titreşim dayanıklılığını ölçmekte ve potansiyel arızaları önceden tespit etmektedir.

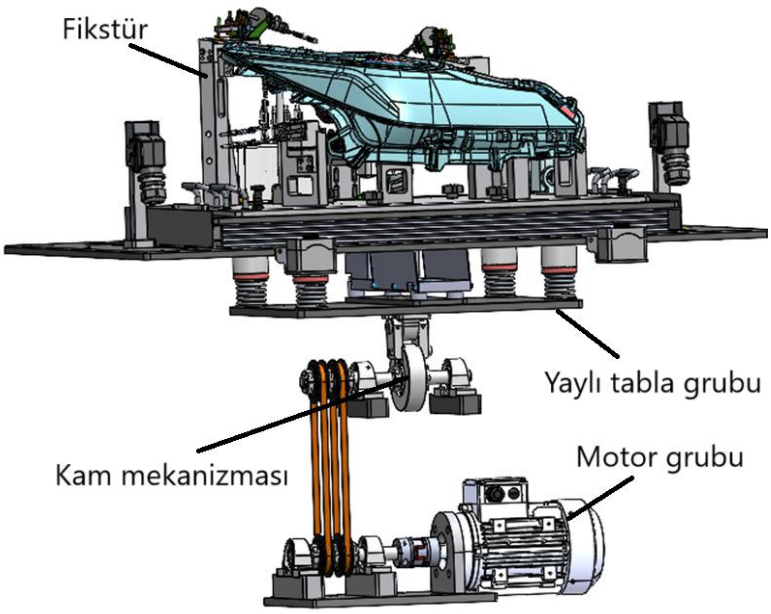
TİTREŞİM TEST DÜZENEĞİ TASARIM VE İŞLEYİŞİ

Test sistemi Şekil 1'de gösterilmektedir. Cihazın tasarımı, dört ana bileşenden oluşmaktadır: 1. Döner motor grubu, 2. Eksantrik kam mekanizması, 3. Yaylı tabla sistemi ve 4. Kontrol ünitesi. Cihazın ana hareket kaynağı, 1.10 kW gücünde yüksek hassasiyetli bir döner AC motordur. Motor, V kayış ve kaplin üzerinden eksantrik kama hareket iletmektedir. Bu yapı, titreşim genliği ve frekansının istikrarlı bir şekilde kontrol edilmesini sağlamaktadır. Eksantrik kam mekanizması, merkezden 1.75 mm kaçıklığa sahip olacak şekilde tasarlanmıştır. Kam, sabit bilyalı rulman ve konik sıkma ile dengeli bir şekilde montajlanmıştır. Bu mekanizma, istenilen titreşim genliği ve frekansının elde edilmesini sağlamaktadır. Tabla, dört UCP rulmanla desteklenmiştir. Böylede, titreşimin homojen dağılımı sağlanmış ve sistemin stabilitesi artırılmıştır. Yaylar, enerji emilimi için optimize edilmiştir. Cihazın kontrolü bir kontrol paneli ile sağlanmıştır. Panel üzerinden frekans (10-100 Hz) ve genlik (0.1-5 mm) ayarları yapılabilmektedir. Bu esneklik, farklı test senaryolarının simüle edilmesini sağlamaktadır.



Şekil 1. Titreşim test düzeneği.

Titreşim mekanizması Şekil 2'de gösterildiği gibi döner motor tarafından hareket ettirilen ve dört köşeden desteklenen bir tabla sistemi ile sağlanmıştır. Mekanizma, hassas titreşim frekansı ve genlik kontrolü sağlamak üzere optimize edilmiştir. Döner motor, sistemin ana hareket kaynağını oluşturmaktadır. Tabla, titreşimin homojen dağılımını sağlamak üzere dört köşeden desteklenmiştir. Bu lineer yataklama sayesinde titreşim genliği ve frekansın istikrarlı bir şekilde kontrol edilmesi sağlanmıştır. Titreşim oluşturma mekanizması, motor tarafından hareket ettirilen eksantrik bir yapıya sahiptir. Bu mekanizma kullanılarak istenilen titreşim genliği ve frekansın elde edilmesini sağlanmıştır.



Şekil 2. Titreşim mekanizması.

Şekil 3'te deneyler sırasında farda bulunan farklı lambaların testleri gösterilmektedir. Bu lambaların açıklamaları aşağıda verilmiştir.

CLL (City Light/City Lamp): Şehir ışığı, düşük ışık şiddetine sahip, genellikle şehir içi kullanım için tasarlanmış farlardır. Bu ışıklar, araçların diğer araçlarla etkileşimini artırmak ve gece sürüşlerini daha güvenli hale getirmek için kullanılır.

DLL (Daytime Running Light): Gündüz farları, gündüz sürüşlerinde araçların daha görünür olmasını sağlamak için kullanılan farlardır. Bu ışıklar, özellikle gün ışığında, aracın fark edilmesini artırır ve genellikle daha düşük parlaklıktadır.

HI (High Beam): Yüksek ışık, yani "uzun farlar" olarak bilinir. Gece sürüşlerinde, yolun daha uzak mesafelerini aydınlatmak için kullanılır. Ancak karşıdan gelen araçlar varsa, kısa farlara (LOW beam) geçmek gerekir.

LOW (Low Beam): Düşük ışık, yani "kısa farlar" olarak bilinir. Gece sürüşlerinde karşıdan gelen araçların gözünü kamaştırmamak için kullanılır ve yolun hemen önünü aydınlatır.

Deneylerde her bir farın yanmasının sürekliliği ve çektiği akım, titreşim altında 5 saniye boyunca izlenmiş ve kayıt altına alınmıştır. Eksantrik kam, merkezden 1,75 mm lik bir kaçıklık ile tasarlanıp üretilmiştir. Titreşim frekansı ve genlik, kontrol panelleri aracılığıyla ayarlanmış ve test süresince kayıt edilmiştir. Makinenin performansı, çeşitli test senaryolarında incelenmiş ve veri analiziyle değerlendirilmiştir.

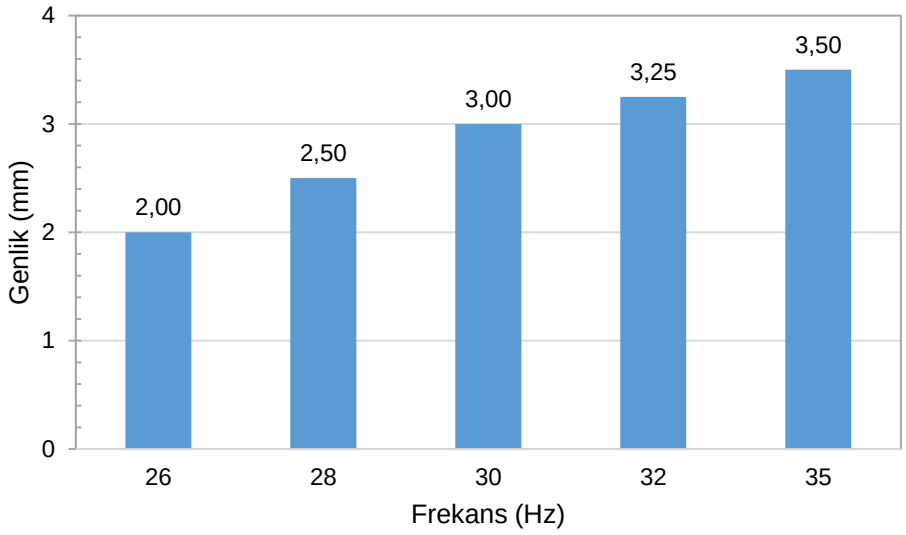
Şekil 3. Farda bulunan farklı lambaların deneyleri.

BULGULAR VE TARTIŞMA

Bu çalışmada, araç farlarının titreşim dayanıklılığını analiz etmek üzere tasarlanan titreşim test cihazının performansı deneysel olarak incelenmiştir. Elde edilen sonuçlar, cihazın far sistemlerinin titreşim karşısındaki davranışını etkin bir şekilde simüle edebildiğini ve kritik arızaları öngörebildiğini göstermektedir.

Titreşim Genliği ve Frekans İlişkisi

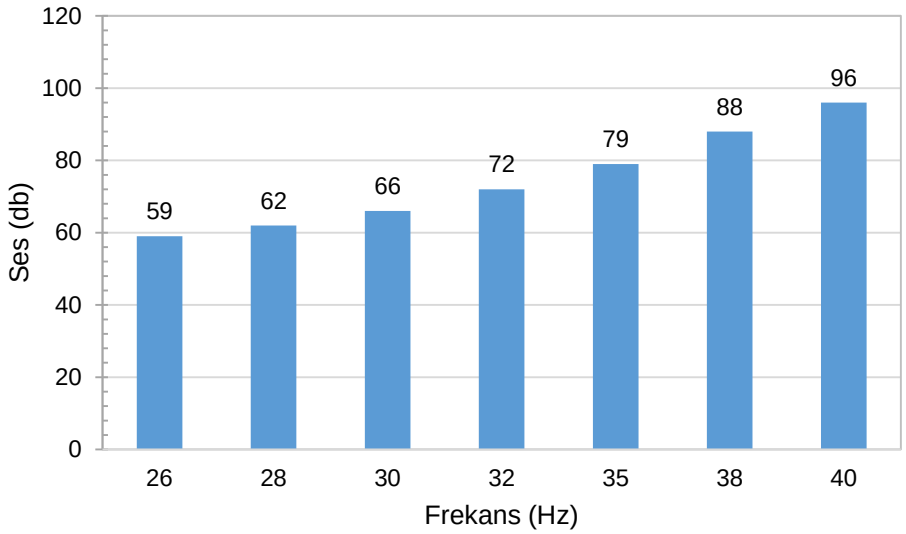
Şekil 4'te, eksantrik kaçıklığı 3.5 mm olan sistemde farklı frekans değerlerine karşılık gelen genlik değerleri gösterilmektedir. Frekans arttıkça, genlik değerlerinde doğrusal olmayan bir artış gözlemlenmiştir. Örneğin, 26 Hz frekansta 2 mm olan genlik, 30 Hz'de 3 mm'ye ulaşmıştır. Bu durum, titreşim test cihazının dinamik aralığının geniş olduğunu ve farklı yol koşullarını simüle edebilecek esnekliğe sahip olduğunu kanıtlamaktadır. Özellikle 35 Hz frekans değerinde, genliğin stabil kalması, far montaj sistemlerinin bu frekansta titreşim enerjisini absorbe edebildiğini göstermektedir.



Şekil 4. Eksantirik kaçıklığı 1.75 mm olan genlik deneyi.

Gürültü Seviyesi ve İş Sağlığı Değerlendirmesi

Şekil 5'te, titreşim test cihazının farklı frekanslarda ürettiği ses seviyeleri görülmektedir. 26 Hz'de yaklaşık 60 dB olan gürültü seviyesi, frekans arttıkça artış göstermiş ve 36 Hz'de 85 dB sınırını aşmıştır. Bu değer, işyerlerinde 8 saatlik maruziyet için belirlenen üst sınırdır (TS EN ISO 9612). Yüksek frekanslarda gürültü seviyesinin artması, cihazın uzun süreli kullanımında operatör sağlığı açısından risk oluşturabileceğini göstermektedir. Bu sorunu çözmek için, motor grubuna ses yalıtımı eklenmesi veya titreşim mekanizmasının viskoelastik malzemelerle desteklenmesi önerilmektedir. Ayrıca, yüksek frekans testlerinin kısa süreli yapılması, gürültü maruziyetini azaltacaktır.

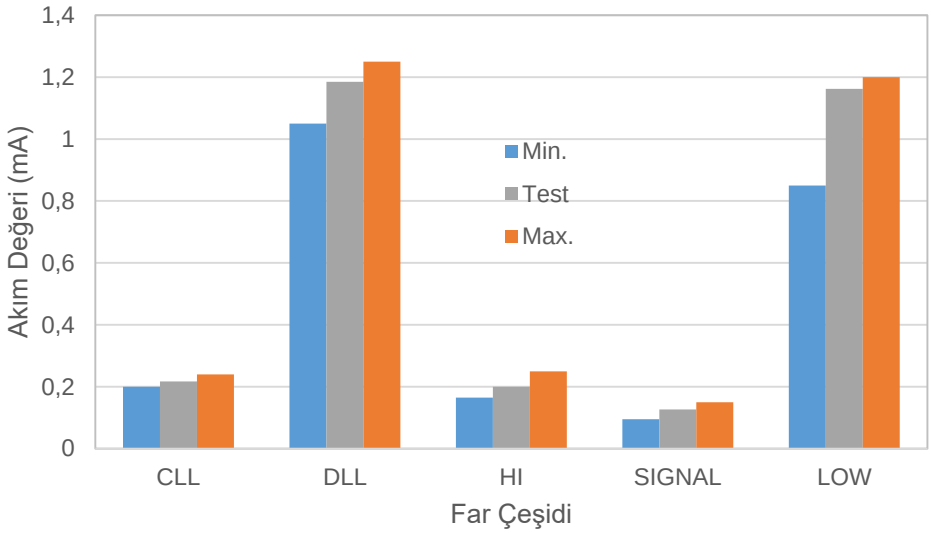


Şekil 5. Eksantirik kaçıklığı 1.75 mm olan ses deneyi.

Far Lambalarının Akım Analizi ve Elektriksel Stabilitesi

Şekil 6'da, 3.5 mm genlik ve 35 Hz frekansta yapılan test sırasında far lambalarının çektiği akımlar (mA cinsinden) gösterilmektedir. Grafikte, her bir far tipi (CLL, DLL, HI, SIGNAL ve LOW) için minimum, ortalama (result) ve maksimum akım değerleri yer almaktadır. 5 saniyelik test süresince, lambaların akım değerlerinin birbirine yakın aralıklarda seyrettiği ve ciddi bir dalgalanma olmadığı görülmüştür. Örneğin, DLL (gündüz farı) lambasının akımı yaklaşık 1.0 mA ile 1.2 mA arasında değişirken, SIGNAL lambası 0.4 mA ile 0.6 mA aralığında kalmıştır.

Bu sonuçlar, titreşim koşullarında bile elektrik devrelerinin stabilitesini koruduğunu ve lambaların sürekli performans sergilediğini göstermektedir.



Şekil 6. 3.5 mm genlikte farın çektiği akımlar. Far 5 saniye boyunca titreşime maruz bırakıldı.

SONUÇLAR

Bu çalışma, araç farlarının titreşim dayanıklılığını analiz etmek üzere tasarlanan test cihazının performansını ve endüstriyel uygulanabilirliğini kapsamlı bir şekilde ele almıştır. Bulgular ve tartışma kısmında elde edilen sonuçlar aşağıdaki gibi özetlenebilir:

Titreşim Performansı ve Genlik-Frekans İlişkisi

Test cihazı, 10–100 Hz frekans aralığında ve 0.1–5 mm genlik değerlerinde kararlı titreşim üretebilmiştir. Frekans arttıkça genlik değerlerinin doğrusal olmayan bir şekilde yükseldiği gözlemlenmiştir. Özellikle 35 Hz'de genliğin stabil kalması, far montaj sistemlerinin bu frekanstaki titreşim enerjisini etkin şekilde absorbe edebildiğini göstermektedir. Bu durum, cihazın farklı yol koşullarını simüle edebilecek geniş bir dinamik aralığa sahip olduğunu kanıtlamaktadır.

Gürültü Seviyesi ve İş Sağlığı

36 Hz frekansın üzerinde gürültü seviyesinin 85 dB'i aşması, uzun süreli kullanımda operatör sağlığı açısından bir risk oluşturabileceğini göstermiştir. Gürültü kontrolü için motor grubuna ek ses yalıtımı uygulanması veya titreşim mekanizmasının viskoelastik malzemelerle desteklenmesi önerilmektedir. Yüksek frekanslardaki testlerin daha kısa süreli tutulması da gürültü maruziyetini azaltmaya katkı sağlayacaktır.

Far Lambalarının Akım Analizi ve Elektriksel Stabilite

1.75 mm genlik ve 35 Hz frekansta yapılan testlerde, CLL, DLL, HI, SIGNAL ve LOW tipi lambaların akım değerlerinin birbirine yakın aralıklarda dalgalandığı ve genel olarak stabil kaldığı görülmüştür. Bu sonuç, titreşim altında bile elektrik devrelerinin kararlılığını koruduğunu ve far lambalarının sürekli performans sergilediğini doğrulamaktadır. Ancak, daha uzun süreli testlerde (örneğin 30 dakika veya daha fazla), bağlantı noktalarında ısınma veya kablolarda gevşeme gibi sorunların ortaya çıkabileceği göz önünde bulundurulmalıdır.

Endüstriyel Uygulanabilirlik ve Gelecek Çalışmalar

Cihaz, otomotiv endüstrisinde kalite kontrol süreçlerini hızlandıracak ve olası arızaları erken aşamada tespit ederek maliyet ve zaman tasarrufu sağlayacak pratik bir çözüm sunmaktadır.

Gürültü seviyesinin düşürülmesi, farklı araç modelleri için hızlı bağlantılı fikstürlerin geliştirilmesi ve titreşim ile termal stresin kombine etkilerini inceleyen hibrit testlerin yapılması, cihazın daha kapsamlı bir test altyapısı sunmasını sağlayacaktır. Özellikle uzun süreli (30+ dakika) testler ve termal etkilerin de dahil edildiği protokollerle, far bileşenlerinin dayanıklılığına dair daha kapsamlı veriler elde edilebilir.

Genel olarak, tasarlanan titreşim test cihazının hem titreşim hem de elektriksel açıdan güvenilir sonuçlar sunduğu görülmektedir. Bununla birlikte, gürültü yönetimi ve uzun süreli test protokolleri konularında yapılacak iyileştirmeler, cihazın endüstriyel anlamda daha geniş bir kullanım alanı bulmasına katkı sağlayacaktır.

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BIBLIOMETRIC ANALYSIS OF ACCOUNTING LAW-THEMED STUDIES

MUHASEBE HUKUKU TEMALI ÇALIŞMALARIN BİBLİYOMETRİK ANALİZİ

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ÖZET

Muhasebe hukuku, işletmelerin finansal işlemlerini yasal çerçevede yürütmelerini sağlayarak mali şeffaflığı ve hesap verilebilirliği güvence altına alan bir kavramdır. Aynı zamanda, vergi uyumu, finansal raporlama ve hukuki sorumluluklar açısından işletmelerin ve paydaşların haklarını koruyarak ekonomik düzenin sürdürülebilirliğine katkı sağlamaktadır.

Bu bağlamda çalışma, muhasebe hukuku alanında gerçekleştirilen akademik yayınları bibliyometrik yöntemlerle analiz etmeyi amaçlamaktadır. Bibliyometrik analiz, belirli bir konuya ilişkin bilimsel üretkenliği, atıf ilişkilerini ve eğilimleri sayısal verilerle ortaya koyan bir yöntemdir. Çalışmada, muhasebe hukuku ile ilgili ulusal ve uluslararası literatürde yayımlanan makaleler, atıf sayıları, yazar işbirlikleri, anahtar kelime analizleri vs. gibi kriterler üzerinden değerlendirilmiştir. Bu doğrultuda, muhasebe hukuku literatürünün gelişim süreci, en çok katkı sağlayan yazarlar, ülkeler, anahtar kavramlar ve gelecekteki araştırma yönelimleri belirlenmiştir. Sonuç olarak, muhasebe hukuku uluslararası platformda çalışılan ve giderek artan bir öneme sahip tema olarak görülmektedir. Yapılan akademik yayınlarda farklı ülke ve yazarlar arası işbirlikler ön plana çıkmaktadır.

Anahtar Kelimeler: Muhasebe, Hukuk, Muhasebe Hukuku, Bibliyometrik Analiz

ABSTRACT

Accounting law is a concept that ensures businesses conduct their financial transactions within a legal framework, guaranteeing financial transparency and accountability. At the same time, it contributes to the sustainability of the economic order by protecting the rights of businesses and stakeholders in terms of tax compliance, financial reporting, and legal responsibilities.

In this context, the study aims to analyze academic publications in the field of accounting law using bibliometric methods. Bibliometric analysis is a method that quantitatively reveals scientific productivity, citation relationships, and trends related to a specific topic. The study evaluates national and international literature on accounting law based on criteria such as the number of citations, author collaborations, keyword analysis, and more. Accordingly, the study identifies the development process of accounting law literature, the most contributing authors,

countries, key concepts, and future research directions. In conclusion, accounting law is recognized as an increasingly important theme in international academic platforms. Academic publications highlight collaborations between different countries and authors.

Keywords: Accounting, Law, Accounting Law, Bibliometrics Analysis.

GİRİŞ

Muhasebe hukuku, işletmelerin finansal işlemlerini düzenleyen ve denetleyen bir hukuk dalıdır. İşletmelerin finansal raporlama, vergi uyumu, mali düzenlemeler ve etik sorumluluklarını kapsayan bu alan, hem yerel hem de küresel ölçekte büyük bir öneme sahiptir. Muhasebe hukuku, finansal şeffaflık, hesap verebilirlik ve yasal uyumluluğu sağlamak amacıyla işletmelerin uygulamaları ile hukuki çerçeveler arasındaki ilişkiyi belirler. Bu bağlamda, muhasebe hukuku sadece işletmelerin hukuki sorumluluklarını yerine getirmeleri için gerekli bir alan değil, aynı zamanda ekonomik düzenin sağlanması ve sürdürülebilirliğinin teminatıdır.

Düzenleyici kurumlar, işletmelerin mali raporlamalarında doğru ve güvenilir bilgilerin sağlanmasını sağlamak için muhasebe hukuku ilkelerini uygular. Bu nedenle muhasebe hukuku, akademik alanda önemli bir araştırma konusu haline gelmiştir.

Akademik çalışmalar, muhasebe hukuku alanındaki teorik gelişmeleri anlamaya ve uygulamalı çözüm önerileri sunmaya yardımcı olmaktadır. Bu çalışmalar, finansal düzenlemeler, vergi mevzuatı, denetim uygulamaları gibi konularda önemli bulgular ortaya koymakta ve işletmelerin hukuki süreçlerini iyileştirmek için öneriler geliştirmektedir. Son yıllarda, muhasebe hukuku alanındaki akademik yayınların sayısında ciddi bir artış gözlemlenmiştir. Ancak, bu artışa paralel olarak, bu alandaki yayınların genel eğilimlerini, işbirliklerini ve etkilerini anlamak için daha derinlemesine bir analiz yapılması gerekmektedir.

Bibliyometrik analiz, belirli bir akademik alanın üretkenliğini, atıf ilişkilerini, anahtar kelimeleri, yazar işbirliklerini ve araştırma eğilimlerini incelemek için kullanılan güçlü bir yöntemdir. Bu analiz, bilimsel yayınların nicel verilerini toplar ve analiz etmekte, böylece ilgili alandaki araştırma trendlerini ve gelişim süreçlerini anlamaya yardımcı olmaktadır. Muhasebe hukuku alanındaki bibliyometrik analizler, bu alandaki en önemli araştırmacıları, ülkeleri, dergileri ve yayın türlerini tanımlamaya olanak sağlamaktadır. Ayrıca, bu analizler, muhasebe hukuku çalışmalarının gelecekteki araştırma yönelimlerini belirlemek için de oldukça değerli bilgiler sunmaktadır.

Bu çerçevede yapılan çalışmanın amacı, muhasebe hukuku temalı akademik yayınları bibliyometrik yöntemlerle analiz etmek ve literatürün gelişim sürecini, anahtar kavramları, yazar işbirliklerini ve araştırma yönelimlerini ortaya koymaktır. Ulusal ve uluslararası düzeyde yayımlanan akademik makaleler üzerinde yapılan bir bibliyometrik analiz, bu alandaki araştırmaların yoğunlaştığı konuları ve bu konularda hangi ülkelerin ve yazarların daha fazla katkı sağladığını belirlemek için etkili bir yol olmaktadır. Ayrıca, muhasebe hukuku alanındaki çalışmalarda sıklıkla karşılaşılan anahtar kelimeler ve kavramlar, bu alandaki araştırma boşluklarını ve potansiyel gelişim alanlarını anlamaya yardımcı olacaktır.

Sonuç olarak, muhasebe hukuku temalı akademik yayınların bibliyometrik analizi, bu alandaki literatürün derinlemesine incelenmesini sağlayarak, muhasebe hukuku araştırmalarının gelecekteki yönelimleri hakkında önemli bilgiler sunmaktadır. Bu çalışma, muhasebe hukuku araştırmalarına katkı sağlamak isteyen akademisyenler ve araştırmacılar için değerli bir kaynak olmayı hedeflemektedir.

KAVRAMSAL ÇERÇEVE

Muhasebe, Hukuk ve Adli Muhasebe

Muhasebe genel olarak iktisadi birimlerde diğer bir ifadeyle işletmelerde meydana gelen ve parayla ifade edilebilen olayları kayıtlayan, sınıflayan, özetleyen, raporlayan ve elde ettiği sonuçları yorumlayan bir bilgi üretim süreci olarak tanımlanmaktadır (Altıntaş, 2011). Muhasebede, para ile ifade edilebilen olayların kaydedilmesi, analiz edilmesi ve yorumlanması işlemlerinin düzenli ve doğru bir şekilde yapılması, sadece ticarette değil aynı zamanda toplumsal ve ekonomik anlamda oldukça önem arz etmektedir. İşletmelerin uluslararası faaliyet göstermesi, işletmelerin ve muhasebe işlemlerinin hacminin artması gibi nedenlerle bir standart oluşturabilmek için, ortak bir muhasebe dili olması elzem bir gereklilik olmaktadır. Ancak bu sayede şeffaf, hesap verilebilir ve karşılaştırılabilir finansal tablolar yaratılmakta, yatırımcı güveni ve ekonomik anlamda istikrar sağlanmış olmaktadır (Kurniawan, 2023). Oldukça geniş bir etki alanına sahip muhasebenin, tüm bilgi kullanıcıları tarafından genel bir anlaşılabilirliğe sahip olması da bu noktada önemli hale gelmektedir (Durak et al., 2011).

Öte yandan bireyler arası borç alacak ilişkisinin düzenlenmesi ve özellikle de alacaklının hakkının korunması yalnız muhasebe için değil hukuken de önemli bir konu olarak görülmektedir. Dolayısıyla yeni kullanılan bir kavram olan muhasebe hukukunun, aslında ticaret hukukunun bir alt kolu olarak ortaya çıktığı açık bir gerçekliktir. Ancak daha sonra yaşanan gelişmeler muhasebe hukukunun içeriğini genişletmiş ve tanımının değişmesine yol açmıştır (Altıntaş, 2011).

Muhasebe hukukun temel düzenlemelerini oluşturan kanunlar, Türk Ticaret Kanunu ve Vergi Usul Kanunu'dur. Mükelleflerin düzenlemesi gereken defterleri ve kayıt düzenini bu kanunlarda bulunan hükümler belirlemektedir. Uluslararası gelişmelere nazaran geç gerçekleşse de, ülkemizde Türkiye Muhasebe Standartları Kurulu'nun kurulması ve Tek Düzen Hesap Planına geçilmesiyle muhasebe sistemindeki gelişim olumlu yönde etkilenmektedir (Öz & Çevikcan, 2010). Muhasebe uygulamalarını düzenleyen kanunlar, finansal tabloların hazırlanması ve defter tutma ilkeleri ve vergi uygulamaları gibi temel kurallarla muhasebe sisteminin daha sistematik ve doğru bilgi üretmesini sağlamaktadır (Aksu Özkan, 2019).

Küreselleşmenin de etkisiyle artan rekabet koşullarında bazı firmalar ayakta kalabilmek için kendi çıkarları uğruna toplum çıkarlarını hiçe sayarak hile ve usulsüzlüklere başvurabilmektedirler (Kızıl et al., 2019). Dünyanın her yerinde karşılaşılan bu usulsüzlüklere ve yolsuzluklara, Enron, Global Crossing, Tyco, Adelphia ve Worldcom şirketleri örnek verilebilir (Bekçioğlu et al., 2013). Yaşanan bu muhasebe skandalları sonucunda ülke ekonomileri ciddi zararlar görmüş, binlerce kişi işsiz kalmış ve sektördeki diğer firmalarda da güvensizlik ortamından kaynaklı itibar ve güven kaybı yaşanmıştır.

Hileli işlemlerin ve usulsüzlüklerin günümüzde artmasının başlıca nedenlerine, firmaların büyümesi ve çeşitlenmesi , bilgi teknolojilerinin kullanımının artması ve güvenlik açıklarını bilen kötü niyetli uzmanların varlığı örnek verilebilir (Bekçioğlu et al., 2013). Bunların yanında yönetici baskıları, yüksek performans beklentileri, yüksek kazanç elde etme arzusu, kurumsal yönetim eksikliği, uygun ortamın oluşması, etkin denetimin eksikliği ve suçu meşrulaştırma gibi nedenler de hile usulsüzlüklerin artmasına örnek verilebilir.

Özellikle kötü niyetli kişiler tarafından kasıtlı yapılan usulsüzlükler şirketlere ve karar vericilere ciddi zararlar vererek finansal bilgilerin güvenilirliğini zedelemektedir. Giderleri fazla göstermek için yapılan borç hesaplarındaki oynamalar, sahte ve olması gerekenden daha fazla sayıda kesilmiş karşılıksız faturalar, muhasebe usulsüzlüklerine örnek verilebilmektedir (Nickell et al., 2023). Bu usulsüzlükler başlangıçta firmaları mali açıdan fazla etkilemese de zamanla çok ciddi kayıplara neden olarak, iflasa kadar gidebilmektedir. Böylesine ciddi sonuçlara yol açabilecek bu usulsüzlüklerin engellenebilmesi konusunda denetim ön plana çıkmaktadır.

Muhasebenin temel amacı bilgi kullanıcılarına gerekli bilgileri doğru, güvenilir ve zamanında sunmaktır. Bu doğrultuda, karar alma süreçlerinin etkinliğini belirleyen en önemli unsur, üretilen bilginin içeriği ve sunuş biçimidir. Aynı zamanda bilgi kullanıcılarına doğru ve güvenilir bilgileri sağlamak için üretilen bu bilgilerin denetimi de muhasebenin kapsamına girmektedir (Durak et al., 2011).

Denetçiler tarafından yapılan geleneksel denetim uygulamaları kimi zaman muhasebe hilelerini ve usulsüzlüklerini tespit etmede yeterli olmamaktadır. Muhasebe ve hukukun kesişim noktasında yeni bir meslek dalı olarak adli muhasebecilik devreye girmektedir.

Denetçiler genellikle denetleme yaptıkları şirketlere ait muhasebe kayıtlarının ve finansal raporlarının standartlara uygun olup olmadığını denetlemekle sorumludurlar. Fakat daha karmaşık ve kapsamlı analiz yöntemlerine ihtiyaç duyulduğunda adli muhasebeciler farklı alanlardaki uzmanlıkları ve tecrübeleriyle usulsüzlükleri ortaya çıkarmak ve gerektiğinde mahkemelerde delil olarak sunulabilecek raporlar hazırlama görevini üstlenmektedirler (Hossain, 2023).

Muhasebe ve hukuk, işletmelerin finansal işlemlerinin yasal düzenlemelere uygun olarak yürütülmesini sağlayan iki ayrı disiplindir. Söz konusu iki disiplin, vergi mevzuatı, finansal raporlama standartları ve ticaret hukuku gibi alanlarda kesişerek işletmelerin mali sorumluluklarını belirlemektedir. Ayrıca, denetim süreçleri ve hukuki yükümlülükler çerçevesinde, muhasebe kayıtlarının doğruluğu hukuki yaptırımlarla güvence altına alınmaktadır. Sonuç olarak muhasebe finansal süreçlerde bilgi kullanıcılarına güvenilir, doğru ve zamanında bilgi sağlamak ve yapılan hata veya usulsüzlüklerin denetlenerek tespit edilmesi ve engellenmesi konusunda hukuk ile sıkı bir ilişki içinde olması oldukça kritik rol oynamaktadır.

METODOLOJİ

Araştırmanın Amacı ve Yöntemi

Araştırmanın amacı; muhasebe hukuku ana temasında çalışılan akademik yayınların görsel haritalama tekniklerinden bibliyometrik analiz ile değerlendirilmesidir. Bu amaç doğrultusunda, söz konusu alandaki eğilimler, ülke bazlı katkılar ve yazarlar arasındaki işbirlikleri detaylı olarak incelenmektedir.

Bibliyometrik analiz, geniş kapsamlı bilimsel verilerin keşfedilmesi ve değerlendirilerek analiz edilmesini sağlayan bir yöntemdir. Bu yöntemle belirli alanlardaki araştırmaların gelişimlerini inceleyerek gelecek çalışmalara ışık tutulmasını sağlanmaktadır (Donthu et al., 2021). Ayrıca ilgili literatürdeki çalışmaların temel eğilimlerinin belirlenmesi, dergi performanslarının değerlendirilmesi ve yazar iş birliklerini analiz etmeye olanak sağlamaktadır (Ellili, 2024).

Tablo 1. Belge İçin Arama Çerçevesi

Parametreler	**Seçim**
Seçim yaklaşımı	Bibliyometrik analiz
Kullanılan veritabanı	WoS (Web of Science)
Analiz için kullanılan araçlar	R, Python
Arama sorgusu	Muhasebe Hukuku
Belgenin niteliği	Makale/Bildiri/Kitap/Kitap Bölümü
Zaman aralığı	1976-2024
Dil	İngilizce
Analiz için toplam belge sayısı	280
Yayın aşaması	Son

Veriler analiz edilirken belge arama noktasındaki genel çerçeve Tablo 1'de gösterilmektedir. Bu aşamada 1976-2024 yılları arasında yayımlanmış olarak 280 adet belgeye ulaşılmıştır.

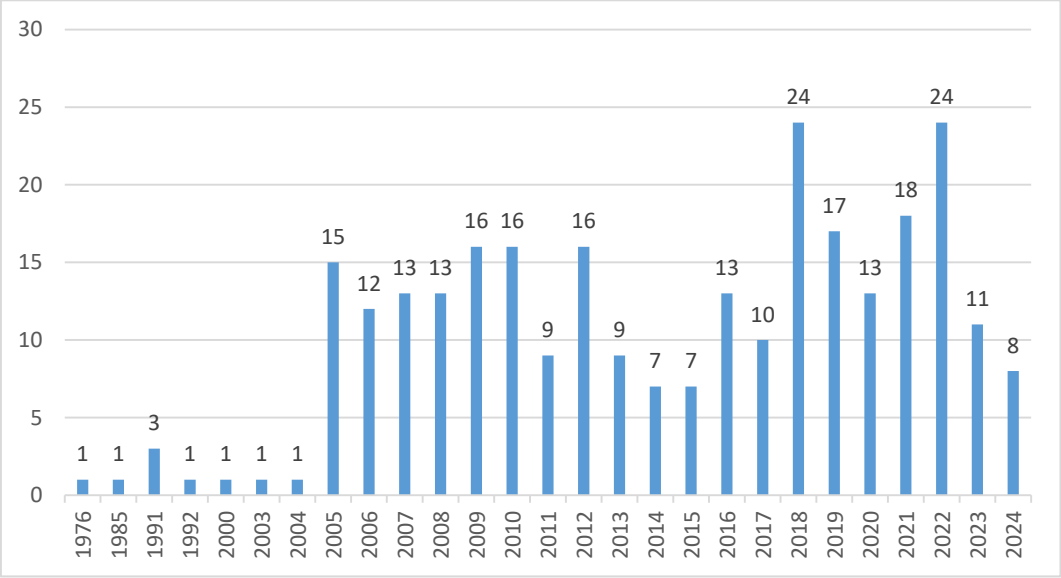
Araştırma Bulguları ve Değerlendirmeler

Bu kısımda analiz sonucu elde edilen bulgular yer almaktadır.

Tablo 2. Belge Ölçütlerinin Değerlendirilmesi

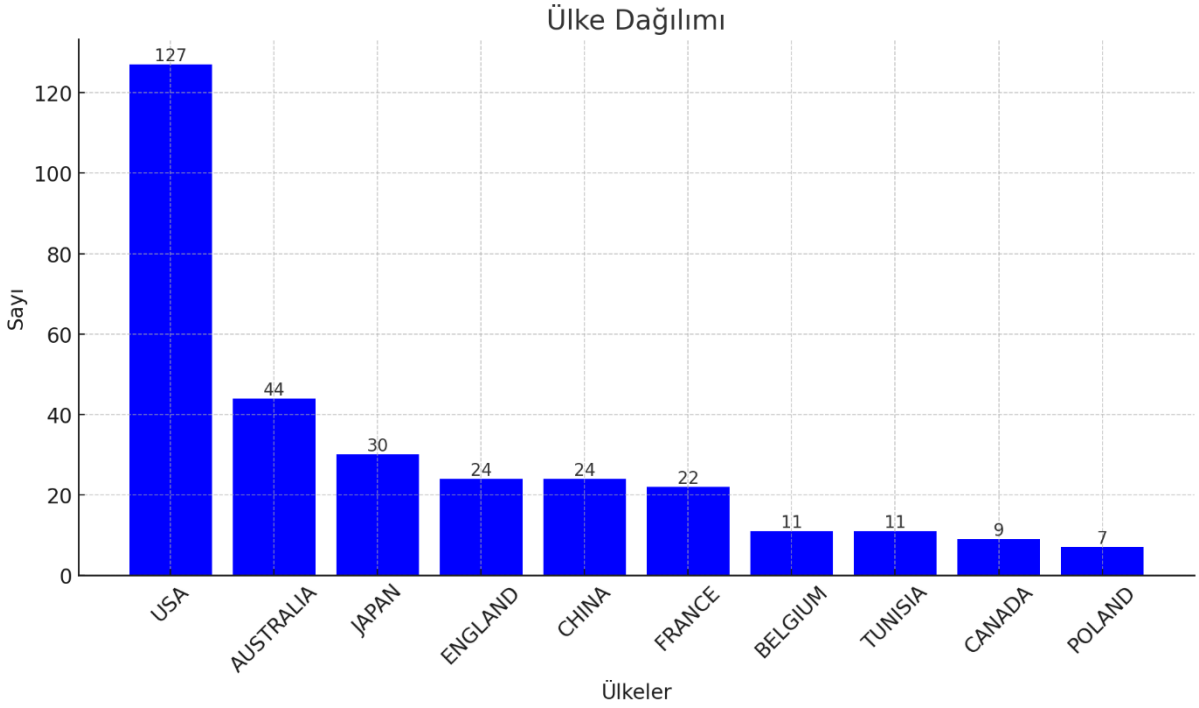
Ölçütler	**Rakamsal Değer**
Belge Türleri	
Makale	252
Bildiri	15
Kitap	11
Kitap Bölümü	2
WoS Kategorileri	
İşletme-Finans	203
Yönetim	62
Ekonomik	10
Sosyal Bilimler Disiplinlerarası	5
WoS Endeksi	
Gelişen Kaynaklar Atıf İndeksi (ESCI)	141
Sosyal Bilimler Atıf İndeksi (SSCI)	112
Konferams Bildirileri Atıf Dizini-Sosyal Bilimler ve Beşeri Bilimler (CPCI-SSH)	21
Kitap Atıf Dizini - Sosyal Bilimler ve Beşeri Bilimler (BKCI-SSH)	6
Toplam	280

Tabloya göre, belge ölçütleri rakamsal değerlerle detaylandırılmıştır. Belge türleri arasında en fazla katkının 252 adet ile makalelerden geldiği görülmektedir. Makaleleri, 15 adet bildiri, 11 adet kitap ve 2 adet kitap bölümü takip etmektedir. WoS kategorileri incelendiğinde, İşletme-Finans alanında 203, Yönetim alanında 62 ve Ekonomi alanında 10 belge yer almaktadır. Sosyal Bilimler Disiplinler arası kategorisinde ise 5 belge bulunmuştur. WoS Endeksi bağlamında değerlendirildiğinde, Gelişen Kaynaklar Atıf İndeksi (ESCI) 141 belge ile en yüksek katkıyı sağlamıştır; bunu 112 belge ile Sosyal Bilimler Atıf İndeksi (SSCI) takip etmektedir. Ayrıca, Konferans Bildirileri Atıf Dizini (CPCI-SSH) kapsamında 21 belge, Kitap Atıf Dizini-Sosyal Bilimler ve Beşeri Bilimler (BKCI-SSH) kapsamında ise 6 belge yer almaktadır. Bu veriler, muhasebe hukuku temasına yapılan akademik katkıları; farklı belge türleri ve kategoriler bağlamında ortaya koymaktadır.



Şekil 1. Yıllara Göre Yayın Sayıları

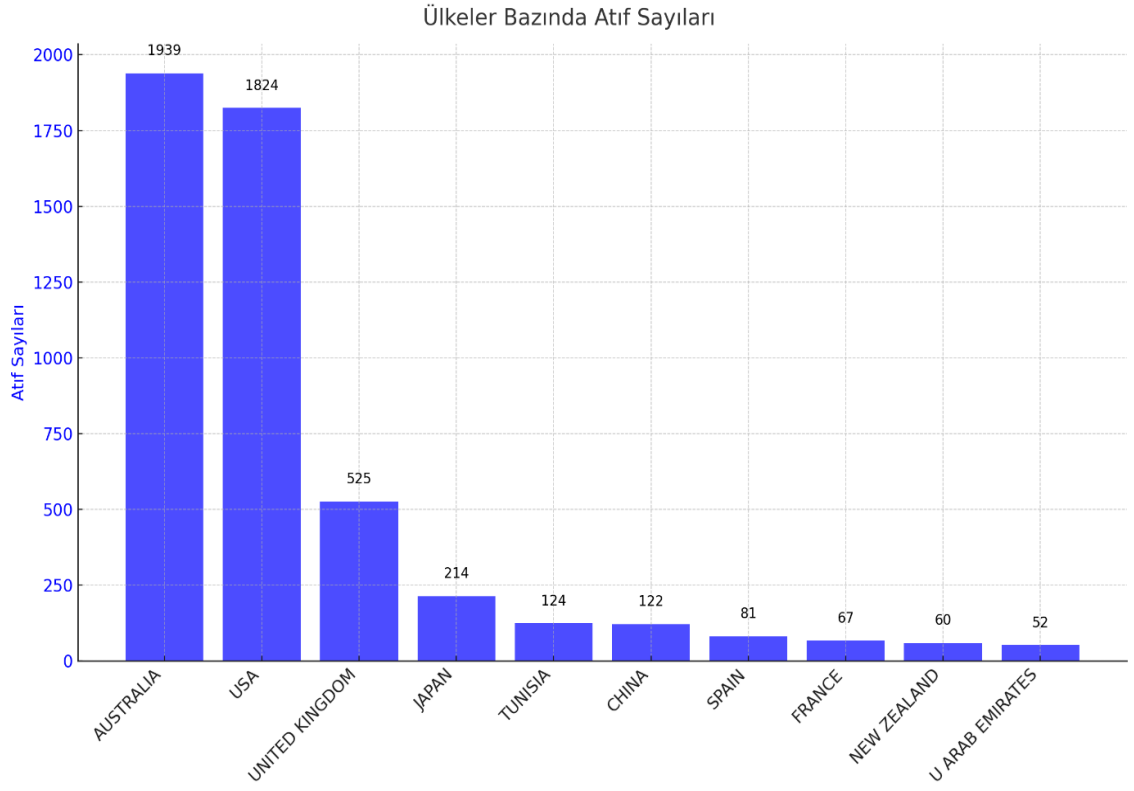
Şekilde yıllara göre makale sayılarının dağılımı gösterilmektedir. 2022 ve 2018 yıllarında en yüksek değer olan 24 makale ile dikkat çekerken, 2024 yılında makale sayısı 8'e düşmüştür. 2000 öncesinde makale sayıları oldukça düşüktür ve çoğunlukla 1 ile 3 arasında değişmektedir. 2000 sonrası dönemden itibaren makale sayılarında belirgin bir artış gözlenmiştir. Özellikle 2010-2020 yılları arasında makale sayıları daha dengeli bir dağılım sergilemektedir. Bu şekil, akademik üretkenliğin son yıllarda artış gösterdiğini, ancak yıllara göre bazı dalgalanmalar yaşandığını göstermektedir.



Şekil 2. Ülkelere Göre Makale Sayıları (İlk 10 Ülke)

Şekil 2, ülkelerin makale sayılarına göre sıralamasını göstermektedir ve ilk 10 ülkenin katkı düzeylerini ortaya koymaktadır. ABD, 127 makale ile açık ara lider konumda yer alırken, onu 44 makale ile Avustralya ve 30 makale ile Japonya takip etmektedir. İngiltere ve Çin, her biri 24 makale ile eşit bir katkı sunmuş, Fransa ise 22 makale ile bu ülkeleri izlemiştir. Belçika ve

Tunus, 11'er makale ile sıralamada yer alırken, Kanada 9 makale ve Polonya 7 makale ile listede yer almaktadır. Bu sonuçlar, ABD'nin akademik makale üretiminde diğer ülkelerden önemli ölçüde önde olduğunu ve Avustralya, Japonya gibi ülkelerin de kayda değer katkılar sağladığını göstermektedir. Listenin alt sıralarında yer alan ülkeler ise daha sınırlı bir akademik üretim ortaya koymuştur. Veriler söz konusu temanın farklı ülkeler bağlamında akademik anlamda ele alındığını, çalışıldığı göstermektedir.



Şekil 3. En Çok Atıf Yapılan Ülkeler (İlk 10 Ülke)

Şekil 3, ülkelerin atıf sayılarını mavi çubuklarla ve çubukların üzerinde yer alan sayılarla görselleştirmektedir. En yüksek atıf sayısına sahip ülke 1939 ile Avustralya olurken, onu 1824 ile ABD takip etmektedir. Diğer ülkeler daha düşük atıf sayılarına sahip olup, Japonya ve Fransa gibi ülkeler özellikle daha düşük seviyelerde dikkat çekmektedir. Bu görselleştirme, ülkelerin akademik ya da bilimsel etkinliklerindeki farklılıkları kolayca analiz etmeye olanak sağlamaktadır.

Tablo 3. En İlgili Yazarlar

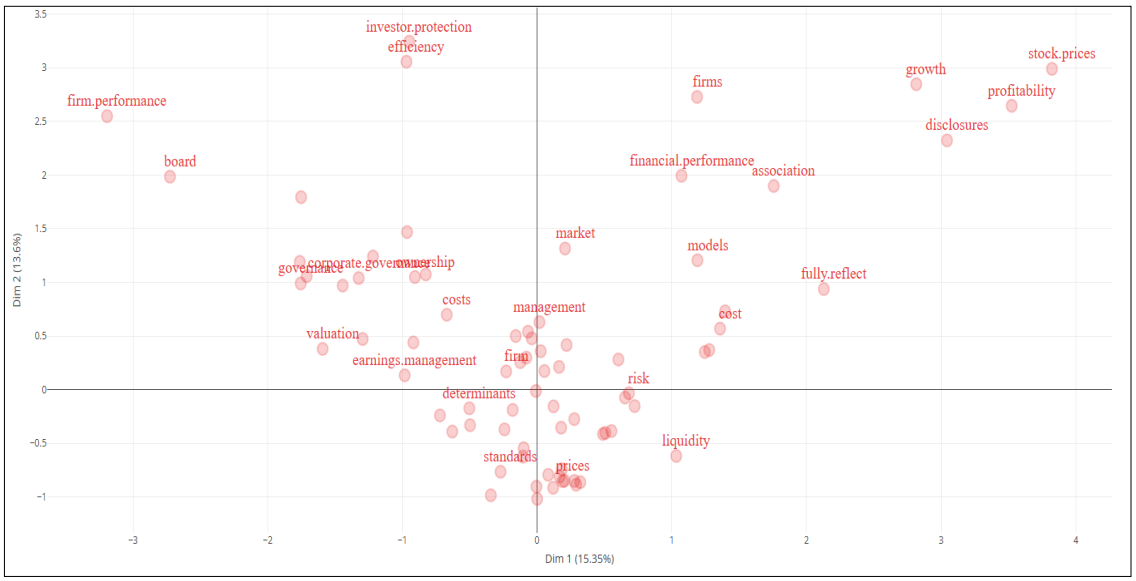
Sıra	Yazarlar	Makale Sayısı
1	Takehara H	14
2	Bernard C	13
3	Petty Rd	13
4	Suto M	11
5	Deegan C	9
6	Kubota K	7
7	Xu W	7
8	Vanduffel S	7
9	De Lange P	6
10	Fernando Gd	6

Tablo 3'teki verilere göre, en ilgili yazarlar arasında 14 yayın sayısıyla TAKEHARA H başı çekmektedir. BERNARD C ve PETTY RD sırasıyla 13 yayınla ikinci sırayı paylaşırken, SUTO M 11 yayınla dikkat çekmektedir. Daha düşük seviyelerde ise DEEGAN C 9 yayın, KUBOTA

K 7 yayınla öne çıkmaktadır. Alt sıralarda XU W, VANDUFFEL S yine 7 yayınla yer alırken, DE LANGE P ve FERNANDO GD 6 yayınla listede bulunmaktadır. Bu tablo, araştırma alanındaki önemli isimlerin yayın sayıları üzerinden bir sıralama sunmaktadır.

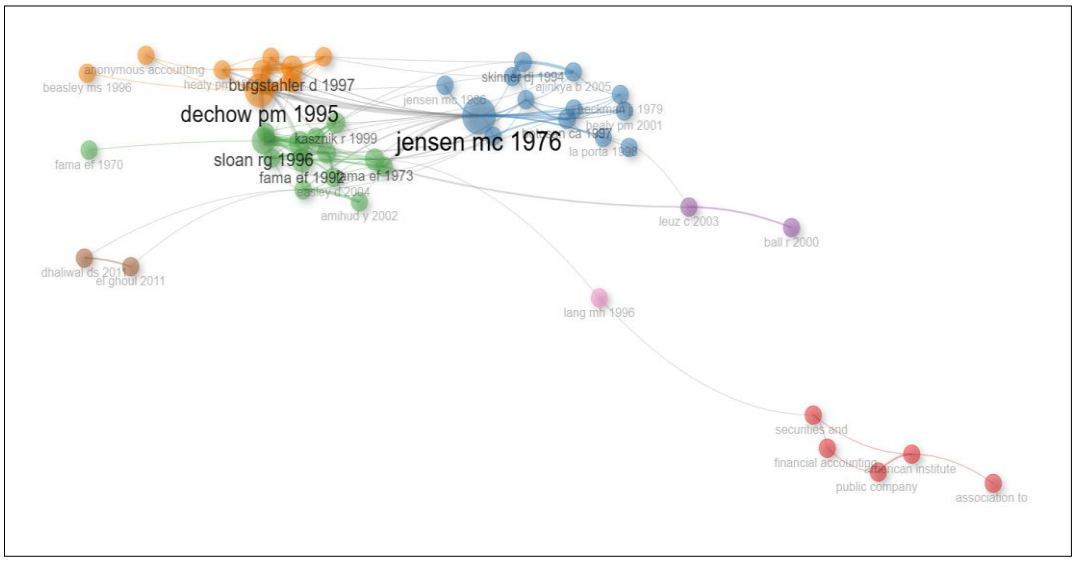
Şekil 4. En Sık Kullanılan Kelimeler (İlk 30 Kelime)

Şekil 4'te kelime bulutu, muhasebe hukuku araştırma literatüründe öne çıkan terimleri görselleştirmektedir. En büyük kelimeler, konunun odak noktalarını temsil ederken "information (bilgi)", "performance (performans)", "management (yönetim)" ve "disclosure (ifşa etme)" gibi terimler, çalışmalarda en sık vurgulanan kavramlardır. Bunun yanı sıra, "impact (etki)", "risk (risk)", "quality (kalite)" ve "ownership (sahiplik)" gibi kelimeler, daha spesifik araştırma alanlarına dikkat çekmektedir. Kurumsal yönetim, risk yönetimi, bilgi kalitesi ve performans değerlendirme gibi temaların, araştırma literatüründe geniş bir şekilde ele alındığını göstermektedir. Bu bulut, akademik çalışmaların hangi konular etrafında yoğunlaştığını özetlemek için etkili bir görselleştirme sunmaktadır.



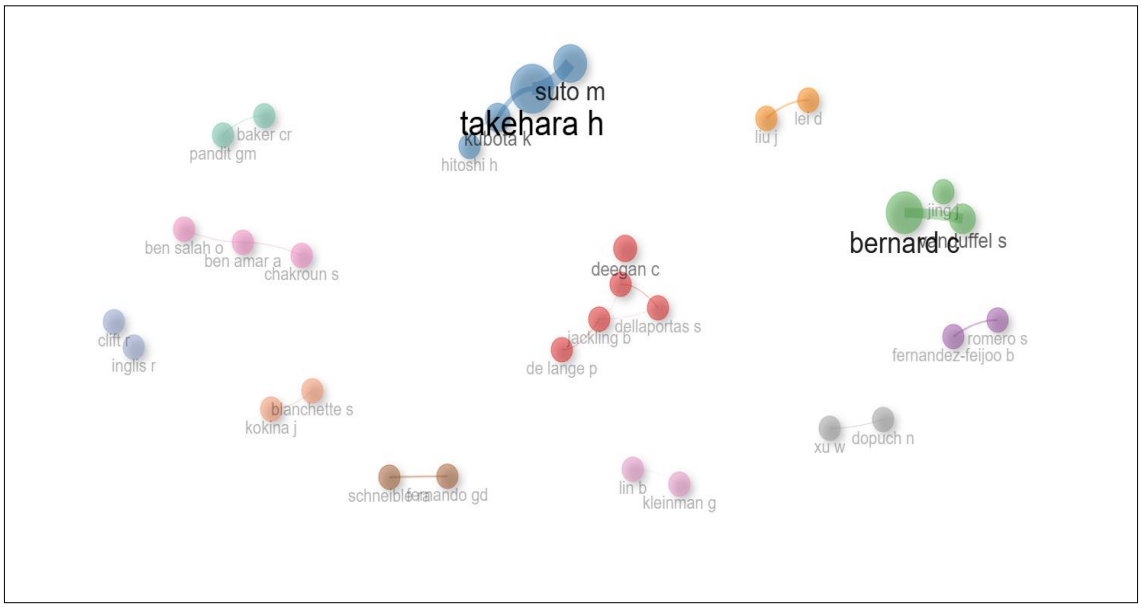
Şekil 5. Kavramsal Yapı Haritası Yönteminin Faktöriyel Analizi: Yüksek Frekanslı Anahtar Kelimelerin MCA'sı

Şekil 5'te, farklı kavramların iki boyutlu bir düzlemde konumlandırılmasıyla aralarındaki ilişkiler görselleştirilmektedir. "Investor protection (yatırımcı koruması)" ve "efficiency (etki)" gibi terimler grafiğin sol üst köşesinde yer alırken, "stock prices(stok fiyatları)", "growth (büyüme)" ve "profitability (karlılık)" gibi finansal performansla ilişkili kavramlar sağ üst köşede toplanmıştır. Merkezde ise "corporate governance (kurumsal yönetim)", "ownership (sahiplik)" ve "management (yönetim)" gibi daha genel iş yönetimi kavramları yoğunlaşmaktadır. Bu dağılım, farklı terim gruplarının birbiriyle olan ilişkilerinin ve yoğunlaşma alanlarının analiz edilmesine olanak tanır. Kavramlar arasında mekânsal yakınlık, araştırmalarda ele alınan konuların ne derece bağlantılı olduğunu ifade etmektedir.



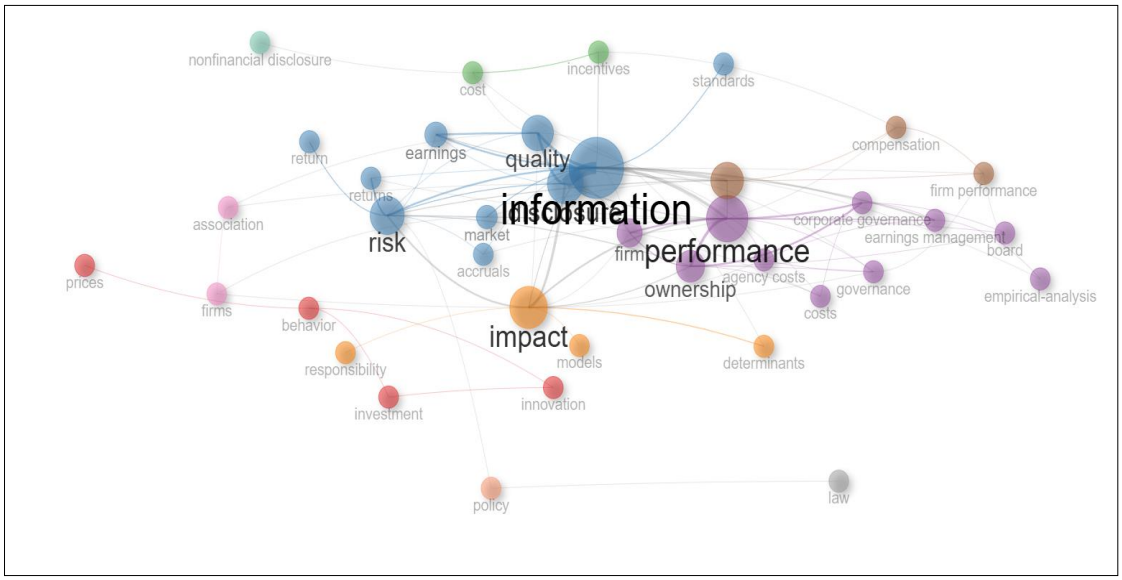
Şekil 6. Yazarların Ortak Atıf Ağı

Şekil 6'da, akademik literatürde önemli makaleler ve yazarlar arasındaki ilişkiler ağ yapısı ile görselleştirilmiştir. Jensen MC'nin 1976'daki çalışması ağın merkezi bir düğümü olarak öne çıkarken, Dechow PM'nin 1995'teki çalışması da diğer birçok çalışma ile güçlü bir bağlantı göstermektedir. Farklı renklerdeki kümeler, belirli araştırma temalarındaki yazar gruplarını temsil etmektedir. Örneğin, yeşil renk ağı ağırlıklı olarak Fama EF'nin finans teorileri üzerine yoğunlaşırken, turuncu ve mavi ağlar kurumsal yönetim ve muhasebe standartları gibi konuları işaret etmektedir. Daha uzak düğümler, spesifik veya bağımsız alanlarda yapılan çalışmaları yansıtarak genel literatür içerisindeki çeşitliliği göstermektedir. Bu ağ, akademik literatürde hangi çalışmaların merkezi ve etkili olduğunu anlamak için güçlü bir görsel araç sunmaktadır.



Şekil 7. Yazarlar arası İşbirlik Ağı

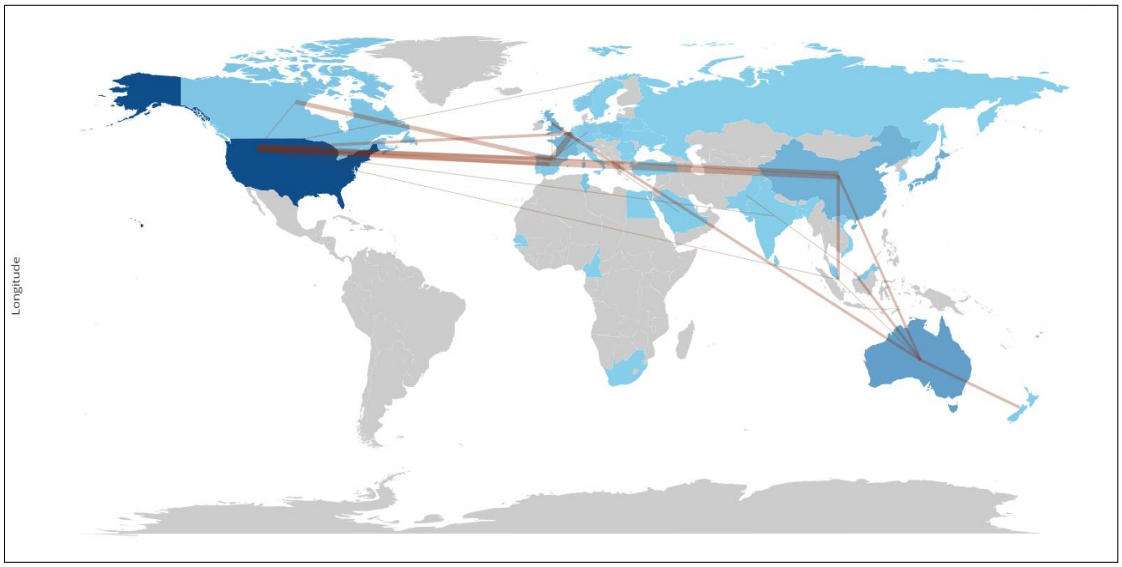
Şekil 7'de, farklı yazar gruplarını ve aralarındaki ilişkileri görselleştirmektedir. "Takehara H" ve "Suto M", mavi küme içerisinde merkezi bir konuma sahiptir ve diğer yazarlarla güçlü bağlantılar sergilemektedir. "Bernard C" ise yeşil küme içinde öne çıkarken, "Deegan C" kırmızı kümenin merkezi bir figürü olarak dikkat çekmektedir. Daha küçük kümeler ise belirli yazar gruplarının bağımsız araştırma temalarını temsil etmektedir. Örneğin, "Blanchette S" ve "Kokina J" turuncu bir bağlantı içinde yer alırken, "Romero S" ve "Fernandez-Feijoo B" mor bir grupta konumlanmıştır. Bu yapı, yazarlar arasındaki işbirliklerini ve akademik etkileşimlerin yoğunluğunu anlamak için etkili bir araç sunmaktadır.



Şekil 8. Kavram Ağı

Şekil 8'de, akademik veya profesyonel çalışmalarda kullanılan anahtar kavramlar arasındaki ilişkileri bir ağ yapısı ile göstermektedir. En büyük düğüm olan "information" (bilgi), ağın merkezi bir konumunda yer alarak birçok diğer kavramla güçlü bir bağlantı kurmaktadır. "Performance" (performans), "impact" (etki), ve "risk" gibi kavramlar, bilgiyle doğrudan ilişkilidir ve önemli alt temaları temsil etmektedir. Diğer düğümler arasında "ownership" (sahiplik), "quality" (kalite), "corporate governance" (kurumsal yönetim) gibi konular dikkat çekmektedir. Farklı renklerle gösterilen kümeler, belirli tematik grupları ve alt alanları işaret etmekte, araştırma veya çalışma konularındaki çeşitliliği ve bağlantısallığı vurgulamaktadır. Bu

görselleştirme, bilgi odaklı ağ yapısını ve temalar arasındaki ilişkileri anlamak için güçlü bir araçtır.



Şekil 9. Ülkelerin İşbirliği Ağı

Şekil 9'da, küresel düzeyde akademik veya profesyonel işbirliklerini ve bağlantıları görselleştirmektedir. Özellikle ABD ve Avustralya gibi ülkeler, daha koyu renklerle gösterilerek işbirliklerinin merkezinde yer aldığı vurgulanmıştır. Çizgiler, ülkeler arasındaki bağlantıları temsil ederken, bu iki ülkenin diğer bölgelerle yoğun bir ilişki içerisinde olduğunu göstermektedir. Avrupa ve Asya'dan gelen bağlantılar da dikkat çekmekte, bu bölgelerin işbirliği ağında önemli bir yer tuttuğunu ortaya koymaktadır. Harita, araştırma ve profesyonel etkileşimlerin küresel dağılımını anlamak için güçlü bir görsel araç sunmaktadır.

SONUÇ

Muhasebe hukuku, işletmelerin finansal işlemlerini düzenleyen ve denetleyen bir hukuk alt dalıdır. İşletmelerin finansal raporlama, vergi uyumu, mali düzenlemeler ve etik sorumluluklarını kapsayan bu alan, hem yerel hem de küresel ölçekte büyük bir öneme sahip görülmekte, giderek artan bir ilgi görmektedir. Muhasebe hukuku, finansal şeffaflık, hesap verebilirlik ve yasal uyumluluğu sağlamak amacıyla işletmelerin uygulamaları ile hukuki çerçeveler arasındaki ilişkiyi belirlemektedir. Bu bağlamda, muhasebe hukuku sadece işletmelerin hukuki sorumluluklarını yerine getirmeleri için gerekli bir alan değil, aynı zamanda ekonomik düzenin sağlanması ve sürdürülebilirliğinin teminatı olarak da görülmektedir.

Bu çerçevede çalışmada, muhasebe hukuku konusunda yapılan akademik çalışmalar bibliyometrik yöntemlerle incelenmiştir. Elde edilen bulgulara göre, muhasebe hukuku alanı zamanla artan bir akademik ilgi görmüş ve küresel çapta önemli araştırma konularından biri haline gelmiştir. En fazla yayına ve atıfa sahip ülkenin ABD olduğu tespit edilse de, Avustralya, Japonya, İngiltere, Çin gibi farklı ülkelerden üniversiteler de alana önemli katkılarda bulunmuştur. Ayrıca, uluslararası yazar işbirliklerinin bu alanda oldukça yaygın olduğu gözlenmiştir.

Muhasebe hukuku ile ilgili çalışmalar, hem akademik hem de uygulama açısından önemli bulgular sunarak, muhasebe mesleğinde hukuk kurallarının uygulanmasının ekonomik sistemin güvenilirliğini korumada oynadığı kritik rolü ortaya koymaktadır. Hata, hile ve usulsüz muhasebe uygulamalarının yarattığı olumsuz etkiler, bu çalışmaların önemini daha da artırmaktadır. Genel olarak, muhasebe hukuku temasına dair yapılan araştırmaların daha da

artması ve bu konuda yeni metodolojik yaklaşımlar geliştirilmesi gerektiği sonucuna ulaşılmıştır. Bu bulgular, muhasebe hukuku konusundaki farkındalığı artırmak açısından yol gösterici olacaktır.

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PRODUCTION OF SWEET POTATO CHIPS AND DETERMINATION OF DRYING CHARACTERISTICS AND SOME PHYSICAL PROPERTIES USING CONVECTIVE AND MICROWAVE DRYING METHODS

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ABSTRACT

In this study, it was aimed to produce chips from sweet potatoes (*Ipomoea Batatas* L.), which have become increasingly popular in recent years, using convective and microwave drying methods. For this purpose, after washing and peeling, the sweet potatoes were sliced to a diameter of 4 ± 0.1 cm and a thickness of 3 ± 0.1 mm, and then dried using the convective drying method at 60 and 70 °C and the microwave drying method at power levels of 240 and 400 W. It was determined that the samples dried using the microwave drying method dried in a shorter time compared to the samples dried using the convective drying method. It was determined that the increase in temperature and microwave power increases the drying rate. The drying time-effective diffusivity coefficients of the samples dried at 60 °C and 70 °C temperatures and 240W and 400W power values were determined as 390 min-1,10 x 10^{-10} m^2 s^{-1}, 240 min-1,64 x 10^{-10} m^2 s^{-1}, 27 min-1,71 x 10^{-9} m^2 s^{-1}, and 11 min-3,21 x 10^{-9} m^2 s^{-1}, respectively. The drying curves of the samples were defined using thin layer drying models and the artificial neural network modeling method, and it was determined that the curves of the Midilli and Küçük model, which is a thin layer drying model, were the best predicting model. The L*, a*, and b* values of fresh sweet potatoes were determined as 62.34 ± 0.22, 26.56 ± 1.26, and 36.38 ± 0.98, respectively. As a result of drying, the L* value showed a decreasing trend, while the a* and b* values did not show any specific trend. Based on the changes in color values, the total color change (ΔE) determined was 13.43 ± 0.63, which was the highest in samples dried at 400W power ($p<0.05$). On the other hand, it was observed that the diameter shrinkage ratio of the samples dried by the convective drying method (60°C-%46.58 ± 4.26, 70°C-%48.67 ± 1.66) was higher than that of the samples dried by the microwave method (240W-%32.42 ± 1.38, 400W-%31.92 ± 1.23) ($p<0.05$). However, the thickness shrinkage ratio of the samples dried by the microwave method (240W-41.11% ± 6.94, 400W-38.89% ± 5.09) were found to be higher than those dried by the convective drying method (60°C-27.78% ±

1.92, 70°C-35.56% ± 1.92) ($p<0.05$). In samples subjected to rehydration for 6 hours at 50 °C, the rehydration ratio was generally found to be higher in samples treated with the convective drying method ($p<0.05$). Additionally, among the samples, the one with the highest rehydration ratio was determined to be the sample dried at 60 °C, with a value of 4.68 ± 0.07 ($p<0.05$). Depending on the drying process, the specific energy consumption (SEC) values decreased as the drying time shortened, with the highest SEC value observed at 19.67 ± 0.64 kWh kg^{-1} at 60 °C, and the lowest value at 1.52 ± 0.001 kWh kg^{-1} in samples dried at 400W power. According to the principal component analysis, all samples are positioned in different areas and do not show significant similarity based on the parameters investigated. As a result of the study, it was observed that the microwave drying method provided effective drying, but particularly at 400W, it negatively affected properties such as color, shrinkage and rehydration ratios. Based on these results, drying fruit and vegetable products at relatively low microwave powers such as 240W can be recommended as a method with potential in terms of drying time, specific energy consumption, and other physical properties.

Key Words: Convective drying, Energy, Microwave, Physical Properties, Sweet Potato

GLYCOALKALOID IN THE SOLANACEAE FAMILY: SOLANINE

SOLANACEAE FAMİLYASINDAKİ GLİKOALKALOİD: SOLANİN

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ÖZET

Alkaloidler, yapılarında en az bir azot atomu bulunduran ve bitkiler tarafından sentezlenen ikincil metabolitlerdir. Bu metabolitler, canlılar üzerinde farklı fizyolojik etkilere sahiptir. Domates, ağaç domatesi, patates, patlıcan, biber gibi Solanaceae familyasına ait bitkiler alkaloidlerce zengindir. Solanaceae familyası, 90 cins ve 2000'den fazla tür içermektedir. Solanin, Solanaceae familyasındaki çeşitli bitkilerin yaprak, meyve ve yumrularında bulunur. Yeşil renkli olup acı tada sahiptir. Solanin miktarı, bitkinin yetiştirilmesi sırasındaki çevresel koşullara, depolama şartlarına ve çeşide bağlı olarak önemli ölçüde değişir. Güneş ve ışığa maruz kalma, sıcaklık, fiziksel darbe, sürgün gelişimi ve patojen maruziyeti gibi etkenler konsantrasyon artışına sebep olur. Solanin, ticari çeşitlerin büyük çoğunluğunda genellikle düşük seviyelerde bulunurken yeşillenmiş, uzun süre depolanmış ve hasarlı yumrularda yüksek seviyelere çıkabilir. Kızartma, haşlama veya mikrodalgada pişirme gibi gıda işleme yöntemleriyle solanin seviyesinde önemli miktarlarda azalma olmamaktadır. Solaninden kaynaklanan zehirlenmelerde, karın ağrısı, ishal, kusma ve nörolojik bozukluklar, baş ağrıları ve halüsinasyonlar gibi durumlar gözlenir. Genel olarak patatesteki solanin konsantrasyonu 0.07 ile 5 mg arasındadır. Dünya Sağlık Örgütü (WHO), patateslerde 100 mg/kg'ın altındaki solanin içeriğinin toksikolojik açıdan endişe verici olmadığını bildirmiştir. Son yıllarda yapılan çalışmalarda, glikoalkaloidlerin anti-alerjik, anti-epileptik, hiperglisemik, anti-enflamatuar glikoalkolaidlerin; anti-kanserojen gibi sağlık üzerine olumlu etkileri olabileceğini bildirmiştir. Bu derlemede, solanin kaynakları, özellikleri, sağlık üzerine yararlı ve zararlı etkileri ele alınmıştır.

Anahtar Kelimeler: Solanin, glikoalkaloid, patates

ABSTRACT

Alkaloids are secondary metabolites synthesized by plants that contain at least one nitrogen atom in their structure. These metabolites have various physiological effects on living organisms. Plants belonging to the Solanaceae family, such as tomato, tree tomato, potato, eggplant, and pepper, are rich in alkaloids. The Solanaceae family comprises 90 genera and over 2000 species. Solanine is found in the leaves, fruits, and tubers of various plants within

the Solanaceae family. It has a green color and a bitter taste. The solanine content varies significantly depending on environmental conditions during plant growth, storage conditions, and variety. Factors such as sun and light exposure, temperature, physical impact, shoot development and pathogen exposure lead to an increase in concentration. While commercial varieties generally contain low levels of solanine, greened, long-stored, and damaged tubers can exhibit higher concentrations. Food processing methods such as frying, boiling, or microwaving do not significantly reduce solanine levels. Symptoms of solanine poisoning include abdominal pain, diarrhea, vomiting, neurological disorders, headaches, and hallucinations. In general, the solanine concentration in potatoes ranges from 0.07 to 5 mg. The World Health Organization (WHO) has stated that solanine levels below 100 mg/kg in potatoes are not toxicologically concerning. Recent studies have reported that glycoalkaloids may have anti-allergic, anti-epileptic, hyperglycemic, anti-inflammatory, and anti-carcinogenic effects. This review discusses the sources, properties, and both beneficial and harmful effects of solanine on health.

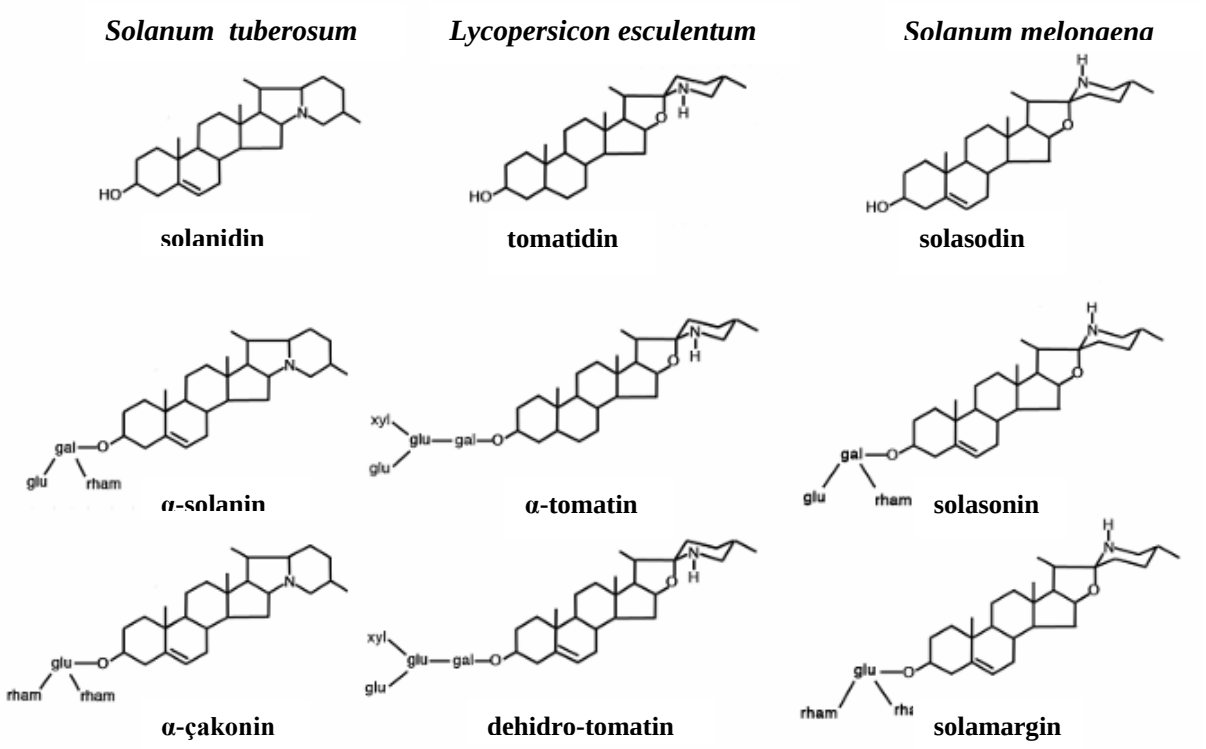
Keywords: Solanine, glycoalkaloid, potato

GİRİŞ

Bitkiler, genellikle otobur kaynaklı hasar, patojen saldırıları veya besin yoksunluğu gibi belirli çevresel uyaranlara yanıt olarak bir dizi kimyasal sentezlerler. İkincil maddeler olarak adlandırılan kimyasallar birincil maddeler yani karbonhidratlar, amino asitler ve lipitlerden üretilen türetilir (Al Sinani ve Eltayeb, 2017). İkincil metabolitler, kimyasal yapılarına, bileşimlerine, farklı çözücülerdeki çözünürlüklerine veya sentez yollarına göre sınıflandırılabilir (Chowański ve ark., 2016). İkincil maddeler, biyosentetik kökenlerine göre terpenoidler, fenolik bileşikler ve alkaloidler olarak üç ana gruba ayrılırlar. Bilinen yaklaşık **12.000 alkaloid**, bir veya daha fazla **azot atomu** içerir ve temel olarak **amino asitlerden** biyosentezlenir (Al Sinani ve Eltayeb, 2017). *A*lkaloidler, benzer yapıları paylaşan bir dizi alt gruba ayrılır. Solanaceae, doğal olarak bir savunma mekanizması olarak üretilen tropan alkaloidleri, glikoalkaloidler, pirolizidin ve indol alkaloidleri gibi alkaloidleri içeren bir familyadır (Chowański ve ark., 2016). Patates (*Solanum tuberosum*), biber (*Capsicum annuum*), patlıcan (*Solanum melongena*), domates (*Lycopersicon esculentum*) gibi çeşitli bitkileri de kapsayan *Solanaceae* yaklaşık 100 cins ve 2500 türden oluşmuştur (Friedman ve ark., 1997; Cárdenas ve ark., 2015). *Solanaceae bitkileri* glikoalkaloidler olarak glikozit formunda alkaloidler içerir. Glikoalkaloidler, baziklik sağlayan N içeren halkalara sahip C27 kolestan iskeletine dayanan aglikon yapısı ile bir oligosakkarit parçasının birleşiminden oluşmuştur. Aglikonlar yapılarına bağlı olarak solanidanlar, spirosolanlar, epiminokloestanlar, α-epiminosiklohemiketaller ve 3-aminospirostanlar şeklinde beş kategoriye ayrılır (Ostreikova ve ark., 2022).

Glikoalkaloid hakkında yapılan araştırmalarının tarihi, yaklaşık 200 yıl öncesine dayanır. İlk olarak Fransız eczacı Desfosses, *Solanum nigrum* meyvelerinden "solanée" adını verdiği alkali bir baz izole etmiştir. Bu özütün küçük bir miktarı etle karıştırılıp bir köpeğe verildiğinde uyuşukluk ve kusma gibi narkotik semptomlara neden olmuştur (Cárdenas ve ark., 2015). Glikoalkaloid ilk olarak 19. yüzyılın başlarında M. Baup tarafından patateslerde tanımlanmıştır. Tanımlandıktan hemen sonra kimyası, biyokimyası, dağılımı, fizyolojisi ve toksikolojisi hakkında geniş bir bilgi edinilmiştir (Smith ve ark., 1996). 1826'da izole edilen α-solanin, patateslerin doğal bir bileşeni olarak bildirilen ilk glikoalkaloid olmuştur. 1954 yılında α-çakonin bulunana kadar mevcut olan tek bileşik olarak kabul edilmiştir. Domates glikoalkaloidi olan α-tomatin 1948 yılında keşfedilmiştir. Keşfinden sonra tomatinin aslında halka yapısında sadece bir çift bağın varlığında veya yokluğunda farklılık gösteren α-tomatin ve dehidro-tomatinin bir karışımı olduğu bulunmuştur. Patlıcanlarda bulunan iki ana steroidal

alkaloid glikozit olan α-solasonin ve α-solamargin çok daha sonra ve 100'den fazla başka türde tespit edilmiştir (Şekil 1) (Milner ve ark., 2011; Chowański ve ark., 2016).



Şekil 1. Patates, domates ve patlıcanda en çok bulunan glikoalkaloid ve bunların aglikonları (Nahar, 2011).

Glikoalkaloidler, *Solanum* cinsi bitkilerin yapraklarında, çiçeklerinde, köklerinde ve filizleri ve kabukları dahil yenilebilir kısımlarında genellikle bitki steroidal glikozitleri olarak bulunur (Milner ve ark., 2011; Ahamad ve ark., 2022). Glikoalkaloidler, bitki büyümesi ve işlevi için gerekli değildir, ancak diğer ikincil metabolitlerde olduğu gibi mantarlar, böcekler, virüsler ve otoburlar gibi bazı organizmalara karşı doğal savunma mekanizmasında önemli rol oynarlar (Şengül ve ark., 2004; Milner ve ark., 2011). Glikoalkaloidlerin bir kısmı acı, buruk olarak tanımlanan hoş olmayan tatlar sergilerler. İnsanlarda gastrointestinal ve nörolojik bozukluklara neden olan gıdalarda antinutrisyonel faktörler olarak kabul edilmektedir (Akiyama ve ark., 2025). Bu derlemede, patates glikoalkaloidi olan solaninin özellikleri, oluşumu ve sağlık üzerine etkileri üzerinde durulmaktadır.

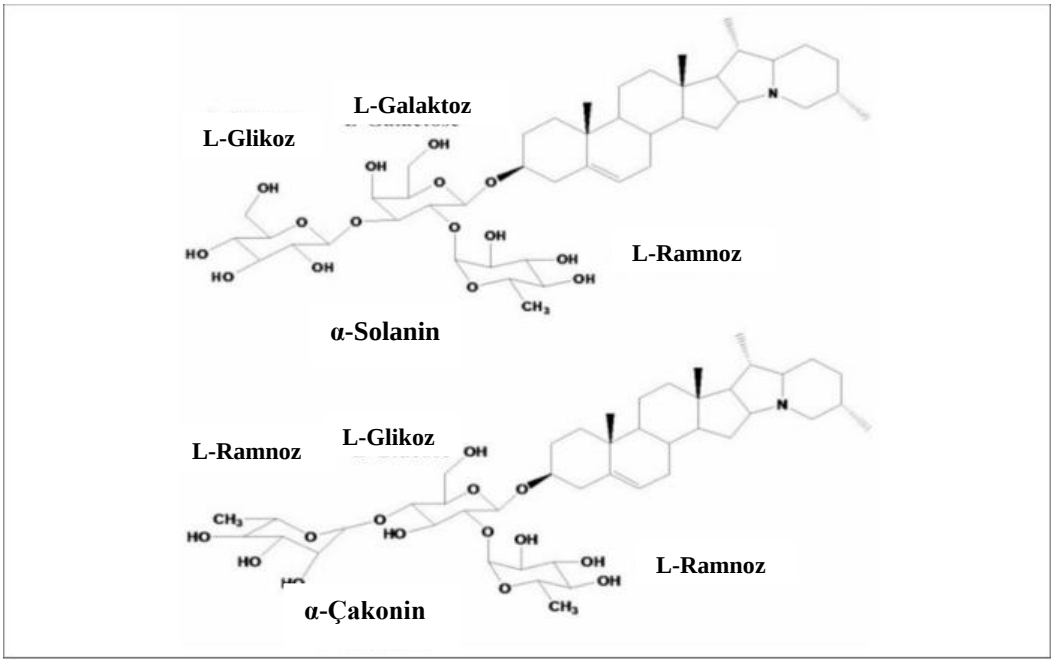
PATATES GLİKOALKALOİDLERİNİN SENTEZ VE AKÜMÜLASYONU

Patates (*Solanum tuberosum L.*), yüksek verimi, depolama kolaylığı, çok yönlü kullanımı ve nispeten düşük maliyeti nedeniyle dünyanın en büyük tarımsal gıda ürünlerinden birini temsil etmektedir. Değişik tarımsal ve iklim koşullarında yetiştirilebildiğinden, dünya çapında yaygın üretilmektedir (Maga ve Fitzpatrick, 1980). Yüksek nişasta, yüksek kaliteli protein, besinsel lif ve vitamin kaynağı olan patatesler ayrıca diyette hem olumsuz hem de yararlı etkiler gösterebilen biyolojik olarak aktif ikincil metabolitler üretir. Bu metabolitlerden biri glikoalkaloidlerdir (Friedman, 2006).

Glikoalkaloidlerin biyosentezi, üç adımda gerçekleşir. Birincil metabolitler ilk iki aşamada sentezlenir ve sırasıyla sikloartanol ve kolesterolü oluşturur. Glikoalkaloidler, üçüncü aşamada ortak öncü kolesterolden oluşur. Kolesterol, önce aglikon solanidine dönüştürülür, ardından şekerlere glikozit bağları oluşturularak solanin ve çakonine dönüşür (Ostreikova ve ark., 2022).

Patateslerdeki birincil glikoalkaloidler (Şekil 2), α-solanin ve α-çakonindir ve toplam glikoaloidin %95'ini oluşturmaktadırlar (Ordoñez-Araque ve ark., 2024; Smith ve ark., 1996). Bunlar, bir ucunda azot içeren heterosiklik halka tarafından uzatılan ve diğer uçta polar suda çözünür bir trisakkarite bağlanan polar olmayan bir lipofilik steroid çekirdeğinden oluşur. Solanin ve çakonin aynı aglikonu, yani solanidini paylaşır, ancak karbonhidrat bileşenlerinde farklılık gösterirler (Smith ve ark., 1996).

Alfa solanindeki trisakkarit galaktoz, glikoz ve ramnozken, α-çakonindeki ise glikoz ve iki ramnoz kalıntısıdır. Glikoakaloidlerin küçük bir yüzdesi (%5) β-solanin, γ-solanin, β-çakonin ve γ-çakonin içerir (Uluwaduge ve ark., 2018). Glikoalkaloidlerdaki α, β ve γ harfleri, moleküllerindeki glikozit bağlarının hidrolizi üzerine oluşan sırasıyla aktif olmayan bir trisakkarit, disakkarit veya monosakkariti belirtir (Ostreikova ve ark., 2022).



Şekil 2. α-Solanin ve α-Çakonin yapısı (Ok ve Şanlı, 2022)

Glikoalkaloid konsantrasyonu, bitkinin büyüme durumu, olgunluk, çeşit, gübreleme, erken hasat, fitopatojenlere maruziyet, hasat öncesi ve sonrası aşırı sıcaklık koşulları, ışığa maruz kalma, hasat ve filizlenme sonrası kesme ve dilimleme gibi mekanik hasarlardan etkilenir (Şengül ve ark., 2004). Kuraklık stresi koşulları altında yetiştirilen patateslerde glikoalkaloid konsantrasyonu %50'ye varan artış gösterir. Bitkilerin büyümesi sırasında soğuk ve nemli veya sıcak ve kuru gibi elverişsiz iklim koşulları da glikoalkaloid konsantrasyonunu artırır (Ostreikova ve ark., 2022). Hasattan sonra patates yumrularının ışık, yüksek sıcaklıkta depolanması glikoalkaloid oluşumunu hızlandırır. Patateslerin glikoalkaloid içeriği filizlendikten sonra dinamik olarak değişir (Chen ve ark., 2025).

Patates kabuğundaki solanin artışı, kabuğun yeşillenmesi (klorofil sentezi) ile yakından ilişkilidir. Bu biyokimyasal süreçler birbirinden bağımsızdır. Ancak her ikisi de ışıkla aktive edilir (Cantwell, 1996). Işık kaynaklı yeşillenme geçiren patateslerde, glikoalkaloid içeriği 0.004'ten %0.08'e yükselebilir ve bu da 20 katlık bir artışı temsil eder (Liu ve ark., 2024). Yapılan bir çalışmada, dolaylı güneş ışığı ve flüoresan ışığa maruz bırakılan patates yumrularındaki glikoalkaloid seviyeleri, oda sıcaklığında karanlıkta saklananlardan yaklaşık 4-6 kat daha yüksek olduğu bulunmuştur. Buzdolabında (7–8 °C) saklanan patatesler, oda sıcaklığında (19–26 °C) saklananlara kıyasla daha yüksek seviyelerde glikoalkaloid sentezlemiştir. Ayrıca patates çeşidine bağlı olarak düşük sıcaklıklarda (4-10 °C) depolanan patates yumrularında da glikoalkaloid birikiminin meydana gelebileceği bildirilmiştir (Machado ve ark., 2007).

Hasat sonrası etkenler dışında tarımsal işlemlerin de glikoalkaloid içeriğini etkilediği bazı çalışmalarla ortaya konmuştur. Azotlu gübrenin doza bağlı olarak toplam glikoalkaloid içeriğini etkileyebileceği bildirilmiştir. Diğer taraftan, organik olarak yetiştirilen patates yumrularının daha yüksek glikoalkaloid içerdikleri bildirilmiştir (Ok ve Şanlı, 2022).

Patates yumrularındaki glikoalkaloid içeriği büyüme sırasında ve olgunlaşma sırasında azalır. Bu bileşiklerin içeriği, olgunlaşmamış yumrulara kıyasla fizyolojik olarak olgun patateslerde 1.5 kat daha düşük olabilir (Tajner-Czopek ve ark., 2008).

Yumru köklerdeki yüksek glikoalkaloid içeriği, patateslerin yenilebilir kalitesi ve gıda güvenliği için önemli bir tehdit oluşturmakla kalmayıp, aynı zamanda patates sektörünün endüstriyel gelişimini de engellemektedir. Bu nedenle, patateslerdeki glikoalkaloidlerin biyokimyasal özelliklerini ve metabolik modellerini keşfetmek, gıda güvenliğini sağlamak ve hasat sonrası kaliteyi korumak için çok önemlidir (Liu ve ark., 2024).

GLİKOALKALOİDLERİN BİTKİDE DAĞILIMI

Glikoalkaloidlerin büyük bir kısmı kabukta veya hemen altında bulunur. Özellikle patates gözlerinin çevresinde (Tajner-Czopek ve ark., 2008), yeşil kısımlarında ve filizlerde yüksek konsantrasyonlarda bulunur (Tablo 1). Toplam seviyeler genellikle yumru boyutu arttıkça azalır, bununla birlikte çeşitler arasında büyük farklılıklar vardır (Knuthsen ve ark., 2009).

Tablo 1. Patates Bitkisinin Çeşitli Kısımlarındaki Glikoalkaloid Seviyeleri

Patates kısımları	Toplam glikoalkaloid miktarı (mg/kg taze ağırlık)	Kaynak
Yaprak	230-1000	(Smith ve ark., 1996)
Çiçek	2150-5000	(Smith ve ark., 1996)
Meyve	180-1350	(Ok ve Şanlı, 2022)
Gövde	23-33	(Smith ve ark., 1996)
Filiz	2000-7300	(Ok ve Şanlı, 2022)
Acı yumru (yeşillenmiş)	250-800	(Smith ve ark., 1996)
Normal yumru	10-150	(Smith ve ark., 1996)
-Kabuk	150-1070	(Ok ve Şanlı, 2022)
-Et	12-100	(Ok ve Şanlı, 2022)
-Korteks	125	(Ok ve Şanlı, 2022)
-Öz	-	(Ok ve Şanlı, 2022)
-Kök	180-400	(Smith ve ark., 1996)

GLİKOALKALOİDLERİN TOKSİSİTESİ

Glikoalkaloidlerin iki ana biyolojik fonksiyonu vardır. Birincisi, **hücre zarı sterolleri ile bağlanarak** zar yapısını bozma yetenekleridir. Bu bozulma, hücresel içeriklerin sızmasına neden olarak **karın krampları, kusma ve ishal gibi gastrointestinal rahatsızlıklara** yol açar. **Glikoalkaloid zehirlenmesinin ayırıcı tanısı zordur. Ç**ünkü akut zehirlenme belirtileri diğer gastrointestinal rahatsızlıklarla benzerlik gösterir. Glikoalkaloidlerin diğer önemli biyolojik etkisi, asetilkolinesteraz enzimini inhibe etmeleridir. Bu enzim, sinir iletiminde görev alan nörotransmitter asetilkolinin kolinerjik sinapslardaki hidrolizinden sorumludur. Glikoalkaloidlerin anti-asetilkolinesteraz aktivitesi, zayıflık, kafa karışıklığı ve depresyon gibi nörolojik semptomlarla kendini gösterir (Uluwaduge ve ark., 2018).

Solaninin mitokondrideki potasyum kanallarının açılmasını kolaylaştırarak bu organellerden Ca^{2+} salınımına neden olabileceği gösterilmiştir. Bu durum, hücre içindeki **Ca^{2+} konsantrasyonunun artmasına** yol açar. **Ca^{2+} seviyesindeki hızlı ve sürekli artış**, apoptoza uğrayan hücrelerde gözlemlenen en erken biyokimyasal değişimdir. Bu nedenle,

solanine maruz kalmak, hücrelerde Ca^{2+} konsantrasyonunu artırarak apoptoz mekanizmasını tetikler ve hücre hasarına yol açar (Karaca ve Erbaş, 2024).

Glikoalkaloidlerin içeriği, genellikle kilogram başına toplam glikoalkaloidler (TA) olarak ifade edilir ve genellikle "solanin" olarak adlandırılan α-çakonin ve α-solaninin toplamı olarak hesaplanır. Çünkü iki bileşik, aynı dokuda mevcut olduğunda sinerjik bir etki gösterirler (Knuthsen ve ark., 2009; Nema ve ark., 2008).

Çoğu patates çeşidi 5 mg/kg'dan az solanin içerir. 14 mg/kg patates konsantrasyonu acı bir tada neden olur ve 20 mg/kg ağızda ve boğazda yanma hissine neden olur (Bock ve Norris, 2015). Patateslerdeki solanin içeriğinin 100 mg/kg'ı aşmadığında, tüketiminin güvenli olduğu genel olarak kabul edilir. Patateslerdeki solanin içeriği 200 mg/kg'ı aştığında zehirlenme semptomları ve hatta akut zehirlenme meydana gelebilir (Tablo 2). Bazı araştırmalar, glikoalkaloidlerin beyin, meme, akciğer ve tiroid kanseri riskini artırmaktan sorumlu olduğunu bulmuştur (Liu ve ark., 2020).

Tahmini oral dozlarda >3-6 mg toplam glikoalkaloid/kg vücut ağırlığı olan ölümcül zehirlenme vakaları bildirilmiştir. hafif zehirlenme 1-5 mg/kg vücut ağırlığı aralığında meydana gelir (Milner ve ark., 2011). FAO / WHO Ortak Uzmanlar Komitesi (JECFA) patateste 100 mg/kg'dan az glikoalkaloid içeriğinin herhangi bir olumsuz etki göstermeyeceğini kabul etmektedir (Ok ve Şanlı, 2022).

Tablo 2. Patates glikoalkaloidleri için tipik değerler (Nema ve ark., 2008)

Özellik	**Değerler**
Acı tat	150–200 mg GA /kg TA
Toksisite ve güvensiz seviyeler	> 200 mg GA/ kg TA
Toksik semptomların görülme süresi	Yuttuktan 8–12 gün sonra
İnsanlarda GA dozu:	
Marjinal olarak toksik doz	1–5 mg/ kg vücut ağırlığı
Ölümcül	3–6 mg/ kg vücut ağırlığı

- GA: Glikoalkaloid TA: Taze Ağırlık

GLİKOALKALOİDLERİN YARARLARI

Son yıllarda yapılan çalışmalar çeşitli Solanum türlerinde bulunan steroidal alkaloidler ve glikozitlerinin anti-mikrobiyal, antifungal, anti-kanser, anti-piretik, anti-inflamatuar, teratojenik, anti-viral, anti-tümör, anti-östrojenik, anti-malaryal, hipoglisemik ve hipokolesterolemik aktiviteler gösterebileceğini göstermiştir (Ahamad ve ark., 2022; Liu ve ark., 2024; Uluwaduge ve ark., 2018). Patates glikoalkaloidlerinin antitümör potansiyeli birçok araştırmada, apoptoz veya otofajinin mitokondriyal yollarının aktivasyonu, hücre döngüsünün geciktirilmesi, anjiyogenez ve metastazın inhibisyonu ve lipid peroksidasyonunun indüksiyonu kullanılarak gösterilmiştir (Ostreikova ve ark., 2022).

Glikoalkaloidler; antialerjik, patojenik bakteri, virüs, protozoa ve mantarlara karşı antibiyotik aktiviteleri, insan kanser hücrelerinin yok edilmesi gibi faydalı etkileri vardır. Solanin yatıştırıcı ve antikonvülsan özelliklere sahiptir ve bronşiyal astım tedavisinin yanı sıra öksürük ve soğuk algınlığı ilaçları olarak da kullanılmıştır. Ancak, her iki kullanım için de etkinliği şüphelidir. Hem α-çakonin hem de α-solanin böcek kovucu, fungisit ve pestisit aktiviteleri gösterir. α-çakonin nematisit olarak, solanin ise astım ve epilepsi tedavisinde kullanılmıştır (Nema ve ark., 2008).

Patates kabuklarının ekstraktının başta *Staphylococcus aureus* ve *Escherichia coli* olmak üzere çeşitli Gram-pozitif bakterilere karşı antibakteriyel aktivitesi olduğu, sadece bir Gram-negatif bakteriye yani *Pseudomonas aeruginosa*'ya karşı etkili olduğu bulunmuştur (Ostreikova ve ark., 2022).

GLİKOALKALOİD MİKTARINI AZALTMA YÖNTEMLERİ

Nakliye, depolama ve pazarlama gibi hasat sonrası süreçler sırasında ışığa, mekanik hasara, filizlenmeye, böcek istilasına veya yerel çürümeye maruz kalma, glikoalkaloidlerin önemli ölçüde sentezini ve birikimini tetikleyebilir. Glikoalkaloidlerin 284 °C'ye kadar olan yüksek erime noktası nedeniyle, buharda pişirme, fırınlama, derin kızartma ve kısa mikrodalga işlemi gibi geleneksel pişirme yöntemleri etkili bozunma için yetersizdir. Soğutma ve soğuk zincir lojistiğinin olmadığı ülke ve bölgelerde, glikoalkaloid birikimi nedeniyle patateslerin kalitesinin bozulması toplam verimin %30-40'ını etkileyebilir (Liu ve ark., 2024).

Yumruların soyulması, dilimlenmiş yumruların suda kaynatılması veya kızartılması, dehidrasyon ve granülasyon işlemleri ile glikoalkaloid seviyesinde önemli azalma sağlanabilmektedir. Kesme, dilimleme, suyla durulama, fırınlama ve pişirme işlemleri patates yumrularında glikoalkaloid seviyesinin azaltılmasına herhangi bir etki göstermemektedir (Ok ve Şanlı, 2022).

Işık, yüksek sıcaklık ve mekanik hasar, patates yumrularında hasat sonrası glikoalkaloid oluşumunu indükleyen önemli çevresel stres faktörleridir. Sonuçlar, patateslerin uzun süre saklanması gerekiyorsa, filizlenmeyi önlemek ve glikoalkaloid içeriğinin artmasını önlemek için yaralanmamış ve yeşillendirilmemiş patateslerin seçilmesi ve karanlıkta 5-8 °C'de saklanması gerektiğini göstermektedir. Patateslerin ışıktan korunmaları, ışınlanmaları, kimyasallarla muamele edilmesi ve kontrollü atmosferde saklanmaları için bazı ambalaj malzemeleri ile paketlenmesi, klorofil ve alkaloid sentezini ve filizlenmeyi önleyebilmektedir (Şengül ve ark., 2004).

SONUÇ

Patates, besleyici içeriği, yüksek verimi ve geniş iklim koşullarına uyumu nedeniyle yaygın olarak tüketilen, bitki savunmasında önemli rol oynayan glikoalkaloidlere sahip bir tarım ürünüdür. Glikoalkaloidler, patatesin yaygın olarak yaprak, çiçek, kök, filiz ve kabuklarında üretilen ikincil metabolitlerdir. Patateste başlıca α-çakonine ve α-solanin olmak üzere iki ana glikoalkaloid vardır. Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO) / Dünya Sağlık Örgütü (WHO) Ortak Uzmanlar Komitesi (JECFA), patateste 100 mg/kg'dan az glikoalkaloid içeriğinin herhangi bir olumsuz etki göstermeyeceğini kabul etmektedir. Ancak patatesteki glikoalkaloid içeriği 200 mg/kg'ı aştığında zehirlenme semptomları ve hatta akut zehirlenme meydana gelebilmektedir. Sağlığı korumak için **filizlenmiş veya yeşillenmiş patateslerin tüketilmemesi veya yeşillenmiş bölgeler atıldıktan sonra tüketilmelidir.** Patatesin besleyici özelliklerinden maksimum fayda sağlamak için glikoalkaloid birikimini en aza indirecek tarımsal uygulamalar ve depolama koşulları geliştirilmelidir. Gıda güvenliği açısından patates tüketimine yönelik bilinçlendirme çalışmaları artırılmalı ve patateslerin güvenli sınırlar içinde glikoalkaloid içeriğine sahip olması sağlanmalıdır.

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RAMAN CHARACTERISTICS OF GOLD-BEARING QUARTZ: AN ANALYTICAL PERSPECTIVE

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ABSTRACT

One of the most important mineral hosts in gold mining and exploration is quartz, which requires significant analytical techniques to comprehend its physicochemical characteristics. It can detect structural characteristics and molecular vibrations. Raman spectroscopy has become a useful non-destructive analytical method for describing such mineral systems. Investigating the Raman spectrum signatures of quartz that contains gold and examining the connections between its mineralogical characteristics and the presence of gold are the goals of this study.

In this study, we used a high-resolution Raman microscope to examine a number of gold-bearing quartz specimens from various geological locations in Kırşehir, Türkiye, and other locations. Under controlled circumstances, Raman spectra were gathered, paying particular emphasis to the spectral areas that corresponded to fluid inclusions, accessory minerals, and silica lattice vibrations. In order to discover distinctive features associated with gold mineralization, comparative investigations were also conducted on barren quartz as a control.

The results of the study showed that gold-bearing quartz has unique Raman peaks linked to inclusions and structural flaws that are not present in barren quartz. Important spectrum characteristics were found to be possible diagnostic indicators for the presence of gold, including shifts in the primary Si-O vibrations and accessory peaks originating from related sulfides.

The results demonstrate how Raman spectroscopy can be used as a quick and non-invasive analytical technique to identify quartz that contains gold. This technology could provide more accuracy, efficiency, and cost-effectiveness in gold exploration when used in conjunction with conventional field and laboratory techniques. In the future, the approach might be expanded to other geological systems and scaled for in-situ applications.

Key Words: Raman spectroscopy, gold-bearing quartz, mineral characterization, Kırşehir

INTRODUCTION

Geological investigation has historically concentrated on gold mineralization because of its economic importance and the intricate processes that control its genesis and deposition. Quartz (SiO_2), one of the most prevalent and economically significant host minerals for gold, stands out among the others. In hydrothermal systems, where gold is carried by aqueous fluids and

then precipitated within fissures and voids, quartz veins are commonly linked to gold deposits. Determining the mechanisms of gold deposition and creating successful exploration plans depend on an understanding of the properties of gold-bearing quartz.

In the study of minerals, Raman spectroscopy has become a potent analytical instrument that provides a nondestructive way to examine the chemical and structural characteristics of materials. Because of its sensitivity to variations in the SiO_2 lattice and the existence of trace elements or defects, this method is especially well-suited for analyzing quartz. Researchers can learn more about the conditions under which the crystal evolved, the types of impurities present, and the mechanisms leading to gold deposition by examining the Raman spectra of quartz. New developments in Raman spectroscopy, like in situ analysis and high-resolution mapping, have made it even more useful for studying quartz that contains gold (Zhang & Li, 2019; Frezzotti et al., 2012).

The modes of vibration of the SiO_4 tetrahedra are represented by separate peaks in the Raman spectra of quartz. Gold and related trace elements, however, can change these spectra, causing broadening, peak shifts, or the emergence of new peaks. These alterations offer important hints regarding the physicochemical circumstances during mineralization as well as the chemical environment of gold within quartz. For instance, the major Raman peak at 464 cm^{-1} may slightly shift when gold is incorporated into the quartz lattice, and other spectral characteristics may be introduced by the presence of sulfide minerals or fluid inclusions (Wopenka & Pasteris, 1993; Rusk et al., 2008).

This article explores the Raman characteristics of gold-bearing quartz from an analytical perspective, highlighting recent advances in the field and their implications for understanding gold mineralization processes. By integrating findings from high-resolution Raman mapping, in situ analysis, and combined Raman, XRF, and EPMA studies, we aim to provide a comprehensive overview of the current state of knowledge.

The study of gold-bearing quartz using Raman spectroscopy not only enhances our understanding of ore-forming processes but also offers a rapid and non-destructive method for identifying potential gold targets. As the demand for gold continues to grow, driven by its use in technology, jewelry, and investment, the development of advanced analytical techniques such as Raman spectroscopy is essential for improving the efficiency and sustainability of gold exploration and extraction.

FUNDAMENTALS OF RAMAN SPECTROSCOPY

Raman spectroscopy is a powerful analytical technique that has revolutionized the study of materials, including minerals like quartz, by providing detailed insights into their molecular structure and chemical composition. Named after the Indian physicist Sir C.V. Raman, who discovered the phenomenon in 1928, Raman spectroscopy is based on the inelastic scattering of light, which occurs when photons interact with the vibrational modes of molecules in a material. This section provides an overview of the fundamental principles of Raman spectroscopy, its instrumentation, and its applications in mineralogical studies, with a particular focus on gold-bearing quartz.

Raman spectroscopy relies on the Raman effect, which involves the interaction of monochromatic light, typically from a laser, with the vibrational energy levels of molecules. When light interacts with a material, most of the scattered photons have the same energy as the incident light (elastic scattering, known as Rayleigh scattering). However, a small fraction of the photons (approximately 1 in 10^6) undergo inelastic scattering, gaining or losing energy due to interactions with molecular vibrations. This energy shift, known as the Raman shift, is measured in wavenumbers (cm^{-1}) and provides a unique fingerprint of the molecular structure of the material. The Raman spectrum is a plot of the intensity of scattered light as a function of

the Raman shift. Each peak in the spectrum corresponds to a specific vibrational mode of the molecules in the material. For example, in quartz (SiO_2), the most prominent Raman peak at 464 cm^{-1} is attributed to the symmetric stretching vibration of the Si-O-Si bonds, while other peaks correspond to bending and lattice modes of the SiO_4 tetrahedra (Wopenka & Pasteris, 1993) (Figure 1 and 2).

Modern Raman spectrometers often include advanced features such as confocal microscopy, which allows for high spatial resolution, and portable designs for field applications. These advancements have expanded the utility of Raman spectroscopy in geological studies, enabling in situ analysis of minerals and rocks (Smith & Brown, 1988).

Raman spectroscopy is widely used in mineralogy to identify mineral phases, study structural defects, and analyze the chemical environment of specific elements within minerals. Its non-destructive nature and ability to provide detailed molecular information make it particularly valuable for studying complex mineral assemblages, such as those found in gold-bearing quartz veins.

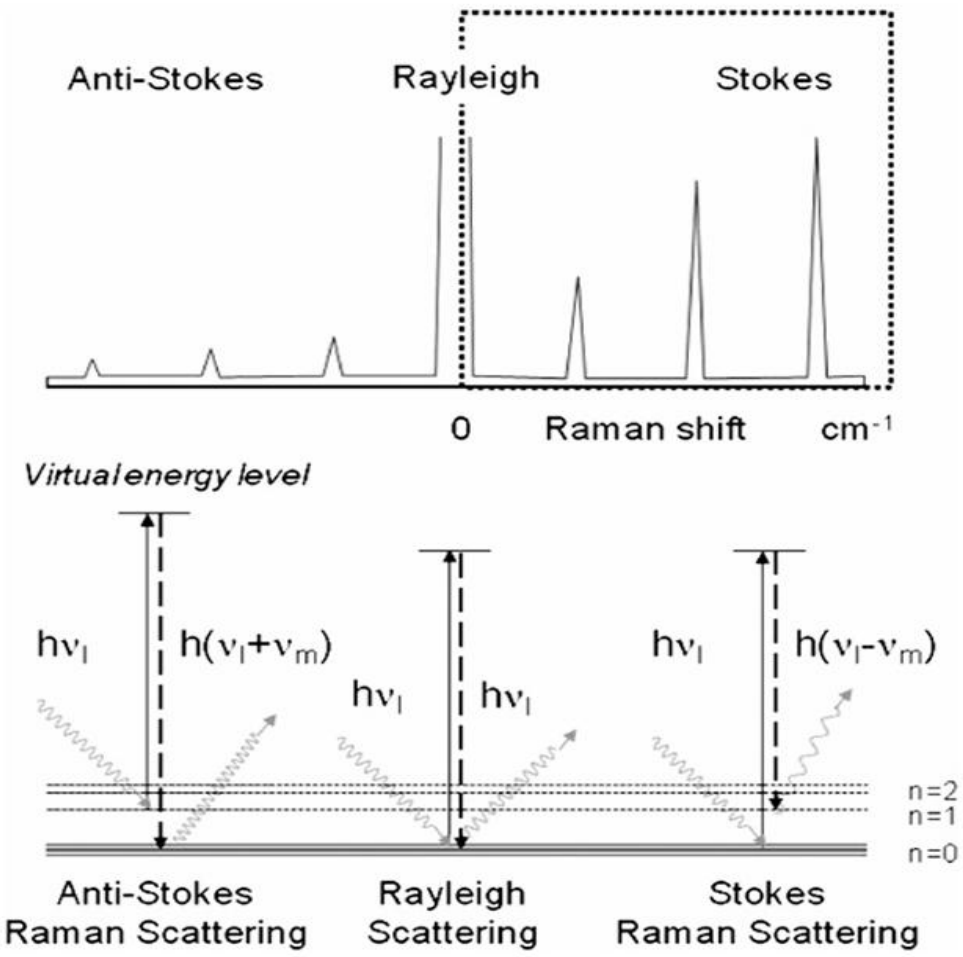

Figure 1. Energy level scheme for elastic (Rayleigh)and inelastic (Raman) scatteringat the frequency of the light source (ν_I),and Ramanand Rayleigh spectra. The molecular vibration of the analyzed sample is of frequency Vm (Frezzotti et al., 2012).

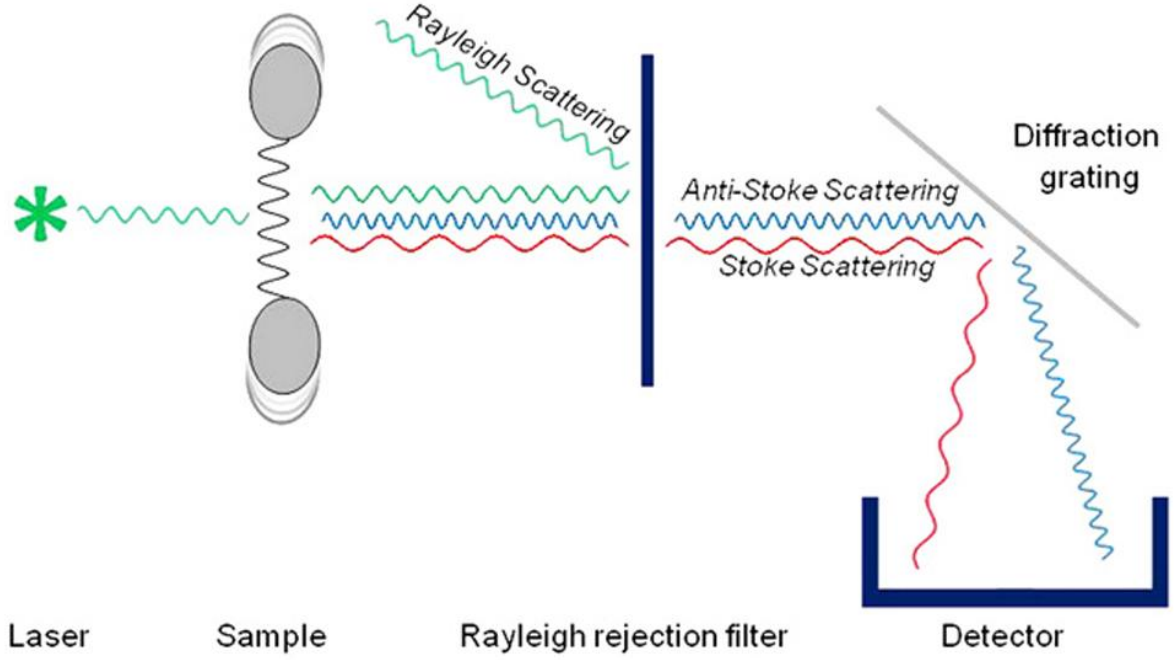

Figure 2. Schematic diagram of a Raman spectrometer (Frezzotti et al., 2012).

METHODOLOGY

After the office study phase, the field study was carried out, and more than 31 samples from the Kırşehır area, central Anatolia, were compared with other samples from different places. In addition to collecting the samples, the study area was mapped.

The samples were then prepared for microscopic studies (mineralogy, petrography, textures, and characteristic structures) and chemical analyses (XRF, Raman spectroscopy, and Electron Probe Microanalyzer (EPMA).

All analyses were carried out at Ankara University's Geosciences Applications and Research Centre (YEBİM).

RESULTS & DISCUSSION

The results include the Raman analysis of quartz in a number of different rock samples and EPMA analysis for some of these samples. For this article, we used 12 samples for Raman analysis and compared them with 4 samples from different places.

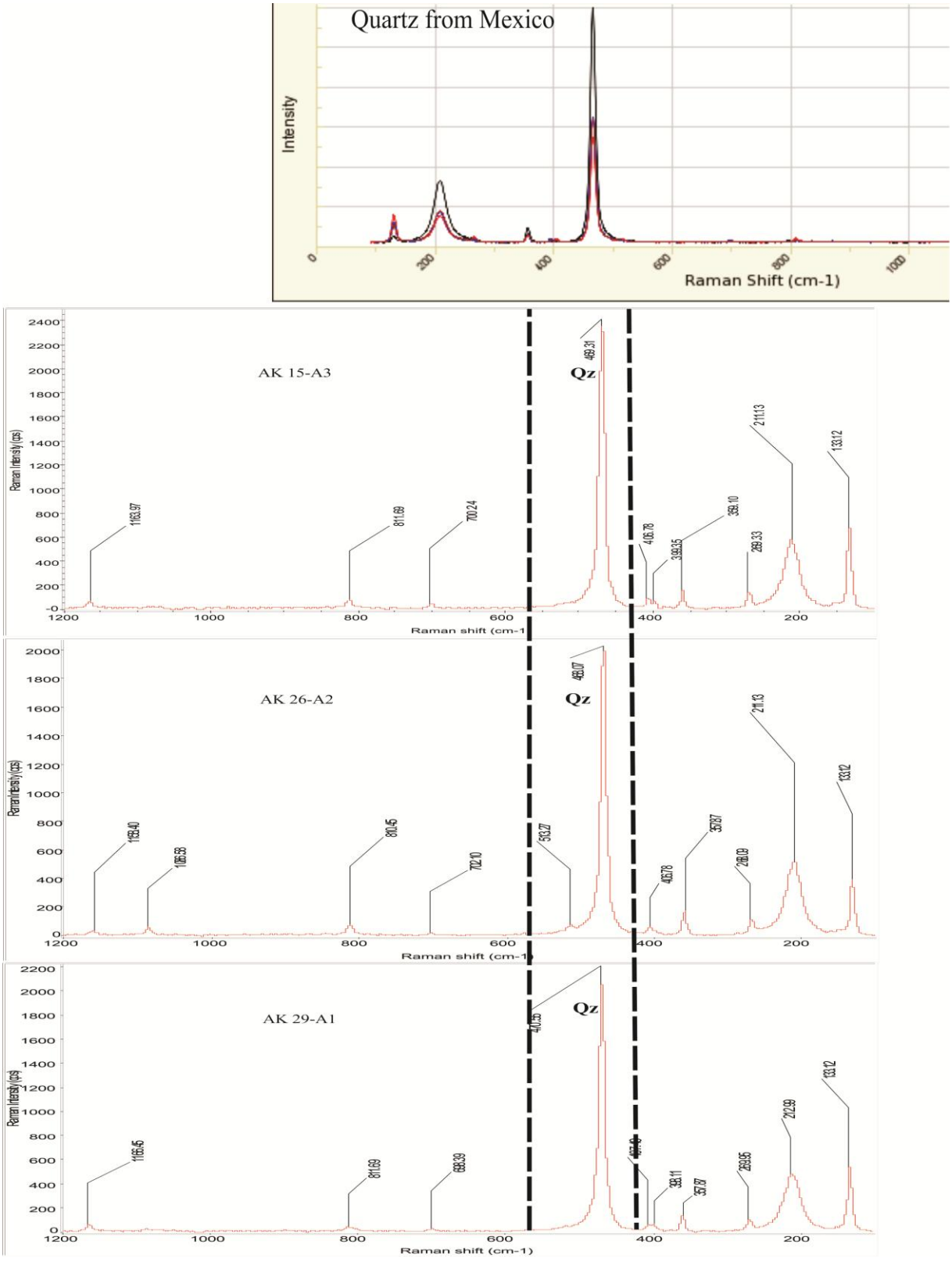

Figure 3. Shows the results of Raman analysis of quartz in a number of different rock samples. The results indicate that there are some slight differences in the Raman peaks of quartz when comparing the samples with each other. Raman spectrum of the quartz for samples AK15-A3, AK26-A2, and AK29-A1 respectively, Qz=Quartz. This samples is compared with Quartz from Mexico.

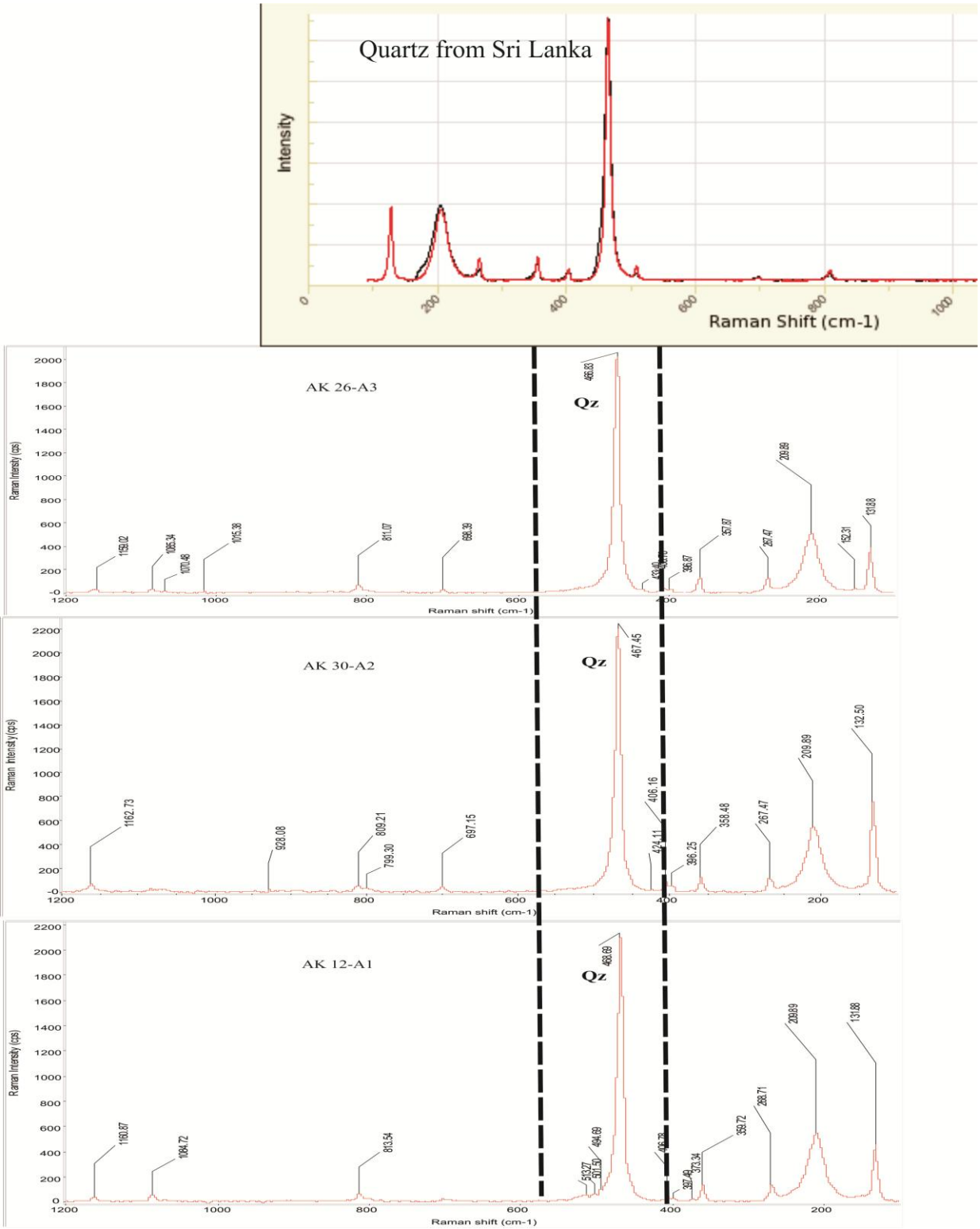

Figure 4. Shows the results of Raman analysis of quartz in a number of different rock samples. The results indicate that there are some slight differences in the Raman peaks of quartz when comparing the samples with each other. Raman spectrum of the quartz for samples AK26-A3, AK30-A2, and AK12-A1 respectively, Qz=Quartz. This samples is compared with Quartz from Sri Lanka.

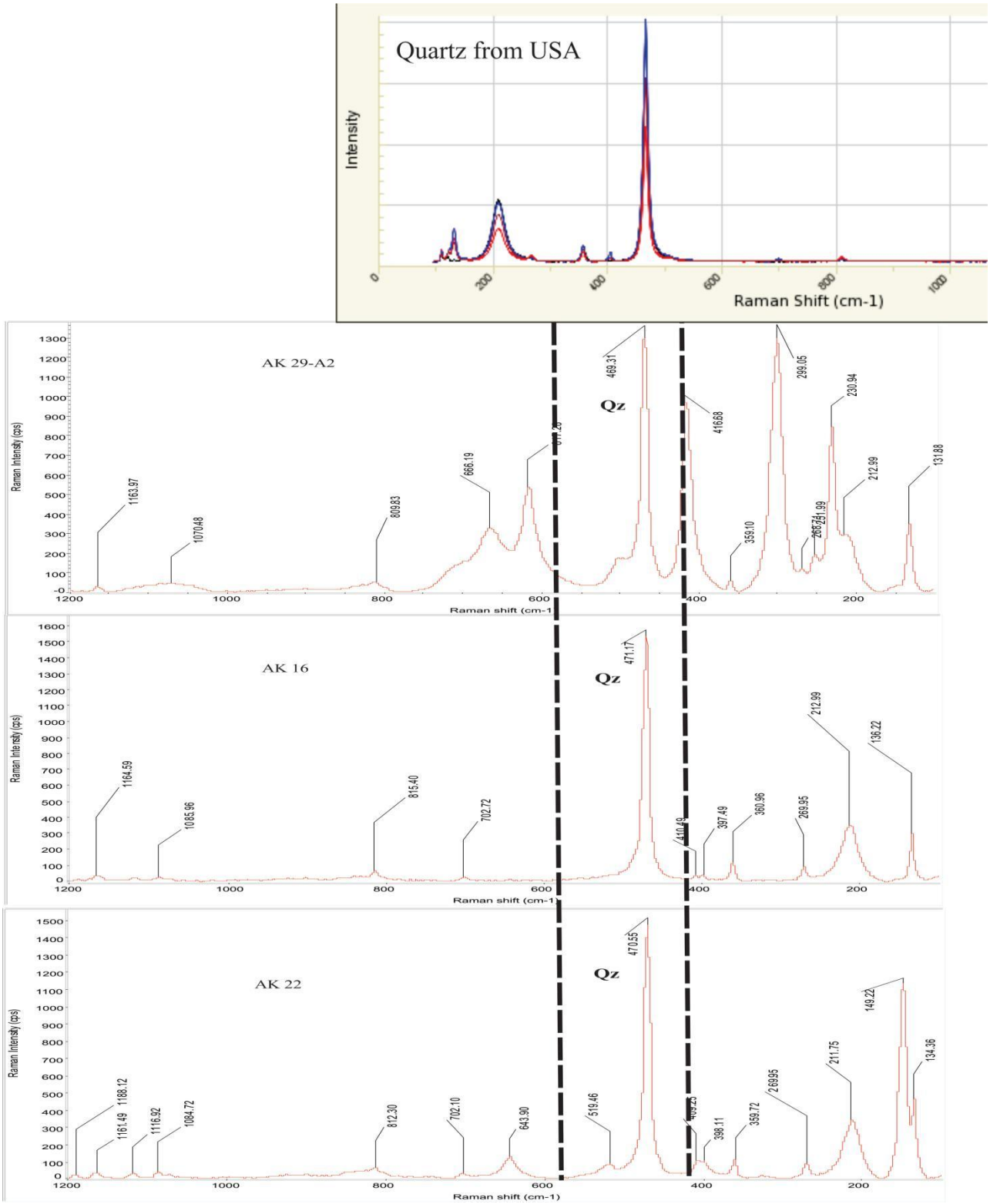

Figure 5. Shows the results of Raman analysis of quartz in a number of different rock samples. The results indicate that there are some slight differences in the Raman peaks of quartz when comparing the samples with each other. Raman spectrum of the quartz for samples AK29-A2, AK16, and AK22 respectively, Qz=Quartz. This samples is compared with Quartz from USA.

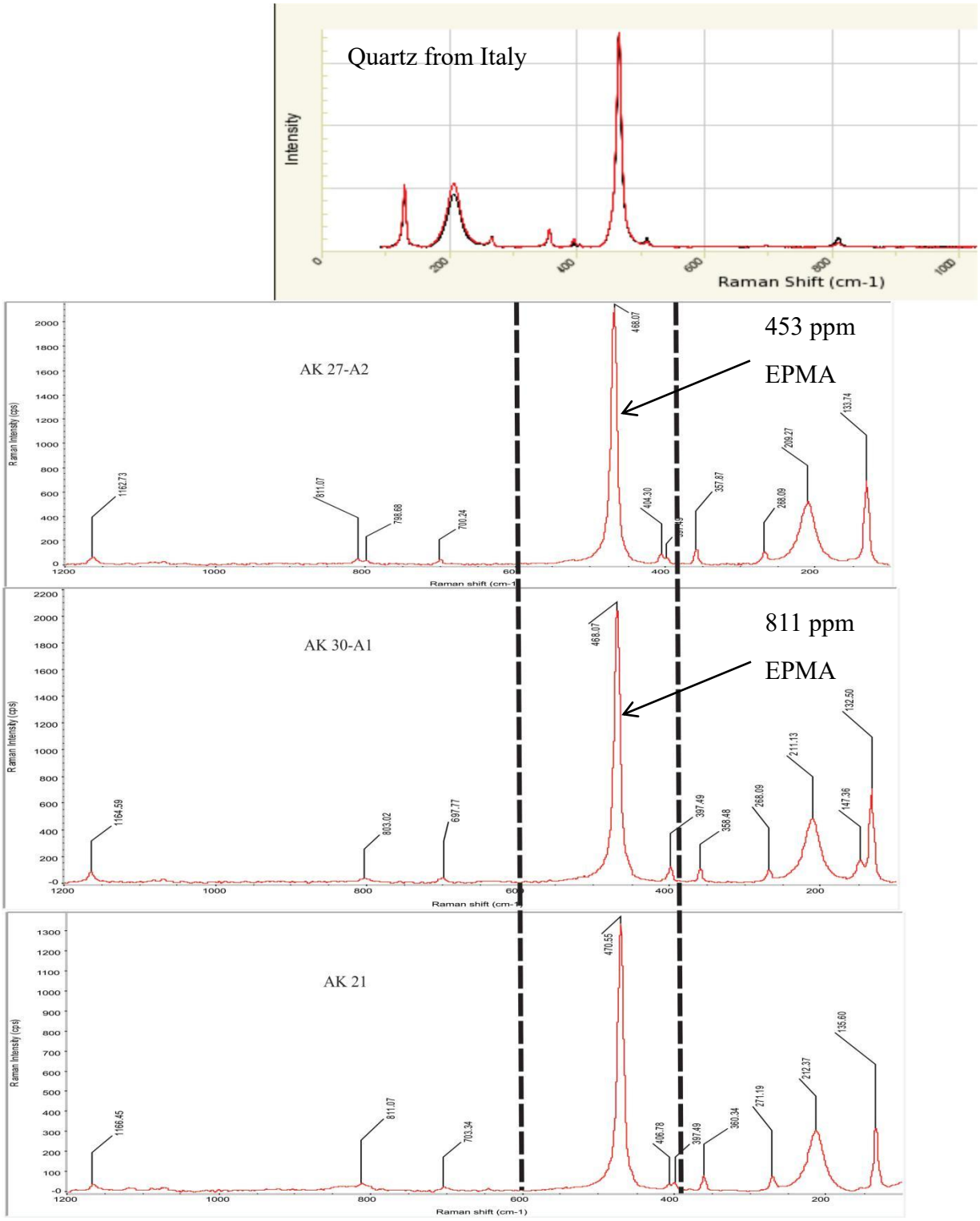

Figure 6. Shows the results of Raman analysis of quartz in a number of different rock samples. The results indicate that there are some slight differences in the Raman peaks of quartz when comparing the samples with each other. Raman spectrum of the quartz for samples AK27-A2, AK30-A1, and AK21 respectively, Qz=Quartz. This samples is compared with Quartz from Italy.

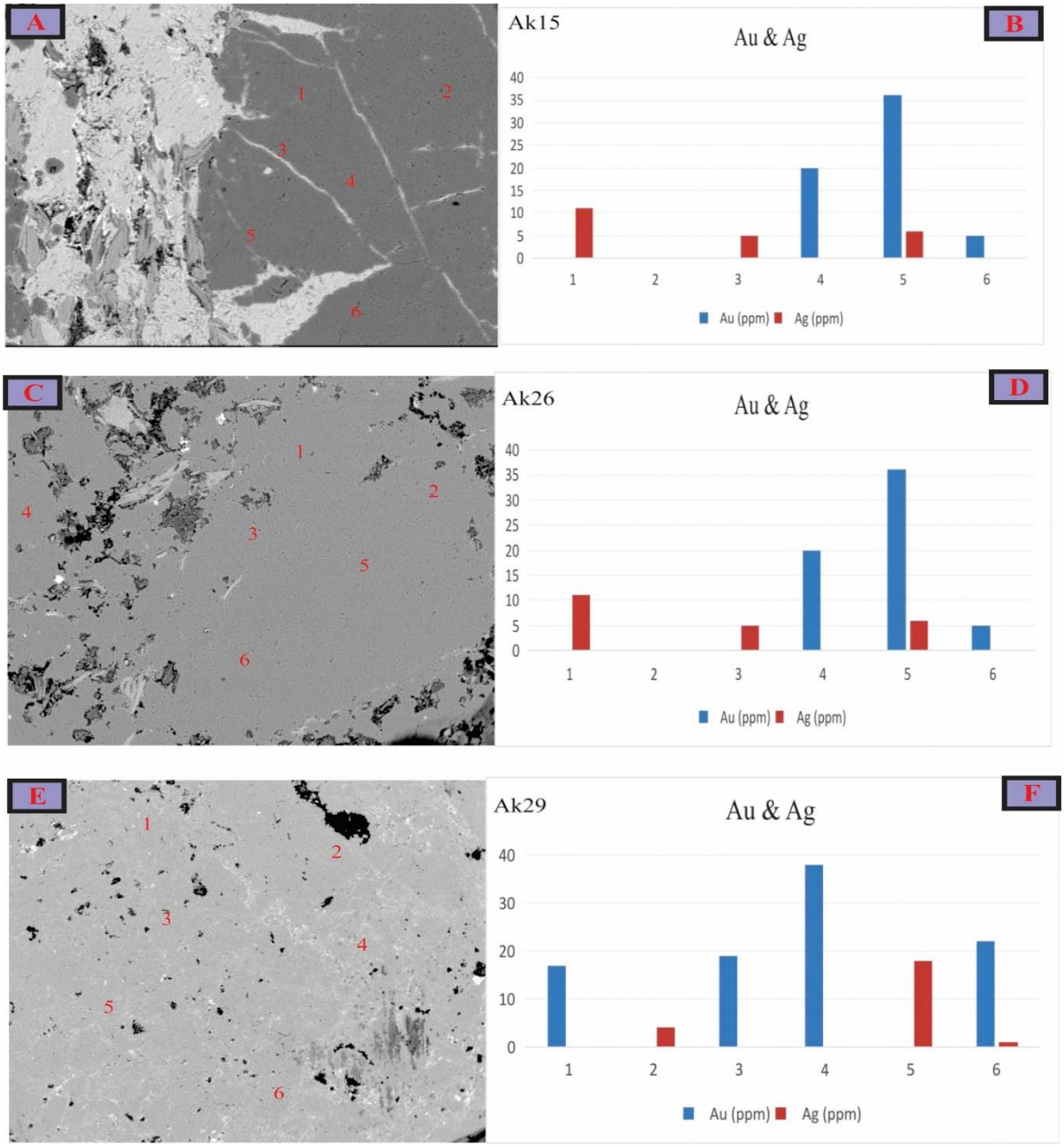

Figure 7. A, C and E shows BSE images of quartz for samples AK15, AK26, and AK29 respectively. B, D, and F shows histogram showing Au & Ag concentration according to EMPA analysis for samples AK15, AK26, and AK29 respectively.

The presence of these unique Raman peaks provides a reliable indicator of gold in quartz. This is significant because it offers a non-destructive, rapid method for identifying gold-bearing quartz in the field or lab. However, there are some limitations. For example, other minerals or impurities in the quartz could potentially interfere with the Raman signal. Additionally, the sensitivity of the technique depends on the concentration and distribution of gold in the sample. Despite these challenges, our findings demonstrate the potential of Raman spectroscopy as a tool for mineral exploration and geochemical analysis.

CONCLUSIONS

In conclusion, our study demonstrates that Raman spectroscopy is a powerful tool for analyzing gold-bearing quartz. By identifying unique Raman peaks, we've shown that this technique can effectively distinguish gold-bearing quartz from non-gold-bearing quartz. These findings are significant because they provide a non-destructive, rapid, and reliable method for detecting gold in quartz-rich environments.

The implications of this research are far-reaching. For mineral exploration, Raman spectroscopy offers a way to quickly and accurately identify gold-bearing quartz in the field, reducing the need for costly and time-consuming laboratory analyses. For geochemical studies, it provides a deeper understanding of the molecular interactions between gold and quartz.

However, there are still challenges to address, such as potential interference from other minerals and the need to analyze samples with varying gold concentrations. Moving forward, we plan to expand this research by studying quartz samples from different geological settings and exploring the effects of gold distribution on Raman spectra.

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LEARNING ENVIRONMENTS IN TURKISH TEACHING COURSE

TÜRKÇE ÖĞRETİMİNDE ÖĞRENME ORTAMLARI

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ÖZET

Dil, bireylerin düşüncelerini, duygularını ve bilgilerini aktarmasını sağlayan temel bir iletişim aracıdır. Ana dili eğitimi, bireyin hem bilişsel hem de sosyal gelişimi açısından büyük önem taşımaktadır. Türkçe öğretimi, öğrencilerin dil becerilerini geliştirmeleri, kendilerini doğru ve etkili bir şekilde ifade edebilmeleri ve eleştirel düşünme yetilerini güçlendirmeleri yönünden kritik bir alan olarak karşımıza çıkmaktadır. Bu süreçte öğrenme ortamlarının niteliği, öğretim sürecinin başarısını doğrudan etkilemektedir. Öğrenme ortamları, öğrencilerin dil öğrenme sürecine aktif katılımını destekleyen fiziksel, teknolojik ve pedagojik unsurları içermektedir. Geleneksel sınıf ortamlarının yanı sıra teknoloji destekli öğrenme platformları, etkileşimli materyaller ve sosyal öğrenme alanları da dil öğretiminde önemli bir yer tutmaktadır. Özellikle dijital çağın gereklilikleri göz önüne alındığında, yenilikçi öğrenme ortamlarının Türkçe öğretimindeki rolü giderek artmaktadır.

Öğrenme ortamlarının niteliği, öğrencilerin akademik başarılarını ve dil becerilerini doğrudan etkileyen önemli bir faktördür. Öğrenme ortamları ne kadar destekleyici, motive edici ve etkileşimli olursa, öğrencilerin derse katılımı ve öğrenme sürecine olan ilgileri de o kadar artmaktadır. Fiziksel ve dijital ortamların yanı sıra, öğretmenlerin yönlendirmesi, akran iş birliği ve farklı öğretim materyallerinin kullanımı, öğrencilerin dil gelişimlerini destekleyen unsurlar arasında yer almaktadır. Bu nedenle, öğrenme ortamlarının planlanması ve geliştirilmesi, etkili bir dil eğitimi için vazgeçilmezdir.

Öğrenme ortamlarındaki farklılıklar, kullanılan öğretim yöntemleri, materyaller ve öğrencilerin etkileşim biçimleri açısından çeşitlilik göstermektedir. Geleneksel öğrenme ortamları genellikle öğretmen merkezli olup, sınıf içi ders anlatımı ve basılı materyallerle desteklenirken, çağdaş öğrenme ortamları öğrenci merkezli, etkileşimli ve teknoloji tabanlı yaklaşımlar içermektedir. Örneğin, akıllı tahta, çevrimiçi eğitim platformları, dijital hikâye anlatımı ve sanal gerçeklik uygulamaları gibi yenilikçi araçlar, öğrencilerin dil becerilerini daha etkili bir şekilde geliştirmelerine yardımcı olmaktadır. Bunun yanı sıra, oyun temelli öğrenme ve iş birlikçi çalışmalar gibi yöntemler, öğrencilerin sürece daha fazla dahil olmasını sağlamaktadır.

Bu çalışmada, Türkçe öğretiminde öğrenme ortamlarının önemi ele alınarak farklı öğrenme ortamlarının öğrenci başarısı ve dil becerileri üzerindeki etkileri incelenecektir. Çalışma kapsamında mevcut uygulamalar ve geleceğe yönelik öneriler tartışılacaktır.

Anahtar Sözcükler: Türkçe Öğretimi, Öğrenme Ortamları, Türkçe Öğretiminde Öğrenme Ortamları

ABSTRACT

Language is a basic communication tool that enables individuals to convey their thoughts, feelings and knowledge. Mother tongue education is of great importance for both the cognitive and social development of the individual. Turkish language teaching is a critical area in terms of students developing their language skills, expressing themselves correctly and effectively and strengthening their critical thinking skills. In this process, the quality of learning environments directly affects the success of the teaching process. Learning environments include physical, technological and pedagogical elements that support students' active participation in the language learning process. In addition to traditional classroom environments, technology-supported learning platforms, interactive materials and social learning areas also have an important place in language teaching. Especially considering the requirements of the digital age, the role of innovative learning environments in teaching Turkish is increasing.

The quality of learning environments is an important factor that directly affects students' academic success and language skills. The more supportive, motivating and interactive learning environments are the more students' participation in the lesson and interest in the learning process increases. In addition to physical and digital environments, teacher guidance, peer collaboration and the use of different teaching materials are among the elements that support students' language development. Therefore, planning and developing learning environments is indispensable for effective language education.

Differences in learning environments vary in terms of teaching methods, materials and student interaction styles. While traditional learning environments are generally teacher-centered and supported by in-class lectures and printed materials, contemporary learning environments include student-centered, interactive and technology-based approaches. For example, innovative tools such as smart boards, online education platforms, digital storytelling and virtual reality applications help students develop their language skills more effectively. In addition, methods such as game-based learning and collaborative work allow students to be more involved in the process.

In this study, the importance of learning environments in Turkish Teaching Course will be discussed and the effects of different learning environments on student success and language skills will be examined. Within the scope of the study, current practices and future suggestions will be discussed.

Key Words: Turkish Teaching Course, Learning Environments, Learning Environments in Turkish Teaching Course

OPINIONS OF TEACHER CANDIDATES ON THEIR TEACHING PRACTICE EXPERIENCES

ÖĞRETMEN ADAYLARININ ÖĞRETMENLİK UYGULAMASI DENEYİMLERİNE YÖNELİK GÖRÜŞLERİ

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ÖZET

Öğretmenlik uygulaması, öğretmen adaylarının mesleki yeterliliklerini geliştirmeleri ve sınıf içi deneyim kazanmaları açısından büyük önem taşımaktadır. Öğretmen adayları, bu süreçte teorik bilgilerini pratiğe dökerek ders planlama, sınıf yönetimi, öğrenci etkileşimi ve ölçme-değerlendirme gibi temel becerileri geliştirme fırsatı bulurlar. Öğretmen adaylarının uygulama sürecinde karşılaştıkları zorluklar, edindikleri kazanımlar ve bu deneyimlere yönelik görüşleri, hem kendi öğretmenlik becerilerinin geliştirilmesi hem de öğretmen yetiştirme süreçlerinin daha etkili hale getirilmesi için önemli ipuçları sunmaktadır. Bu çalışmada, öğretmen adaylarının öğretmenlik uygulaması deneyimlerine yönelik görüşlerinin incelenmesiyle, onların mesleki gelişimlerine katkı sağlayan ve geliştirilmesi gereken yönlerin belirlenmesi amaçlanmaktadır. Öğretmenlik uygulamasına yönelik geri bildirimler, eğitim fakülteleri ve uygulama okulları için değerli bir kaynak oluşturabilir.

Bu araştırmanın çalışma grubunu; 2024-2025 Eğitim-Öğretim yılı güz yarıyılında Ankara Üniversitesi Eğitim Bilimleri Fakültesi Temel Eğitim Bölümü Sınıf Eğitimi Anabilim Dalına devam etmekte olan toplam 6 öğretmen adayı oluşturmaktadır. Veri toplama sürecinde yazarlar tarafından geliştirilen yarı yapılandırılmış görüşme formu kullanılmıştır. Veriler betimsel analiz yöntemiyle değerlendirilmiş, grafikler hâlinde sunulmuş ve yorumlanmıştır.

Araştırmadan elde edilen verilere göre öğretmen adaylarının; ders planı hazırlama konusunda kendilerini geliştirdikleri, etkinlikleri hazırlarken ilgi çekici olmasına özen gösterdikleri, etkili yöntem ve teknikleri seçmeye çalıştıkları ve öğrenci katılımını teşvik etmeyi önemsedikleri tespit sonucuna ulaşılmıştır. Araştırma bulgularına dayalı olarak, öğretmen adaylarının mesleki becerilerinin geliştiğini ve öğretim süreçlerinde bilinçli tercihler yapabildikleri söylenebilir. Gelecekte daha etkili öğretim uygulamaları gerçekleştirebilmeleri için öğretmen adaylarının bu becerilerini destekleyen uygulamaların artırılması önerilmektedir.

Anahtar Sözcükler: Öğretmen Adayları, Öğretmenlik Uygulaması, Öğretmen Adaylarının Görüşleri

ABSTRACT

Teaching practice is of great importance for teacher candidates to develop their professional competence and gain classroom experience. During this process, teacher candidates have the opportunity to put their theoretical knowledge into practice and develop basic skills such as lesson planning, classroom management, student interaction, and measurement and evaluation. The difficulties that teacher candidates encounter during the practice process, the gains they gain, and their views on these experiences provide important clues for both developing their own teaching skills and making teacher training processes more effective. In this study, it is aimed to determine the aspects that contribute to their professional development and those that need to be developed by examining the views of teacher candidates on their teaching practice experiences. Feedback on teaching practice can be a valuable resource for education faculties and practice schools.

The study group of this research consists of a total of 6 teacher candidates who are continuing their education at Ankara University, Faculty of Educational Sciences, Department of Elementary Education, Department of Primary Education in the fall semester of 2024-2025 Academic Year. A semi-structured interview form developed by the authors was used in the data collection process. The data were evaluated with the descriptive analysis method, presented in graphs and interpreted.

According to the data obtained from the research, it was determined that the teacher candidates improved themselves in preparing lesson plans, took care to make the activities interesting while preparing them, tried to choose effective methods and techniques, and cared about encouraging student participation. Based on the research findings, it can be said that the professional skills of teacher candidates have improved and they can make conscious choices in the teaching process. It is recommended that practices that support these skills of teacher candidates be increased so that they can implement more effective teaching practices in the future.

Key Words: Prospective Teachers, Teaching Practice, Opinions of Prospective Teachers

COMPARISON OF DIGITAL GAME ADDICTION LEVELS OF STUDENTS STUDYING AT THE FACULTY OF SPORTS SCIENCES

SPOR BİLİMLERİ FAKÜLTESİNDE OKUYAN ÖĞRENCİLERİN DİJİTAL OYUN BAĞIMLILIĞI DÜZEYLERİNİN KARŞILAŞTIRILMASI

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ÖZET

Çalışmanın Amacı: Yapılan bu çalışmanın amacı, Iğdır Üniversitesi Spor Bilimleri Fakültesinde okuyan öğrencilerin dijital oyun bağımlılığı düzeylerini çeşitli değişkenler acısından karşılaştırmaktır. Çalışmanın evreninin Spor Bilimleri Fakültesinde okuyan tüm öğrenciler oluştururken, örneklemini ise çalışmaya gönüllü olarak katılmayı kabul eden 119 öğrenci oluşturmaktadır.

Materyal Metod: Çalışmada veri toplama aracı olarak, Hazar ve Hazar (2019) tarafından geliştirilen 21 soru 3 alt boyuttan oluşan "Üniversite Öğrencileri İçin Dijital Oyun Bağımlılığı Ölçeği" kullanılmıştır. Elde edilen verilerin analizinde SPSS 20 programı kullanılmıştır. Verilerin analizinde tanımlayıcı istatistik, Bağımsız örneklem t testi ve tek yönlü varyans analizi uygulanmıştır.

Sonuç: Çalışmanın sonunda, aşırı odaklanma ve erteleme boyutunda erkeklerin; çatışma, yoksunluk ve arayış alt boyutunda kadınların; duygu değişimi ve dalma alt boyutunda kadınların daha yüksek puan aldığı belirlenmiştir. Ancak cinsiyet değişkenine bağlı alınan puanların karşılaştırılmasında ise, istatistiki olarak anlamlı bir farklılık tespit edilmemiştir.

Anahtar Kelime: Dijital Oyun, Bağımlılık, Üniversite Öğrenci, Spor Bilimleri.

ABSTRACT

Introduction and Purpose: The purpose of this study is to compare the digital game addiction levels of students studying at the Faculty of Sports Sciences at Iğdır University in terms of various variables. While the universe of the study consists of all students studying at the Faculty of Sports Sciences, the sample consists of 119 students who agreed to participate in the study voluntarily.

Materials and Methods: The "Digital Game Addiction Scale for University Students", consisting of 21 questions and 3 sub-dimensions developed by Hazar and Hazar (2019), was used as the data collection tool in the study. SPSS 20 program was used in the analysis of the

obtained data. Descriptive statistics, Independent sample t-test and one-way analysis of variance were applied in the analysis of the data.

Results: At the end of the study, it was determined that men scored higher in the over-focus and procrastination dimension; women scored higher in the conflict, deprivation and search sub-dimension; and women scored higher in the mood swing and absorption sub-dimension. However, no statistically significant difference was found in the comparison of the scores obtained based on the gender variable.

Key Words: Digital Game, Addiction, University Student, Sports Sciences.

BIBLIOMETRIC ANALYSIS OF THESIS ON 'RESVERATROL' IN THE FIELD OF NUTRITION AND DIETETICS

BESLENME VE DİYETETİK ALANINDA 'RESVERATROL' KONULU TEZLERİN BİBLİYOMETRİK ANALİZİ

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ÖZET

Amaç: Bu çalışmanın amacı Beslenme ve Diyetetik alanında gerçekleştirilmiş "Resveratrol" konulu lisansüstü tezlerin içeriğinin çeşitli değişkenlere göre incelemektir.

Materyal ve Yöntem: Veriler Yükseköğretim Kurulu Ulusal Tez Merkezi veri tabanında "resveratrol" anahtar kelimesi ile yapılan tarama sonucunda elde edilmiştir. Tarama sırasında çıkan tezlerden anabilim dalı "Beslenme ve Diyetetik" olan tezler tezin yılı, yapıldığı üniversite, tez türü, örneklem grubu ve tezden elde edilen bulgular temelinde kategorize edildi.

Bulgular: Yapılan aramada toplam 9 teze erişildi. Bu tezlerin yıllara göre dağılımı incelendiğinde 1'inin 2016 yılında, 1'inin 2020, 1'inin 2021, 1'inin 2022, 3'ünün 2023 ve 2'sinin de 2024 yılında yapıldığı belirlendi. Tezlerin 2'si Acıbadem, 1'i Ankara, 1'i Başkent, 1'i Hacettepe, 1'i Erciyes, 1'i Süleyman Demirel, 1'i Dokuz Eylül ve 1'i de İstanbul Okan Üniversitesi'nde yapılmıştı. Tezlerin 4'ü yüksek lisans, 5'i doktora teziydi. Tezlerin 3'ü ratlar, 4'ü hücre ve/veya hücre hatları ve 2'si ise insanlar üzerinde yürütülmüştü. Yapılan araştırmalar sonucu resveratrolün antioksidan ve antiinflamatuar özellikleri olan bir besin desteği olduğu bulunmuştu.

Sonuç: Bu analizde Türkiye'de Beslenme ve Diyetetik alanında resveratrol ile ilgili yapılan tezlerin sınırlı sayıda olduğu görüldü. Resveratrolün çalışma bulgularında bildirilen olumlu sonuçları düşünüldüğünde bu konudaki çalışma sayısının arttırılması yararlı olabilir.

Anahtar Kelimeler: Bibliyometrik Analiz, Resveratrol, Besin Desteği, Beslenme ve Diyetetik

ABSTRACT

Purpose: The purpose of this study is to examine the content of postgraduate theses on the subject of "Resveratrol" conducted in the field of Nutrition and Dietetics according to various variables.

Material and Method: Data were obtained as a result of the search conducted in the National Thesis Center database of the Council of Higher Education with the keyword “resveratrol”. The theses with the main branch of “Nutrition and Dietetics” among the theses found during the search were categorized based on the year of the thesis, the university where it was conducted, thesis type, sample group and the findings obtained from the thesis.

Findings: A total of 9 theses were reached in the search. When the distribution of these theses by year was examined, it was determined that 1 was made in 2016, 1 in 2020, 1 in 2021, 1 in 2022, 3 in 2023 and 2 in 2024. 2 of the theses were made in Acıbadem, 1 in Ankara, 1 in Başkent, 1 in Hacettepe, 1 in Erciyes, 1 in Süleyman Demirel, 1 in Dokuz Eylül and 1 in Istanbul Okan University. 4 of the theses were master's and 5 were doctoral theses. 3 of the theses were conducted on rats, 4 on cells and/or cell lines and 2 on humans. As a result of the studies, it was found that resveratrol is a nutritional supplement with antioxidant and anti-inflammatory properties.

Conclusion: In this analysis, it was seen that there are limited number of theses on resveratrol in the field of Nutrition and Dietetics in Turkey. Considering the positive results of resveratrol reported in the study findings, it may be useful to increase the number of studies on this subject.

Keywords: Bibliometric Analysis, Resveratrol, Food Supplement, Nutrition and Dietetics

GİRİŞ

Bibliyometri kavramı dergi, makale ve kitap gibi yayınların matematiksel ve istatistiksel yöntemlerle incelenmesi olarak tanımlanmaktadır (Pritchard, 1969). İçerik analizi olarak da adlandırılabilen bibliyometri, akademik çalışmaların farklı yönlerini sayısal analiz ve istatistiksel yöntemlerle incelenmesini sağlamaktadır (Erdoğan, 2020). Bibliyometrik analizlerle çalışmalar arasındaki ilişkilerin boyutları incelenirken, ele alınan konulara bağlı olarak kurumlar, ülkeler ve ekoller arasında arasında kıyaslamalar yapılabilmektedir (Koehler W, 2001). Başka bir deyişle bibliyometrik analizlerle, yayınların belirli bir bölgede, belirli bir zaman diliminde, yayınlandığı bölgede, kullanılan kaynaklar, atıf sayısı, dergi, konu ve anahtar kelimeleri bakımından niceliksel olarak incelemeleri yapılabilmektedir (Aydin & Bulut, 2012). Bibliyometrik analiz yönteminin kullanıldığı ilk çalışma 1917 yılında anatomi alanında yayımlanan eserleri ile Cole ve Eales aittir (Polat et al., 2019).

Resveratrol (RE; ((3,5,4′-trihydroxystilbene)), 1939 yılında ilk kez Takaoka tarafından beyaz helleborus (Veratrum grandiflorum) köklerinden izole edilen ve yaban mersini, çilek, üzüm, yer fıstığı gibi çok sayıda bitkisel besinde bulunan doğal polifenolik bileşendir (Takaoka, 1939). Stres, yaralanma, ultraviyole ışınları, bakteri veya mantar enfeksiyonuna bağlı olarak çok sayıda bitki tarafından resveratrol sentezi yapılmaktadır (Hasan & Bae, 2017). Resveratrol sentezi, flavonoidlerin sentezine benzer şekilde resveratrol sentaz aracılığıyla fenilpropanoid yolaklarında yapılmaktadır (Kapetanovic et al., 2011). Resveratrol doğada hem trans hem de cis izomerik formlarında bulunmaktadır. Trans izomer formu sağlık üzerindeki faydalı etkileri sebebiyle dikkat çekmektedir (Borriello et al., 2014). Trans formunun Cis formuna kıyasla daha yüksek biyoyararlılık ve kararlılığa sahip olduğu bilinmektedir (Gambini et al., 2015; Wenzel & Somoza, 2005). Resveratrolün düşük biyoyararlılığa sahip olması hücre içindeki etkinliğini azaltabilmektedir. yapılan in vitro çalışmalarda resveratrol hücrelerde yüksek biyolojik aktiviteler gösterse de, canlı dokulardaki etkisinin daha düşüktür (Gambini et al., 2015).

Anti-diyabetik (Hoseini et al., 2019), anti-aging (Subedi et al., 2017), anti-kanser (Alam et al., 2024) özellikler gösteren resveratrolün nörodejeneratif hastalıklar (Moussa et al., 2017), göz sağlığı (Soufi et al., 2012) ve kardiyovasküler sağlık (Damay & Ivan, 2024) üzerinde de iyileştirici etkilerinin olduğu bilinmektedir. Ayrıca hidroksil-, süperoksit- ve radikal temizleyici özellikleriyle anti-oksidatif etkiler göstermektedir (Breuss et al., 2019). Günlük güvenli kullanım aralığı 1-5 gram arasında değişmektedir (Çıracı & Kalafat, 2021). İnsanlar üzerinde

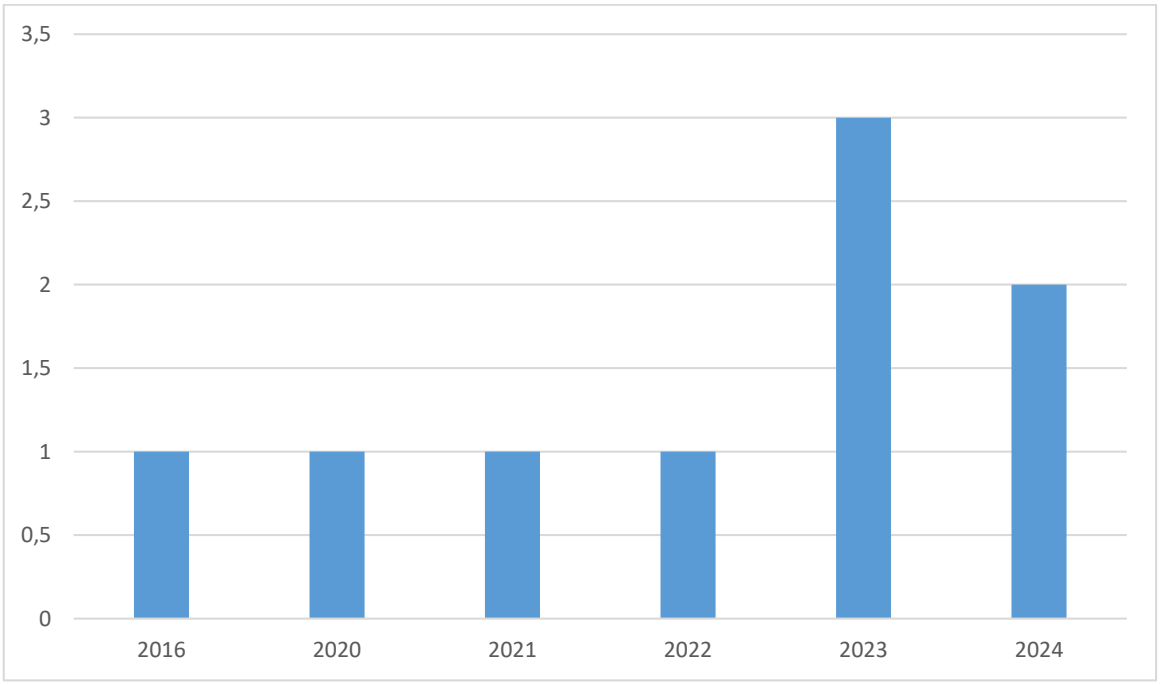
yapılan çalışmalarda resveratrolün genellikle iyi tolere edildiği bildirilmektedir (Brown et al., 2010; Sergides et al., 2016; Seyyedebrahimi et al., 2018). Ancak oral yoldan yüksek dozlarda kullanımı (2x2000 mg) sağlıklı bireylerde hafif-orta seviyede gastrointestinal semptomlara yol açabilmektedir (La Porte et al., 2010).

GEREÇ VE YÖNTEM

Veriler Yükseköğretim Kurulu Ulusal Tez Merkezi veri tabanında "resveratrol" anahtar kelimesi ile yapılan tarama sonucunda elde edilmiştir. Tarama sırasında çıkan tezlerden anabilim dalı "Beslenme ve Diyetetik" olan tezler tezin yılı, yapıldığı üniversite, tez türü, örneklem grubu ve tezden elde edilen bulgular temelinde kategorize edildi. Açık erişim ile ulaşılabilen tezler değerlendirmeye alındı.

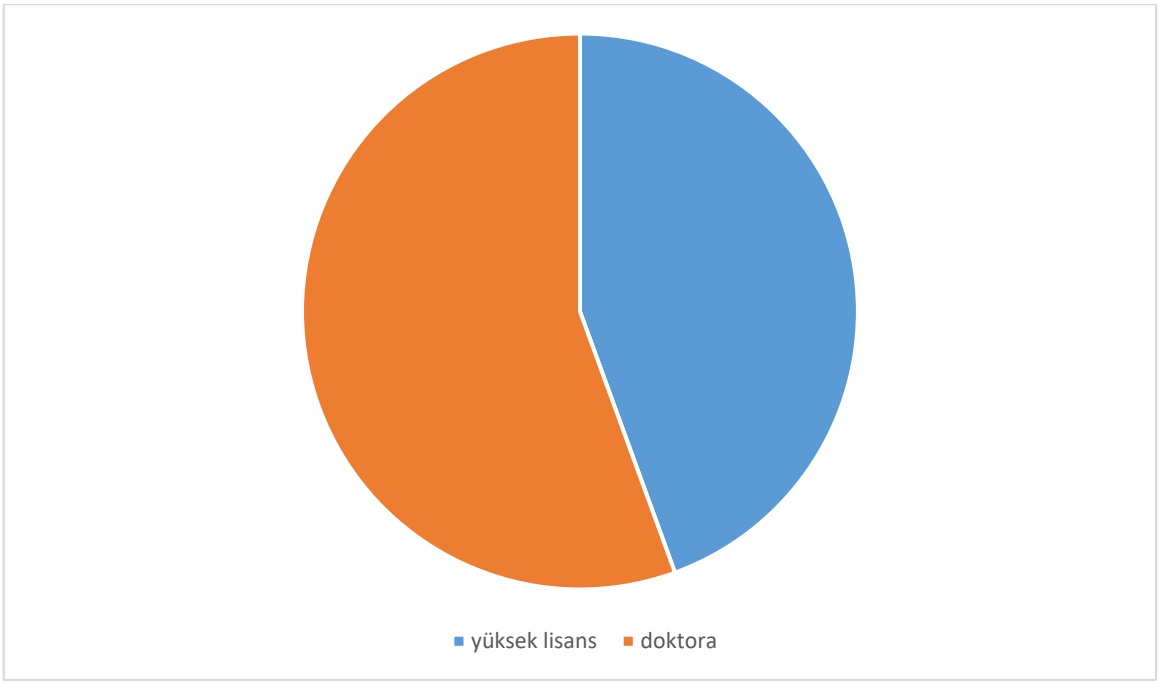
BULGULAR

Yapılan aramada toplam 9 teze erişildi. Bu tezlerin yıllara göre dağılımı incelendiğinde 1'inin 2016 yılında, 1'inin 2020, 1'inin 2021, 1'inin 2022, 3'ünün 2023 ve 2'sinin de 2024 yılında yapıldığı belirlendi. Tezlerin 2'si Acıbadem, 1'i Ankara, 1'i Başkent, 1'i Hacettepe, 1'i Erciyes, 1'i Süleyman Demirel, 1'i Dokuz Eylül ve 1'i de İstanbul Okan Üniversitesi'nde yapılmıştı.



Şekil 1. Tezlerin yıllara göre dağılımı

Tezlerin 4'ü yüksek lisans, 5'i doktora teziydi.



Şekil 2. Tezlerin türüne göre dağılımları

Tezlerin 3'ü ratlar, 4'ü hücre ve/veya hücre hatları ve 2'si ise insanlar üzerinde yürütülmüştü. Yapılan araştırmalar sonucu resveratrolün antioksidan ve antiinflamatuar özellikleri olan bir besin desteği olduğu bulunmuştu.

TARTIŞMA

Tamamlanan ve ulaşılabilen tezlerde farklı konular işlenmektedir. Dahil edilen 9 tezde "Farelerde resveratrol ile beslenmenin myogenin ve mTOR düzeyleri üzerinde etkisi", "Laurik asit ve resveratrol alımının farelerde diyetle indüklenen nöroinflamasyon, CD36 düzeyi ve kognitif davranışlar üzerine etkileri", "Böbrek hasarı oluşturulan ratlarda resveratrol desteğinin üremik toksinler ve inflamasyon üzerine etkisi", "Ülseratif kolitli hastalarda akdeniz diyetine eklenen kurkumin ve resveratrol takviyelerinin hastalık şiddeti ve inflamatuvar biyobelirteçler üzerine etkilerinin incelenmesi", "Gökçeada'da yetişen üç çeşit kırmızı üzümde kateşin, epikateşin ve resveratrolün incelenmesi", "Kolistin dirençli klebsiella pneumoniae sepsisinde mezenkimal kök hücre ve resveratrol+piperin kombine tedavisi etkinliğinin araştırılması", "Nöronal hücrelerde hidrojen peroksit hasarına karşı epigallokateşin gallat ve resveratrolün koruyucu etkilerinin araştırılması", "Kuersetin ve resveratrol tüketiminin elit adölesan atletizm mesafe koşucularının laktik asit düzeyleri ile koşu performansı üzerine etkilerinin incelenmesi" ve "Preadipositlerin bej yağ dokusuna farklılaşmasında resveratrol'ün SIRT1 gen ürünü üzerinden etkisinin incelenmesi" gibi konular ele alınmıştır. Bu tez çalışmalarında genel olarak Resveratrolün inflamasyon ve inflamatuar belirteçler üzerindeki etkileri incelenmiştir.

Resveratrol ve inflamasyon arasındaki ilişkiyi inceleyen bu çalışmalar incelendiğinde, resveratrol desteğinin genellikle inflamatuar belirteçler üzerinde azalma sağladığı görülmektedir. Hem genel çalışma sayısının sınırlılığı hem de doz-yanıt ilişkisine dayanan sonuçların az olması sebebiyle kesin öneriler sunmak henüz mümkün değildir.

SONUÇ

Beslenme ve diyetetik alanında 'Resveratrol' desteğinin etkinliği üzerinde yeni çalışmalar yapılan gelişime açık bir konudur. Bu analizde Türkiye'de Beslenme ve Diyetetik alanında resveratrol ile ilgili yapılan tezlerin sınırlı sayıda olduğu görüldü. Resveratrolün çalışma

bulgularında bildirilen olumlu sonuçları düşünüldüğünde bu konudaki çalışma sayısının arttırılması yararlı olabilir.

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SOURCES, PROPERTIES, EXTRACTION AND HEALTH EFFECTS OF CURCUMIN

KURKUMİNİN KAYNAKLARI, ÖZELLİKLERİ, EKSTRAKSİYONU VE SAĞLIK ÜZERİNE ETKİSİ

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ÖZET

Kurkumin, zerdeçal (*Curcuma longa*) bitkisinin rizomlarından elde edilen sarı renkli, bir fenolik bileşiktir. Kurkuminin tıbbi kullanımı 2500 yıl öncesine Asya'ya, özellikle Hindistan'a dayanmaktadır. Kurkuminin, antioksidan, antiviral, antibakteriyel, anti-inflamatuar , antifungal, antikanser, antiproliferatif, proapoptotik ve anti-aterosklerotik etkiler gibi çeşitli biyolojik özelliklere sahip olup literatürde nörodejeneratif hastalıklar, artrit, alerji, inflamatuar bağırsak hastalığı, nefrotoksisite, diyabet, multipl skleroz, kardiyovasküler ve sedef hastalıklar üzerine etkileri bildirilmiştir. Çok yönlü biyolojik etkileriyle ilgi çeken kurkumin, kurkuminoidler grubunun ana bileşenidir. Hint mutfağında köri baharatının temel unsurlarından biri olan bu bileşik, gıda endüstrisinde E100 koduyla margarin, peynir, şekerleme ve içecekler gibi ürünlerde doğal renklendirici olarak kullanılmaktadır. Kurkuminin gıda katkısı olarak kullanımı, yalnız renklendirme ile sınırlı kalmaz; aynı zamanda antioksidan ve antimikrobiyal etkileri nedeniyle doğal bir koruyucu olarak da değerlendirilir. Kurkumin, asidik veya nötr özellikte suda neredeyse çözünmez. Güçlü asidik çözücülerde, polar veya polar olmayan organik çözücülerde çözünür. Suda çözünürlüğünün düşük olması, ışığa, ısıya karşı hassasiyeti, kimyasal kararsızlığı ve hızlı metabolik degradasyonu, biyoyararlanımını sınırlandırmaktadır. Son zamanlarda, kurkuminin biyoyararlanımını artırmak için yöntemler geliştirmiştir. Nanopartiküller, miseller, fosfolipid kompleksleri, lipozomlar biyoyararlanımı artırmak için kullanılmıştır. Kurkuminin ekstraksiyonunda, sokselet ve maserasyon gibi geleneksel yöntemlerle mikrodalga, ultrason, süperkritik akışkan, yüksek basınç ve enzim destekli ekstraksiyon gibi modern yöntemlerden yararlanılmaktadır. Bu makalede, kurkuminin tarihçesi, kaynakları, ekstraksiyon yöntemleri, fizikokimyasal özellikleri, sağlık üzerine etkileri ile potansiyel toksisitesi tartışılmaktadır.

Anahtar Kelimeler: Kurkuminoid, sağlık, zerdeçal, ekstraksiyon

ABSTRACT

Curcumin is a yellow phenolic compound obtained from the rhizomes of the turmeric (Curcuma longa) plant. The medicinal use of curcumin dates back 2500 years to Asia, especially India. Curcumin has various biological properties such as antioxidant, antiviral, antibacterial, anti-inflammatory, antifungal, , anticancer, antiproliferative, proapoptotic and anti-atherosclerotic effects, and its effects on neurodegenerative diseases, arthritis, allergies, inflammatory bowel

disease, nephrotoxicity, diabetes, multiple sclerosis, cardiovascular and psoriasis diseases have been reported in the literature. Curcumin, which attracts attention with its versatile biological effects, is the main component of the curcuminoids group. This compound, which is one of the basic elements of curry spice in Indian cuisine, is used in the food industry as a natural colorant in products such as margarine, cheese, confectionery and beverages with the code E100. The use of curcumin as a food additive is not limited to coloring alone; It is also considered a natural preservative due to its antioxidant and antimicrobial effects. Curcumin is almost insoluble in acidic or neutral water. It is soluble in strong acidic solvents, polar or non-polar organic solvents. Its low water solubility, sensitivity to light and heat, chemical instability and rapid metabolic degradation limit its bioavailability. Recently, methods have been developed to increase the bioavailability of curcumin. Nanoparticles, micelles, phospholipid complexes and liposomes have been used to increase bioavailability. Traditional methods such as soxhlet and maceration and modern methods such as microwave, ultrasound, supercritical fluid, high pressure and enzyme-assisted extraction are used in the extraction of curcumin. In this article, the history, sources, extraction methods, physicochemical properties, health effects and potential toxicity of curcumin are discussed.

Keywords: Curcuminoid, health, turmeric, extraction

GİRİŞ

Kurkumin, Zingiberaceae (zencefil) ailesine ait zerdeçal (*Curcuma longa* L.) bitkisinin rizomlarından izole edilen, sarı renkli bir polifenoldür (Aggarwal et al., 2007). Bu doğal madde, Hint mutfağında binlerce yıldır baharat ve renklendirici olarak kullanılmasının yanı sıra, Ayurveda ve Çin geleneksel tıbbında terapötik amaçlarla da önemli bir yer edinmiştir (Prasad & Aggarwal, 2011). Modern bilim, kurkuminin antioksidan, antienflamatuar, antimikrobiyal ve antikanser gibi çok yönlü biyolojik etkilerini ortaya koyarak geleneksel kullanımlarını destekleyen kapsamlı bulgular sunmuştur (Amalraj et al., 2017; Gupta et al., 2013).

Zerdeçal rizomlarında %3-5 oranında bulunan kurkumin, curcuminoidler grubunun ana bileşenidir. Bu grupta demetoksikurkumin (DMC) ile bisdemetoksikurkumin (BDMC) gibi diğer önemli türevler de yer alır (Jayaprakasha et al., 2002). Gıda endüstrisinde E100 koduyla doğal renklendirici olarak kullanılan kurkumin, margarin, peynir ve şekerleme gibi ürünlere katılmaktadır. Aynı zamanda kozmetik ve ilaç sektörlerinde de potansiyel bir bileşen olarak dikkat çekmektedir (Hewlings & Kalman, 2017). Sudaki çözünürlüğünün düşük olması (yaklaşık 11 ng/mL), ışığa ve ısıya karşı hassasiyeti ile hızlı metabolik degradasyonu, biyoyararlanımını kısıtlamaktadır (Anand et al., 2007; Tønnesen et al., 1986). Bu zorlukları aşmak amacıyla, son yıllarda ekstraksiyon teknikleri, nanoformülasyonlar ve kimyasal modifikasyonlar üzerine yoğun araştırmalar yapılmaktadır (Rafiee et al., 2019; Jiang et al., 2021). Bu derlemede kurkumin tarihçesi, kaynakları, sağlık üzerine etkileri, ekstraksiyonu yanında gıda katkısı olarak kullanımı üzerinde durulmaktadır.

KURKUMİNİN TARİHÇESİ, TÜRLERİ VE KAYNAKLARI

KURKUMİNİN TARİHÇESİ

Kurkuminin kullanımı, Hindistan'da yaklaşık 4000 yıl öncesine dayanır ve Ayurveda tıbbında zerdeçalın temel bileşeni olarak bilinir. Başlangıçta baharat ve renklendirici olarak kullanılan zerdeçal, antiinflamatuar ve yara iyileştirici etkileriyle tıbbi amaçlar için tercih edilmiştir (Prasad & Aggarwal, 2011). Çin'de ise geleneksel tıp "jiang huang" adıyla zerdeçalı karaciğer, sindirim ve dolaşım sorunları için yaklaşık 2000 yıldır kullanmaktadır (Amalraj et al., 2017). Güneydoğu Asya'da, özellikle Endonezya ve Tayland'da, zerdeçal bağışıklık güçlendirme, cilt bakımı ve mutfakta (örneğin köri sosları) değerlendirilmiştir. Batı'ya 13. yüzyılda Marco

Polo'nun Hindistan'dan "Hint safranı" olarak tanıttığı zerdeçal, Avrupa'da sınırlı mutfak kullanımıyla renk verici ve tıbbi bir baharat olarak yer almıştır. Bilimsel çalışmalar, 19. yüzyılda başlamış, kurkuminin kimyasal yapısı 1815'te Vogel ve Pelletier tarafından tanımlanmış, saf olarak izolasyonu ise 1842'de gerçekleşmiştir (Gupta et al., 2013). 1949'da Schraufstatter ve Bernt, kurkuminin antibakteriyel etkisini ortaya koymuş ve modern araştırmalar hız kazanmıştır (Schraufstatter & Bernt, 1949). ABD'de 20. yüzyılın ortalarından itibaren alternatif tıpta antioksidan ve antikanser özellikleriyle popüler hale gelmiştir. Japonya'da zerdeçal, karaciğer detoksifikasyonu için geleneksel çay ve modern takviyelerde kullanılmıştır. Orta Doğu'da ise İslam tıbbında sindirim ve solunum rahatsızlıkları için önerilmiştir. Günümüzde kurkumin, kanser ve kronik hastalıklar için terapötik potansiyeliyle araştırılmaktadır (Aggarwal et al., 2007).

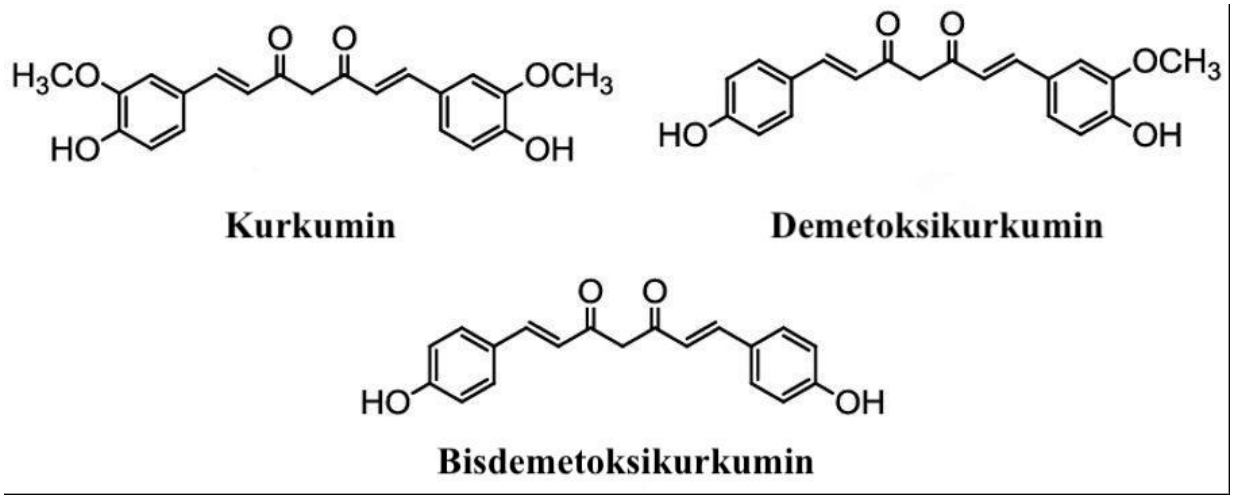
TÜRLERİ VE LATİNCE İSİMLERİ

Kurkumin, kurkuminoidler adı verilen bir bileşik grubunun ana üyesidir. Üç temel kurkuminoid şunlardır (Şekil 1):

1. **Kurkumin** (diferuloilmetan): Zencefilde en yüksek oranda bulunan bileşiktir (%75).

2. **Demetoksikurkumin (DMC)**: Kurkuminin bir metoksi grubunun eksik olduğu türevidir (%10-20).

3. **Bisdemetoksikurkumin (BDMC)**: İki metoksi grubunun eksik olduğu formdur (%5).



Şekil 1. Kurkumin Türleri ve Kimyasal Yapıları (Jiang et al., 2021)

KURKUMİN KAYNAKLARI

Kurkuminoidler, kurkuma cinsine ait çeşitli bitkilerden elde edilir. Doğada kurkuminoid içeren başlıca türler ve latince isimleri Tablo 1 de verilmiştir.

Tablo 1. Kurkuminin Doğal Kaynakları

Latince İsim	Kullanım Alanı	Özelliği	İçerdiği Temel Bileşenler	Kaynak
Curcuma longa L.	Mutfak (baharat), tıp, renklendirici	Parlak sarı renk, yoğun aroma	Kurkumin (%75), DMC (%10-20), BDMC (%5)	Jiang et al. (2021)
Curcuma amada Roxb.	Mutfak, geleneksel tıp	Mangoya benzer hafif tat	Kurkumin (%1-3), DMC, BDMC (düşük oran)	Shirsath et al. (2017)
Curcuma zedoaria (Christm.) Roscoe	Geleneksel tıp, kozmetik	Acı tat, antiseptik özellik	Kurkumin (%1-3), uçucu yağlar	Paramasivam et al. (2009)
Curcuma aromatica Salisb.	Kozmetik, tıp, mutfak	Güçlü aromatik koku	Kurkumin (%2-4), DMC, uçucu yağlar	Dosoky & Setzer (2018)
Curcuma raktakanta Mangaly & M.Sabu	Geleneksel tıp	Nadir, bölgesel kullanım	Kurkumin (düşük oran), DMC, BDMC	Sasikumar (2012)
Curcuma mangga Valeton & Zijp	Mutfak, bitkisel ilaçlar	Mangomsu tat ve koku	Kurkumin (%1-2), DMC, uçucu yağlar	Sasikumar (2012)
Curcuma xanthorrhiza Roxb.	Tıp (karaciğer desteği), mutfak	Hafif acı, koyu sarı renk	Kurkumin (%2-5), xanthorrhizol	Shirsath et al. (2017)
Curcuma kwangsiensis S.G.Lee & C.F.Liang	Geleneksel Çin tıbbı	Hafif tat, yerel kullanım	Kurkumin (%1-3), DMC, BDMC	Li et al. (2011)

Her bir türün kurkuminoid içeriği ve oranı bakımından farklılık gösterebilmektedir. Ancak *Curcuma longa* en yüksek kurkumin içeriğine sahip tür olarak öne çıkmaktadır (Shirsath et al., 2017). Kurkumin, esas olarak *Curcuma longa*'nın kurutulmuş rizomlarından elde edilir. Taze zerdeçal rizomlarında kurkuminoid içeriği %3-5 arasında değişirken, bu oran kurutma ve işleme yöntemlerine bağlı olarak artabilir (Jiang et al., 2021). Ticari zerdeçal tozlarında kurkuminoidlerin oranı genellikle %2-8 arasında bulunur ve kurkumin bu toplamın yaklaşık %75'ini oluşturur (Wakte et al., 2011). Geri kalanını ise demetoksikurkumi (DMC) (%10-20) ve bisdemetoksikurkumin (BDMC) (%5) paylaşır (Shirsath et al., 2017). Diğer türlerde (örneğin, *Curcuma zedoaria*) kurkuminoid içeriği daha düşüktür (Paramasivam et al., 2009).

Kurkumin miktarı, bitkinin yetiştiği bölge, toprak koşulları ve hasat zamanı gibi çevresel faktörlerden etkilenir. Örneğin, Hindistan'da yetişen *Curcuma longa*'nın kurkumin içeriği, Endonezya veya Çin'dekilere göre daha yüksek olabilir (Jayaprakasha et al., 2002). Ayrıca, genetik varyasyonlar da kurkuminoid oranlarını etkileyebilmektedir (Sasikumar, 2012).

Zerdeçalın yaprakları ve çiçekleri, bazı geleneksel uygulamalarda kullanılsa da, bu kısımların kurkumin içeriği oldukça düşüktür (genellikle %0.1'den az). Bu nedenle ticari veya bilimsel amaçlar için tercih edilmezler (Paramasivam et al., 2009). Kurutulmuş zerdeçal tozu, gıda endüstrisinde en yaygın tüketilen formdur ve ortalama 1 gramında 20-80 mg kurkuminoid bulunur (Amalraj et al., 2017). Ancak bu miktar, işleme yöntemine ve zerdeçalın kalitesine bağlı olarak değişebilir. Örneğin, organik zerdeçal tozlarında kurkumin içeriği, kimyasal gübrelerle yetiştirilenlere göre daha yüksek bulunmuştur (Sasikumar, 2012).

STABİLİTESİNİ ETKİLEYEN FAKTÖRLER

Kurkumin, kimyasal yapısı gereği çevresel faktörlere karşı hassastır ve çeşitli koşullar altında degradasyona uğrayabilir. Işık, ısı, pH değişiklikleri ve oksijen varlığı, kurkuminin stabilitesini etkileyen başlıca faktörlerdir (Heger et al., 2014). Alkalin pH (>7) olduğunda, kurkumin hızla hidrolize olur ve ferulik asit, feruloilmetan ve vanilin gibi degradasyon ürünlerine dönüşür (Tønnesen et al., 1986). Nötr veya asidik ortamlarda ise daha stabildir, ancak uzun süreli ışık

maruziyeti fotodegradasyona yol açar ve sonuçta siklokurkumin gibi ürünler oluşur (Priyadarsini, 2014). Diğer ifadeyle kurkumin, termal ve fotokimyasal stabilitesi düşük bir bileşiktir. 70°C üzerindeki sıcaklıklarda, özellikle sulu çözeltilerde, degradasyon hızı artar ve ferulik asit gibi ürünler oluşur (Tønnesen et al., 1986). Işık maruziyeti, UV ışınlarının etkisiyle kurkuminin β-diketon yapısını bozar ve fotooksidasyon yoluyla vanilin ve diğer küçük moleküller üretilir (Priyadarsini, 2014). Oksijen varlığı da oksidatif degradasyonu hızlandırır. Bu nedenle, kurkuminin saklama koşulları (karanlık, serin ve kuru ortam) stabilitesi açısından kritik öneme sahiptir (Heger et al., 2014).

Metabolik degradasyon da kurkuminin biyoyararlanımını etkileyen önemli bir faktördür. Oral yolla alındığında; karaciğerde ve bağırsaklarda glukuronidasyon ve sülfasyon yoluyla metabolize edilir. Bu süreçte kurkumin glukuronid ve kurkumin sülfat gibi suda çözünür konjugatlar oluşur (Anand et al., 2007). Ayrıca, bağırsak mikroflorası tarafından tetrahidrokurkumin (THC) ve hekzahidrokurkumin gibi redüksiyon ürünlerine dönüştürülebilir (Holder et al., 1978). Bu metabolitlerin bazısı (örneğin THC), kurkuminin antioksidan aktivitesini korursa da, genel biyoaktivite genellikle azalır (Amalraj et al., 2017).

KURKUMİNİN ÖZELLİKLERİ

FİZİKSEL VE KİMYASAL ÖZELLİKLER

Kurkumin, moleküler formülü C21H20O6 olan hidrofobik bir polifenoldür ve 183°C'de erir. Sarı-turuncu rengiyle dikkat çeker, bu özellik gıda endüstrisinde doğal bir renklendirici olarak kullanımını sağlar (E100 koduyla) (Jiang et al., 2021). Moleküler yapısında iki feruloil grubu ve bir β-diketon köprüsü bulunur. Bu yapı, hem antioksidan hem de kimyasal reaktivite kazandırır (Priyadarsini, 2014). Kurkuminin kristal formu ortorombiktir ve çözünürlüğü, solventin polaritesine bağlıdır. Organik solventlerde (örneğin, etanol, aseton) iyi çözünürken, sudaki çözünürlüğü son derece düşüktür (11 ng/mL) (Tønnesen et al., 2002). Bu hidrofobik doğası, biyoyararlanımını sınırlayan ana faktörlerden biridir (Rafiee et al., 2019).

SUDA VE DİĞER ORTAMLARDA ÇÖZÜNÜRLÜĞÜ

Kurkuminin sudaki düşük çözünürlüğü, pH'a bağlı olarak değişir (Tablo 2). Asidik ve nötr pH'da (pH 1-7) stabildir ve çözünürlüğü minimaldir. Alkali pH'da (pH > 8) çözünürlüğü artar, fakat bu koşullar altında hızlı degradasyona uğrar (Wang et al., 1997). Organik solventlerde çözünürlüğü ise oldukça yüksektir. Etanolde 1 mg/mL, asetonda 20 mg/mL ve dimetil sülfoksit (DMSO)'da 25 mg/mL'ye ulaşır (Jiang et al., 2021). Biyoyararlanımı artırmak için mikroemülsiyonlar, lipozomlar ve nanosüspansiyonlar gibi formülasyonlar geliştirilmiştir. Örneğin, Lin et al. (2017), kurkuminin Tween 80 ve lesitin ile kapsüllenmiş haliyle sudaki çözünürlüğünü artırarak biyoyararlanımını iyileştirmiştir.

Tablo 2. Kurkuminin farklı ortamlarda çözünürlüğü ve degradasyonu

Ortam	Çözünürlük	pH Etkisi	Degradasyon Ürünleri	Kaynaklar
Su	11 ng/mL	Asidik/Nötr: Stabil, Alkalin: Hızlı degradasyon	Ferulik asit, vanilin	Tønnesen et al. (2002)
Etanol	1 mg/mL	Stabil	-	Jiang et al. (2021)
Aseton	20 mg/mL	Stabil	-	Jiang et al. (2021)
DMSO	25 mg/mL	Stabil	-	Jiang et al. (2021)
Işık (UV) maruziyeti	-	Fotodegradasyon	Siklokurkumin, vanilin	Priyadarsini (2014)
Isı (>70°C)	-	Termal degradasyon	Ferulik asit	Tønnesen et al. (1986)

SAĞLIK ÜZERİNE ETKİLERİ

Kurkumin, çok yönlü biyolojik aktiviteleriyle dikkat çekmektedir (Tablo 3). Literatürde antioksidan, antiviral, antikanser, antiinflamatuar, nöroprotektif etki, metabolik sendrom önleyici etkileri konusunda yagın çalışma yapılmıştır (Meghana et al., 2007). Antioksidan özelliğini, reaktif oksijen türlerini (ROS) temizleyerek oksidatif stresi azaltma ve glutatyon gibi hücresel antioksidanların seviyesini artırma (Menon & Sudheer, 2007; Hewlings & Kalman, 2023); antienflamatuar etkisini, NF-κB ve AP-1 gibi inflamatuar yolakları baskılayarak sitokin üretimini (örneğin TNF-α, IL-6) azaltma şeklinde göstermektedir. Bu da artrit gibi kronik inflamasyonla ilişkili durumlarda potansiyel bir terapötik etki sağlar (Kang et al., 2004).

Kurkuminin antikanser etkisi, kanser hücrelerinin çoğalmasını inhibe etmesi, apoptozu teşvik etmesi (p53 ve Bax genlerini aktive ederek) ve anjiyogenezi baskılaması ile öne çıkar (Dorai et al., 2001). Özellikle meme, kolorektal ve prostat kanser modellerinde etkili olduğu klinik öncesi çalışmalarla gösterilmiştir (Hewlings & Kalman, 2023). Nöroprotektif etkileri ise Alzheimer hastalığında amiloid-β plak birikimini azaltması, tau protein fosforilasyonunu inhibe etmesi ve BDNF seviyelerini artırarak nöronal korumayı desteklemesiyle dikkat çeker (Aggarwal et al., 2007). Kardiyovasküler sistemde, kurkumin LDL kolesterol oksidasyonunu önleyerek ateroskleroz riskini düşürür, endotel fonksiyonunu iyileştirir ve hipertansiyonu azaltıcı etkiler gösterir (Hong et al., 2010). Metabolik etkileri arasında, Tip 2 diyabette insülin hassasiyetini artırması, glukoz toleransını iyileştirmesi ve obezite modellerinde yağ birikimini azaltması yer alır (Amalraj et al., 2017). Ayrıca, antimikrobiyal etkisiyle *Staphylococcus aureus, Escherichia coli* gibi bakterilere, HIV ve HSV gibi virüslere ve çeşitli mantar türlerine karşı etkinlik gösterir (Liu & Huang, 2013; Hewlings & Kalman, 2023).

Kurkumin genellikle güvenli (GRAS statüsü) kabul edilmektedir. Ancak, yüksek dozlarda bazı yan etkiler bildirilmiştir. Gastrointestinal rahatsızlıklar (örneğin, bulantı, ishal) ve karaciğer enzimlerinde hafif yükselmeler gözlenmiştir (Lao et al., 2006). Ayrıca, bazı bireylerde demir emilimini inhibe ederek anemi riskini artırabilir (Chin et al., 2014). Toksik doz, hayvan modellerinde 2000 mg/kg vücut ağırlığına kadar güvenli bulunmuş; insanlarda ise 12 g/gün'e kadar ciddi toksisite rapor edilmemiştir (Sharma et al., 2001). Ancak, uzun süreli yüksek doz kullanımın güvenliği henüz tam olarak aydınlatılmamıştır (Hewlings & Kalman, 2017).

Tablo 3. Kurkuminin sağlık üzerine yararlı ve zararlı etkisi

Etkileri	Açıklama	Kaynaklar
Antioksidan Etki	Kurkumin, reaktif oksijen türlerini (ROS) temizleyerek oksidatif stresi azaltır ve glutatyon seviyesini artırır.	Menon & Sudheer (2007); Meghana et al. (2007); Hewlings & Kalman (2023)
Antiinflamatuar Etki	NF-κB ve AP-1 gibi inflamatuar yolakları baskılayarak TNF-α ve IL-6 gibi sitokin üretimini azaltır.	Kang et al. (2004)
Antikanser Etki	Kanser hücrelerinde apoptozu teşvik eder (p53 ve Bax genlerini aktive ederek) ve anjiyogenezi baskılar.	Dorai et al. (2001); Hewlings & Kalman (2023)
Nöroprotektif Etki	Alzheimer'da amiloid-β plak birikimini azaltır ve tau protein fosforilasyonunu inhibe eder.	Aggarwal et al. (2007)
Kardiyovasküler Fayda	LDL kolesterol oksidasyonunu önler, endotel fonksiyonunu iyileştirir ve hipertansiyonu azaltır.	Hong et al. (2010)
Metabolik sendrom	Tip 2 diyabette insülin hassasiyetini artırır ve glukoz toleransını iyileştirir.	Amalraj et al. (2017)
Antimikrobiyal Etki	Staphylococcus aureus, Escherichia coli, HIV ve HSV gibi patojenlere karşı etkinlik gösterir.	Liu & Huang (2013); Hewlings & Kalman (2023)
Gastrointestinal Etki	Yüksek dozlarda (örneğin 8 g/gün) bulantı, ishal ve karaciğer enzimlerinde yükselme görülebilir.	Lao et al. (2006)
Demir Emilimi Üzerine Etki	Yüksek dozlarda demir emilimini inhibe ederek anemi riskini artırabilir.	Chin et al. (2014)

EKSTRAKSİYON YÖNTEMLERİ

Kurkuminin bitkisel kaynaklardan elde edilmesi, onun biyolojik ve ticari potansiyelini realize etmek için kritik bir adımdır. Ekstraksiyon yöntemleri, hem verimi hem de elde edilen kurkuminin saflığını doğrudan etkiler. Geleneksel yöntemlerden yenilikçi teknolojilere kadar geniş bir yelpazede teknikler geliştirilmiştir (Jiang et al., 2021).

GELENEKSEL EKSTRAKSİYON YÖNTEMLERİ

SOKSELET EKSTRAKSİYONU

Sokselet ekstraksiyonu, 1879'da Franz von Soxhlet tarafından geliştirilen klasik bir katı-sıvı ekstraksiyon yöntemidir. Bu teknikte, zerdeçal tozu bir organik solvent (genellikle etanol veya aseton) ile sürekli olarak ekstrakte edilir. Shirsath et al. (2017), sokselet ekstraksiyonunun yüksek kurkumin verimi (%72) sağladığını bildirmiştir. Ancak bu yöntem yüksek sıcaklık (60-80°C) ve uzun süre (6-8 saat) gerektirir, bu da ısıya duyarlı bileşiklerin degradasyonuna yol açabilir (Jiang et al., 2021). Ayrıca, büyük miktarda solvent kullanımı çevresel ve ekonomik dezavantajlar yaratır (Luque de Castro & Priego-Capote, 2010).

MASERASYON (SOLVENT EKSTRAKSİYONU)

Maserasyon, zerdeçal tozunun bir solventte (örneğin, etanol, metanol) bekletilmesiyle gerçekleştirilen basit bir yöntemdir. Popuri ve Pagala (2013), etanol ile 30°C'de 1 saatlik maserasyonun 0.26 mg/g kurkumin verimi sağladığını rapor etmiştir. Bu yöntem düşük

maliyetli ve ekipman gereksinimi az olsa da, ekstraksiyon süresi uzun (genellikle 8-24 saat) ve selektivitesi düşüktür (Paulucci et al., 2013).

HİDRO/BUHAR DİSTİLASYONU

Bu yöntem, uçucu yağların (turmeric aroma) ayrılması için kullanılır ve ardından kalan katı materyalden kurkumin ekstrakte edilir. Silva et al. (2005), hidro-distilasyonun düşük maliyetle deodorize edilmiş zerdeçal sağladığını ve kurkuminoid kaybı olmadan etkili olduğunu göstermiştir. Ancak, bu yöntem kurkuminin direkt ekstraksiyonu için uygun değildir ve ek işlem gerektirir.

YENİLİKÇİ EKSTRAKSİYON YÖNTEMLERİ

ULTRASON DESTEKLİ EKSTRAKSİYON (UAE)

Ultrasonik dalgalar (20 kHz-100 MHz), bitki matrisinde kavitasyon oluşturarak çözgenin hedef bileşiklerle temasını artırır. Shirsath et al. (2017), UAE ile optimum koşullarda (35°C, 1:25 katı/çözgen oranı, 250 W ultrasonik güç) %72 verim elde edildiğini ve bu yöntemin maserasyona göre 8 kat daha hızlı olduğunu bildirmiştir. Vurgulu UAE ise enerji tasarrufu sağlayarak verimi artırır (Li et al., 2014). UAE, çevre dostu ve hızlı bir alternatif olarak öne çıkar (Garavand et al., 2019).

MİKRODALGA DESTEKLİ EKSTRAKSİYON (MAE)

MAE, mikrodalga enerjisi (2.45 GHz) kullanarak ısı ve kütle transferini hızlandırır. Mandal et al. (2008), 140 W güç ve 4 dakikalık işlemle %4.98 kurkumin verimi elde etmişlerdir. Bu yöntem, sokseletten daha yüksek ve hızlı bir sonuç vermektedir. MAE, solvent ve enerji tüketimini azaltarak "yeşil teknoloji" kategorisine girer. Ancak, mikrodalga gücünün ve süresinin dikkatle optimize edilmesi gerekir. Aksi takdirde kurkumin degradasyonu riski artar (Praveen et al., 2019).

ENZİM DESTEKLİ EKSTRAKSİYON (EAE)

Bitki hücre duvarını hidrolize eden enzimler (örneğin, α-amilaz, glukoamilaz) kullanılarak kurkumin salınımı artırılır. Sahne et al. (2016), EAE ile %4.1 verim elde etmiş, Kurmudle et al. (2013) ise %31.83'e varan verim artışı rapor etmişlerdir. EAE, çevre dostu ve sürdürülebilir bir yöntemdir. Ancak enzim maliyeti ve optimum koşullar (pH, sıcaklık) gereksinimi dezavantajlarıdır.

BASINÇLI SIVI EKSTRAKSİYONU (PLE)

PLE tekniğinde, yüksek sıcaklık ve basınç altında sıvı solventler (genellikle su veya etanol) kullanır. Kiamahalleh et al. (2016), subkritik su ekstraksiyonu (SWE) ile 140°C ve 10 bar'da %3.8 kurkumin verimi elde etmişlerdir. SWE organik solvent kullanımını azaltarak çevre dostu bir alternatif sunar. Ancak yüksek sıcaklık, kurkumin stabilitesini riske atabilir (Osorio-Tobón et al., 2016).

SÜPERKRİTİK AKIŞKAN EKSTRAKSİYONU (SFE)

SFE, genellikle süperkritik CO_2 ile gerçekleştirilir ve düşük polariteli bileşikleri ekstrakte etmekte etkilidir. Wakte et al. (2011), %10 etanol ilavesiyle 30 MPa ve 50°C'de %1.46 kurkumin verimi rapor etmişlerdir. SFE, toksik solvent kullanımını ortadan kaldırır ve otomasyona uygundur. Ancak kurkuminin polar yapısı nedeniyle verimi sınırlıdır (Garavand et al., 2019).

İYONİK SIVILARLA EKSTRAKSİYON

İyonik sıvılar, düşük volatilite ve yüksek termal stabilite sunan "yeşil çözgenler"dir. Xu et al. (2015), [Bmim]Br ile UAE uygulayarak %6.14 kurkuminoid verimi elde etmişlerdir. Bu verim, etanol bazlı yöntemlerden daha yüksektir. İyonik sıvılar çevre dostudur, ancak maliyetleri ve geri dönüşüm zorlukları sınırlayıcıdır (Sahne et al., 2017).

EKSTRAKSİYON YÖNTEMLERİNİN KARŞILAŞTIRMASI

Geleneksel yöntemler (Sokselet, maserasyon) yüksek verim sunarken, uzun süre ve solvent tüketimi nedeniyle sürdürülemezdir. Yenilikçi yöntemler (UAE, MAE, SFE) ise hız, çevre dostuluğu ve enerji tasarrufu açısından üstündür. Ancak her yöntemin optimum koşulları ve maliyet etkinliği, uygulama amacına göre değerlendirilmelidir (Jiang et al., 2021). Tablo 4'de özetlenmiştir.

Tablo 4. Geleneksel Ve Yenilikçi Yöntemlerin Temel Parametreleri

Yöntem	Verim ve Miktar	Süre	Solvent Kullanımı (Çözelti ve Miktar)	Avantajlar	Dezavantajlar	Kaynaklar
Sokselet	%70-72	6-8 saat	Etanol veya aseton (büyük miktarda, belirtilmemiş)	Yüksek verim	Uzun süre, yüksek enerji	Shirsath et al. (2017); Jiang et al. (2021)
Maserasyon	0.26 mg/g	8-24 saat	Etanol veya metanol (orta düzey, belirtilmemiş)	Düşük maliyet	Düşük selektivite, uzun süre	Popuri & Pagala (2013); Paulucci et al. (2013)
UAE	%70-72	1 saat	Etanol (1:25 katı/çözgen oranı)	Hızlı, çevre dostu	Ekipman maliyeti	Shirsath et al. (2017); Li et al. (2014)
MAE	%4.98	4-10 dk	Etanol (düşük miktar, belirtilmemiş)	Hızlı, yüksek verim	Degradasyon riski	Mandal et al. (2008); Wakte et al. (2011)
EAE	%4.1	2-8 saat	Su + enzim (α-amilaz, glukoamilaz, düşük miktar)	Sürdürülebilir	Enzim maliyeti	Sahne et al. (2016); Kurmudle et al. (2013)
PLE/SWE	%3.8	5-20 dk	Subkritik su (organik solvent yok, düşük miktar)	Çevre dostu	Yüksek sıcaklık etkisi	Kiamahalleh et al. (2016); Osorio-Tobón et al. (2016)
SFE	%1.46	1-5 saat	Süperkritik CO_2 + %10 etanol (çok düşük miktar)	Toksik solvent yok	Düşük polarite verimi	Wakte et al. (2011); Garavand et al. (2019)
İyonik Sıvılar	%6.14	1-2 saat	[Bmim]Br (iyonik sıvı, düşük miktar)	Yüksek verim, çevre dostu	Maliyet ve geri dönüşüm zorluğu	Xu et al. (2015); Sahne et al. (2017)

GIDA KATKISI OLARAK KURKUMİN KULLANIMI

GENEL KULLANIM ALANLARI

Kurkumin, gıda endüstrisinde hem renklendirici hem de fonksiyonel katkı maddesi olarak yaygın bir şekilde kullanılmaktadır. Avrupa Birliği'nde ve Türkiye'de "E100" koduyla tanınan kurkumin, sarı-turuncu rengiyle gıdalara estetik bir görünüm kazandırırken, antioksidan özellikleri sayesinde ürünlerin raf ömrünü uzatmaya da katkıda bulunur (Jiang et al., 2021). Geleneksel olarak Hint mutfağında baharat olarak kullanılan zerdeçalın aktif bileşeni olan kurkumin, modern gıda endüstrisinde margarin, peynir, şekerleme, içecekler ve işlenmiş et ürünleri gibi geniş bir yelpazede yer alır (Amalraj et al., 2017).

Kurkuminin gıda katkısı olarak kullanımı, yalnız renklendirme ile sınırlı kalmaz. Aynı zamanda antioksidan ve antimikrobiyal etkileri nedeniyle doğal bir koruyucu olarak da rol oynar. Kurkuminin mikroemülsiyon formunun gıdalarda oksidatif bozulmayı önlediği ve çözünürlüğünü artırdığı gösterilmiştir (Amalraj et al., 2017). Bu özellikler, onu sentetik katkı maddelerine alternatif bir seçenek haline getirir ve "temiz etiket" trendine uygunluğuyla dikkat çeker (Hewlings & Kalman, 2017).

TÜRK GIDA KODEKSİ'NDEKİ HÜKÜMLER

Türkiye'de gıda katkı maddelerinin kullanımı, **Türk Gıda Kodeksi Gıda Katkı Maddeleri Yönetmeliği** ile düzenlenmektedir. 13 Ekim 2023 tarihinde Resmi Gazete'de yayımlanan yönetmelik (Sayı: 40365), Avrupa Birliği mevzuatıyla uyumlu şekilde hazırlanmış ve kurkuminin kullanımını detaylı bir şekilde ele almıştır. Yönetmeliğe göre:

- **Tanımlama ve Fonksiyon**: Kurkumin (E100), "renklendirici" kategorisinde sınıflandırılmıştır ve gıdalara renk vermek amacıyla kullanılır. Aynı zamanda antioksidan etkisi nedeniyle teknolojik bir fonksiyon da sağlayabilir.
- **Genel Kullanım İlkesi**: Yönetmeliğin 6. maddesi, gıda katkı maddelerinin "İyi Üretim Uygulamaları (GMP)" çerçevesinde, istenen teknolojik etkiyi sağlayacak en düşük miktarda kullanılması gerektiğini belirtir.
- **Saflık Kriterleri**: Kurkuminin saflığı, Ek-1'de tanımlanmış olup, en az %90 kurkuminoid içeriği (kurkumin, DMC, BDMC) gerektirir. Sentetik kurkumin yerine doğal kaynaklardan elde edilen formu tercih edilir.
- **Etiketleme Zorunluluğu**: Yönetmeliğin 9. maddesine göre, son tüketiciye sunulan ürünlerde "E100" kodu veya "kurkumin" adı açıkça belirtilmelidir. Ayrıca, "gıdada kullanım içindir" ifadesi ambalajda yer almalıdır (Türk Gıda Kodeksi, 2023).

Yönetmelik, bebek ve küçük çocuklara yönelik gıdalarda (örneğin, bebek formülleri) kurkumin kullanımını özel düzenlemelere tabi tutar ve genellikle aksi belirtilmedikçe (Madde 8, Fıkra 4) bu kategorilerde izin verilmez.

Türk Gıda Kodeksi (TGK) Gıda Katkı Maddeleri Yönetmeliği'nin Ek-2 ve Ek-3'ünde, kurkuminin (E100) hangi gıdalarda ve hangi maksimum düzeylerde kullanılabileceği listelenmiştir (Tablo 5).

Tablo 5. TGK'da izin verilen ürünler ve miktarlar (TGK, 2023)

Gıda Kategorisi	Maksimum Kullanım Limiti	Kullanım Amacı
Margarin	100 mg/kg	Renk ve stabilite
Olgunlaştırılmamış Peynir	150 mg/kg	Renklendirme
Şekerleme	300 mg/kg	Parlak sarı renk
Alkolsüz İçecekler	100 mg/L	Renk verici
İşlenmiş Et Ürünleri	20 mg/kg	Renklendirme
Reçel ve Marmelat	200 mg/kg	Renk ve antioksidan etki

Yönetmelik, "quantum satis" (gerektiği kadar) ilkesini bazı geleneksel gıdalarda (örneğin, zerdeçal bazlı baharat karışımları) uygulasa da, bu durum teknolojik gereklilikle sınırlıdır. Maksimum limitler, JECFA (Gıda Katkı Maddeleri Uzman Komitesi) ve EFSA (Avrupa Gıda Güvenliği Otoritesi) tarafından belirlenen güvenlik verilerine dayandırılmıştır. JECFA, kurkumin için ADI (Kabul Edilebilir Günlük Alım) değerini 3 mg/kg vücut ağırlığı olarak belirlemiştir. Bu, 70 kg'lık bir birey için günlük 210 mg'a denk gelmektedir (FAO/WHO, 2016).

TAKVİYE EDİCİ GIDALARDA KULLANIMI VE KISITLAMALAR

Kurkumin, takviye edici gıdalarda antioksidan ve sağlık destekleyici özellikleriyle giderek daha fazla yer bulan bir bileşiktir. Türkiye'de bu tür ürünlerin kullanımı, Tarım ve Orman Bakanlığı tarafından yayımlanan "Takviye Edici Gıdalar Kısıtlı Maddeler Listesi" ile düzenlenir. Bu belgeye göre, kurkumin "kısıtlı maddeler" arasında yer almamakla birlikte, genel güvenlik ve dozaj kurallarına tabi tutulmuştur. Kurkuminin takviye edici gıdalarda kullanımı, Türk Gıda Kodeksi Gıda Katkı Maddeleri Yönetmeliği'nde belirtilen İyi Üretim Uygulamaları (GMP) çerçevesinde olmalı ve günlük porsiyon dozajı, JECFA'nın 0-3 mg/kg vücut ağırlığı olarak belirlediği kabul edilebilir günlük alım (ADI) değerini aşmamalıdır. Ayrıca, ürün etiketlerinde "gıdada kullanım içindir" ibaresi ve dozaj bilgisi açıkça yer almalıdır (TGK, 2023). (Türk Gıda Kodeksi Gıda Katkı Maddeleri Yönetmeliği, 2023). Genellikle kapsül, tablet veya toz formunda sunulan kurkumin, biyoyararlanımını artırmak için piperin gibi bileşenlerle desteklenebilir. Ancak yüksek dozların gastrointestinal yan etkilere yol açabileceği unutulmamalıdır. Kurkumin etken maddesi için belirlenen günlük kullanım miktarları yaş gruplarına göre farklılık göstermektedir. 4-10 yaş grubu için minimum doz belirtilmemiş olup, maksimum günlük doz 20 mg olarak tanımlanmıştır. Bu bilgi 15 Ocak 2020 tarihinde yayımlanmıştır. 11 yaş üstü bireyler için ise minimum doz yine belirtilmemişken, maksimum günlük doz 600 mg olarak belirlenmiş ve bu veri 2 Mayıs 2016 tarihinde yayımlanmıştır.

KURKUMİN KULLANIMINI KISITLAYAN DURUMLAR

Kurkumin, genel olarak güvenli (GRAS) kabul edilse de, gıda katkısı olarak kullanımında bazı hassasiyetler göz önünde bulundurulmalıdır:

- **Alerjik Reaksiyonlar**: Nadir de olsa, zerdeçala veya kurkumine duyarlı bireylerde deri döküntüsü veya gastrointestinal rahatsızlıklar rapor edilmiştir (Liddle et al., 2006).
- **Demir Emilimi Üzerindeki Etkisi**: Yüksek dozlarda kurkumin, demir emilimini inhibe edebilir ve demir eksikliği riski taşıyan bireylerde (örneğin, anemik hastalar) dikkat gerektirir (Chin et al., 2014).
- **Stabilite Sorunları**: Kurkumin, ışık, ısı ve alkali pH'a karşı hassastır; bu nedenle gıda işleme süreçlerinde degradasyon riski taşıyabilir (Heger et al., 2014). Örneğin, yüksek sıcaklıkta pişirilen ürünlerde (fırın ürünleri gibi) renk kaybı veya etkinlik azalması gözlenebilir.

- **Biyoyararlanım ve Etkinlik**: Gıda ürünlerinde düşük çözünürlüğü nedeniyle kurkuminin antioksidan etkisi sınırlı kalabilir. Bu sorunu aşmak için emülsiyon veya nanoenkapsülasyon gibi teknolojiler önerilmektedir (Rafiee et al., 2019).
- **Tüketici Algısı**: Doğal bir katkı maddesi olmasına rağmen, bazı tüketiciler E kodlu maddelere karşı önyargılıdır. Bu nedenle, etiketlemede "doğal renklendirici: kurkumin" gibi ifadeler tercih edilebilir (Hewlings & Kalman, 2017).

Kurkuminin gıdalarda kullanımında, özellikle hassas gruplar (çocuklar, hamileler) için dozajların dikkatle kontrol edilmesi ve teknolojik gerekliliklerin ötesinde kullanılmaması önemlidir. Türk Gıda Kodeksi, bu hassasiyetleri dikkate alarak sıkı denetim ve etiketleme kuralları getirmiştir.

SONUÇ

Kurkumin, *Curcuma longa*'dan elde edilen doğal bir polifenol olup hem geleneksel hem de modern uygulamalarda önemli bir yer tutmaktadır. Geçmişte, Ayurveda ve Çin tıbbında terapötik bir ajan olarak kullanılan kurkumin, günümüzde antioksidan, antieinflamatuar, antikanser ve antimikrobiyal özellikleriyle dikkat çekmektedir. Kurkuminoidler, bitkinin rizomlarında %3-5 oranında bulunur. Ancak, kurkuminin fizikokimyasal özellikleri –özellikle sudaki düşük çözünürlüğü, fotodegradasyon eğilimi ve hızlı metabolik degradasyonu– biyoyararlanımını sınırlar. Zencefilden geleneksel ve modern yöntemlerle ekstrate edilebilen kurkumin, gıdalarda renklendirici olarak kullanılmaktadır. Türk Gıda Kodeksi'ne göre kurkumin (E100), margarin, peynir, şekerleme ve içecekler gibi ürünlere belirli limitler dahilinde eklenebilmektedir. Renklendirici olma yanında koruyucu özelliği de olan kurkuminin yüksek dozlarda tüketimi sağlık açısından olumsuz sonuçlar doğurabilmektedir. Toksisite açısından, 12 g/gün'e kadar ciddi yan etki rapor edilmemiş olsa da uzun vadeli güvenlik çalışmaları eksiktir. Ayrıca, kurkuminin gıda, kozmetik ve ilaç endüstrilerindeki potansiyelini tam anlamıyla realize edebilmek için ekstraksiyon verimliliğini artıran, biyoyararlanımı iyileştiren ve stabilitesini koruyan yenilikçi yaklaşımlara ihtiyaç vardır. Nanoformülasyonlar, mikroemülsiyonlar ve enzimatik modifikasyonlar bu bağlamda gelecek vaat etmektedir..

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EFFECT OF CRYOGENIC TREATMENT ON COMPRESSIVE RESISTANCE AND DENSITY CHANGE IN THERMOWOOD® POPULUS TREMULA

KRİYOJENİK İŞLEMİN THERMOWOOD® POPULUS TREMULA ODUNUNDA LİFLERE PARALEL BASINÇ DAYANIMI VE YOĞUNLUK ÜZERİNE ETKİSİ

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ÖZET

Bu çalışmada, modifiye edilmiş Titrek kavak ağacı odununda sığ kriyojenik işlemin liflere paralel basınç dayanımı ve yoğunluk değişimine etkisi araştırılmıştır. Sığ ve derin kriyojenikolmak üzere iki farkl zaman prosesinde özellikle metalik malzemelerde kullanılan ve malzemenin yapısına kullanım açısından bazı teknolojik avantajlar sağlayan bir uygulamadır. Çalışma kapsamında kriyojenik işlemin ısıl işlem görmüş ağaç malzemeye tatbiki amaçlanmıştır. Bu amaçla Titrek kavak odunları 190°C'de 1 saat (TW_1) ve 212°C'de 1 saat (TW_2) olmak üzere iki farklı sıcaklıkta ısıl işleme tabi tutulmuştur. Daha sonra kontrol numuneleri (CON) ile birlikte hazırlanan deney numuneleri Core DF 490 tipi derin dondurucuda -80 °C'de iki farklı sürede (18 saat ve 54 saat) olmak üzere olmak üzere iki farklı sürede sığ kriyojenik işleme tabi tutulmuş ve liflere paralel basınç dayanımı (σ//B) ve yoğunluk (δ) değerleri belirlenmiştir. Çalışma sonuçlarına göre en yüksek ve en düşük σ//B sırasıyla TW_1, 18 saat ve TW_2, 54 saatte 52,87 N/mm^2 ve 44,64 N/mm^2 olarak bulunmuştur. Öte yandan δ'da en yüksek ve en düşük değerler sırası ile olmak üzere 54 saat CON ve TW_2, 18 saat varyasyonlarında 0,51 g/cm^3 ve 0,43 g/cm^3 olarak bulunmuştur. Liflere paralel basınç dayanımı değerleri açısından çalışma sonuçları tatmin edici bulunmuştur. Özellikle sıcaklığın artmasıyla yoğunluğun azalmasına rağmen liflere paralel basınç dayanımının hemen hemen aynı kalması, kriyojenik işlemle elde edilecek avantajların anlaşılması açısından ayrı bir önem taşımaktadır.

Keywords: Ağaç malzeme, ısıl işlem, kriyojenik işlem, titrek kavak, liflere parallel basınç dayanımı, yoğunluk.

ABSTRACT

In this study, the effect of shallow cryogenic treatment on compressive strength parallel to the fibers and density changes in modified aspen wood was investigated. It is an application that is used especially in metallic materials in two different time processes as shallow and deep cryogenic and provides some technological advantages in terms of usage in terms of the structure of the material. The aim of the study was to apply the cryogenic treatment to heat-treated wood material. For this purpose, aspen woods were subjected to heat treatment at two different temperatures as 190°C for 1 hour (TW_1) and 212°C for 1 hour (TW_2). Then, the experimental samples prepared together with the control samples (CON) were subjected to shallow cryogenic treatment in a Core DF 490 type deep freezer at -80 °C for two different periods (18 hours and 54 hours) and the compressive strength parallel to the fibers (σ//B) and density (δ) values were determined. According to the study results, the highest and lowest σ//B were found as 52.87 N/mm^2 and 44.64 N/mm^2 at TW_1, 18 hours and TW_2, 54 hours,

respectively. On the other hand, the highest and lowest values of δ were found as 0.51 g/cm^3 and 0.43 g/cm^3 at 54 hours CON and TW_2, 18 hours variations, respectively. The study results were found to be satisfactory in terms of compressive strength values parallel to the fibers. Especially, the fact that the compressive strength parallel to the fibers remained almost the same despite the decrease in density with the increase in temperature is of particular importance in terms of understanding the advantages to be obtained with the cryogenic process.

Keywords: Wood material, Heat treatment, Cryogenic treatment, Populus tremula, Compressive resistance parallel to fibers, density.

INTRODUCTION

Ağaç malzeme organik, higroskopik ve anizotropik bir malzeme olarak hem fiziksel hem de mekanik özellikleri bakımından kullanıma oldukça uygundur. Alternatif sayılabilecek bir çok malzeme ile neredeyse imkansız olan bir çok yapıyı sadece ahşap ürünler kullanarak inşa etmek mümkündür (Anonim 2025-1). Ancak kullanım yeri şartları ağaç malzeme kullanımını, onun doğal yapısından kaynaklanan bazı olumsuz özellikleri (boyutsal değişim, biyodegredasyon ve renk değişikliği gibi) nedeni ile çoğu zaman kısıtlanabilmektedir (Aytin 2013). Böyle olmasına rağmen ağaç malzemenin yenilenebilir kaynak olması, geleneksel ve enerji yoğun inşaat malzemelerine göre daha az enerji kullanması ve yaşam döngüleri boyunca daha az sera gazı ve kirletici madde yayması, ve sonuçta yapısal olarak ahşabın kullanılmasında çoğu binanın karbon ayak izinin azaltılması nedeni ile çekiciliğini artırmaktadır (Anonim 2025-2). Ağaç malzemeye çeşitli teknik ve araçlarla yapılan, çevre ve insan dostu işlemler ile yapısal özelliklerinin kullanım yerleri için iyileştirilmesi de bu durumu desteklemektedir. Esas amaçları odunun mekanik direnç özelliklerini iyileştirmekten ziyade odun-su etkileşimini azaltmaya yönelik geliştirilen çeşitli modifikasyon yöntemleri bu kapsamda akla gelen uygulamaların başında gelmektedir (Yıldız 2005).

Genel olarak modifikasyon herhangi bir materyalde fiziksel ve/veya kimyasal sınırlı değişimlerin meydana geldiği değişiklikler şeklinde tanımlanmakta, böylece modifikasyon ile malzemelerin fonksiyonel özelliklerinde iyileşme olmaktadır (Karahan ve ark. 2007). Ağaç malzeme için modifikasyon denilince kimyasal, fiziksel, termal ve enzimatik modifikasyon şeklinde başlıca dört farklı şekilde uygulanan işlemden bahsetmek mümkün bulunmaktadır. Bu uygulamalarda etkinlik çeşitli parametrelere bağlı olup, her bir modifikasyon yönteminde etkinliği reaksiyon sıcaklığı, zaman, pH ve katalizör gibi reaksiyon parametrelerinin uygunluğu ile odun türlerinin özelliklerine bağlı olarak değişmektedir. Ağaçların heterojen yapıda olması da modifikasyonun etkinliğini değiştirebilmektedir (Tomak ve Yıldız, 2010).

Herhangi bir malzeme üzerinde yapılan modifikasyon ve benzeri işlemlerin özellikle artı değer üretmesi önemli olup, ağaç malzemenin ticari olarak değer artışının sağlanması başlıca hedefler arasında gelmektedir. Günümüzde ağaç malzeme modifikasyon işlemleri analiz edildiğinde en fazla ticarileşme potansiyeline sahip olan uygulamanın termal bir modifikasyon yöntemi olan ThermoWood® olduğu görülmektedir. ThermoWood® ağaç malzeme endüstrisinde önemli yeri bulunan termal bir modifikasyon uygulamasıdır. Termal modifikasyon özellikle 20. yüzyılın son çeyreğinde yapılan çalışmaların sonucunda ortaya çıkmış; Finlandiya, Fransa, Almanya ve Hollanda'da önemli çalışmalara imza atılmış ve birçok termal modifikasyon yöntemi (Plato-Hollanda, Retification ve Les Bois Perdure-Fransa, yağla ısıl muamele-Almanya, ThermoWood®-Finlandiya) geliştirilmiştir. Bu yöntemler içerisinde önemli ölçüde ticarileşebilen ThermoWood®, ağaç malzemenin 180°C ve üzerindeki sıcaklıklarda su buharının koruması altında ısıtılması esasına dayanmaktadır. Bu işlem sonucunda daha ziyade fiziksel özelliklerinde olumlu yönde değişime uğramış çevre dostu bir ağaç malzeme elde edilmiş olur. Bununla birlikte özellikle mekanik direnç değerlerinde meydana gelebilecek düşüşlerin boyutu çoğunlukla bu tür malzemelerin kullaımını kısıtlayabilmektedir (Aydemir ve Gündüz, 2009).

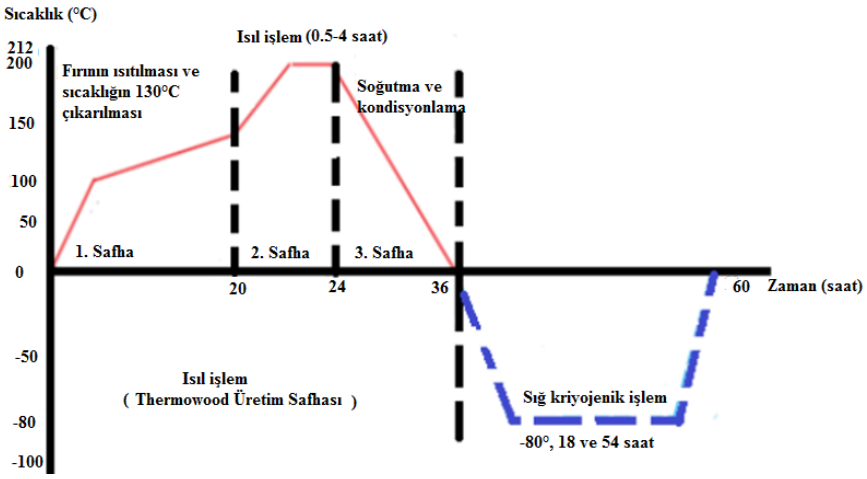
Kriyojenik işlem günümüzde çoğunlukla metalik malzemelere uygulanmakta ve özellikle takım çeliklerinin sertlik ve aşınma direnci değerlerinde önemli sayılabilecek iyileşmelere sebep olabilmektedir (Arslan ve ark. 2013). Kriyojenik işlem sıcaklıkları -80°C sıcaklıktan başlayarak 200°C sıcaklıklara kadar uygulanmakta, pratikte sığ ve derin kriyojenik işlem olmak üzere iki bölüme ayrılmaktadır (Arslan ve ark. 2017).

Bu çalışmada ThermoWood® ile termal modifikasyon uygulanmış Titrek kavak odunu sıfır altı sıcaklıklarda farklı sürelerde sığ kriyojenik işleme tabi tutularak liflere paralel basınç dayanımı ve yoğunluk değişimi belirlenmiştir. Çalışma kapsamında iki farklı sıcaklıkta ThermoWood® ile termal modifikasyon uygulanmış Titrek kavak odunu örneklerine kontrol örnekleri ile birlikte olmak üzere -80° sıcaklık ve 18 ile 54 saat sürelerde sığ kriyojenik işlem uygulandıktan sonra liflere paralel basınç direnci ve yoğunluk değerleri araştırılmıştır. Çalışmanın kriyojenik işlemin ağaç malzeme üzerinde uygulanabilirliği ve sağlayabilecek olduğu katkılar bakımından önemli faydalar sağlayacağı beklenmektedir.

MATERYAL ve METHOD

Çalışmada kullanılan Titrek kavak (*Populus tremula*) ağaçları Türkiye doğal olarak yetişmekte olan bir ağaç türü olup, çalışma ağaçları Bolu Orman Bölge Müdürlüğü Düzce Orman İşletme Müdürlüğü'ne bağlı orman alanından doğal yetişme ortamı meşçeresinden TS 4176 (1984) esas alınarak seçilmiştir.

Daha sonra Titrek kavak tomruklarından hazırlanan kalaslardan özel olarak boyutlandırılan 26 x 100 x 600 (kalınlık x genişlik x uzunluk) mm ölçülerindeki taslaklar Novawood Orman Ürünleri Fabrikasında (Gerede/Bolu) ThermoWood® ile 190 ve 212° sıcaklık ve 1 saat süre ısıl işleme tabi tutulmuş ve ThermoWood® paneller hazırlanmıştır ((TS CEN/TS 15679, (2010). Ardından ThermoWood® paneller 20 x 20 x 30 (kalınlık x genişlik x uzunluk) mm ölçülerinde 30 mm boyuna yönde olacak hazırlanmış ve iklimlendirme ortamında %65±5 bağıl nem 20±°C sıcaklıkta bekletildikten sonra 611 litre kapasiteli ve 1°C hassasiyetle soğutma yapabilen Core DF 490 derin dondurucuda sığ kriyojenik işleme tabi tutulmuşlardır. Core DF 490 derin dondurcu -86°C sıcaklığa kadar soğutma yapabilme özelliğinde olup, örnekler derin dondurucuda sığ kriyojenik işlemin hassasiyetle gerçekleşebilmesi için işlem süreci başlamadan önce yaklaşık 12 saat -80° sıcaklıkta ön soğutmada bekletilmişlerdir. Daha sonra sığ kriyojenik işlem safhası başlamış ve örnekler 18 ile 54 saat süre ile -80°C sıcaklıkta işlem tamamlanmıştır. Çalışmanın işlem süreci Şekil 1'de verilmiştir



Şekil 1. İşlem süreci (Isıl işlem + sığ kriyojenik işlem)

İşlem süreci sonunda oluşturulan örnek deneme deseni Çizelge 1'de verilmiştir.

Çizelge 1. Çalışma örnekleri deneme deseni verileri

Varyasyonlar	**Kısaltma**	**Sığ kriyojenik işlem**		**Kısaltma**
		Örnek	**Süre (saat)**	
Kontrol	CON	10	18	CON_{18}
		10	54	CON_{54}
190°C 1 saat	TW_1	10	18	$TW_{1,18}$
		10	54	$TW_{1,54}$
212°C 1 Saat	TW_2	10	18	$TW_{2,18}$
		10	54	$TW_{2,54}$

Çalışma örneklerinin yoğunluklarının (δ) belirlenmesinde TS ISO 13061-2 (2021), iflere paralel basınç dayanımının (σ//B) belirlenmesinde ise TS 2595 (1977) standartlarına göre hareket edilmiştir.

Daha sonra elde edilen veriler SPSS Uygulamalı Çok değişkenli İstatistik Teknikleri ile analiz edilmiş ve Duncan testi uygulanarak varyasyonlar arasındaki farklılıklar belirlenmiştir.

BULGULAR

Liflere paralel basınç direnci ve yoğunluk değişimine ait basit varyans analizi sonuçları Çizelge 2'de verilmiştir.

Çizelge 2. Liflere paralel basınç direnci ve yoğunluk değişimine ait basit varyans analizi sonuçları.

		Kareler toplamı	**df**	**Kareler ortalaması**	**F**	**Önem**
σ//B	Gruplar	350.59	2	165.29	6.15	0.05
	Gruplar	684.79	27	25.36		
	Toplam	1015.39	29			
δ	Gruplar	0.024	2	0.012	5.49	0.010
	Gruplar	0.059	27	0.002		
	Toplam	0.083	29			

Varyas analizi sonuçlarına göre hem σ//B , hem de δ değerlerinin arasında istatistiksel olraak $P \leq 0.05$düzeyinde anlamlı farklılıkların olduğu anlaşılmıştır. Farklılıkların hangi varyasyonlar arasında olduğunu belirlemek için yapılan istatistiki hesaplamalara ait veriler ve Duncan testi sonuçları Çizelge 3'de verilmiştir.

Çizelge 3. Liflere paralel basınç dayanımı ve δ'a ilişkin istatistiki veriler ve Duncan testi sonuçları.

Özellik	Varyasyon	Örnek Sayısı	Ortalama	Homojenlik grubu	Standart sapma	Standart hata	En yüksek değer	En düşük değer
$\sigma_{//B}$	CON_{18}	10	45.06	C	3.83	1.21	52.7	40.2
	CON_{54}	10	44.64	C	6.13	1.93	64.26	44.01
	$TW_{1,18}$	10	52.86	**A**	4.88	1.54	55.19	36.52
	$TW_{1,54}$	10	50.11	AB	6.13	1.94	64.26	44.01
	$TW_{2,18}$	10	46.97	CB	4.88	1.54	55.19	36.52
	$TW_{2,54}$	10	44.88	C	6.04	1.91	54.01	36.56
	Total	60	50.11		4.63	1.46	56.87	44.50
δ	CON_{18}	10	0.49	A	3.65	1.15	51.68	40.08
	CON_{54}	10	0.50	A	5.67	0.73	64.26	36.52
	$TW_{1,18}$	10	0.47	BA	0.07	0.02	0.67	0.44
	$TW_{1,54}$	10	0.47	BA	0.03	0.01	0.54	0.45
	$TW_{2,18}$	10	0.43	**C**	0.03	0.01	0.50	0.40
	$TW_{2,54}$	10	0.44	CB	0.06	0.02	0.59	0.39
	Total	60	0.47		0.03	0.01	0.54	0.44

Çizelge 3'e göre en yüksek σ//B değeri TW1,18 varyasyonunda 52.86 N/mm2 ve en düşük CON54 varyasyonunda 44.64 N/mm2 olarak belirlenmiştir. Sonuçlara göre sığ kriyojenik işlem süresi uzadıkça σ//B değerinin azaldığı görülmeltedir. Aynı şekilde ısıl işlem sıcaklığının artışına bağlı olarak σ//B değerinin azaldığı anlaşılmaktadır. Elde edilen sonuçlar mevcut literatür ile uyumluluk göstermektedir. Literatürde -145°C'ta kriyojenik işlem yapılmış Titrek kavak odununda elde edilen sonuçlarda 190°C ve 2 saat süreli ısıl işlem sonucunda 57.42 N/mm2 σ//B değeri edilmiş olup, ilgi çalışmada sıfır altı sıcaklık nitrojen gazı ortamında 24 saatlik sürede elde edilmiştir (Aytin 2016). Bir başka çalışmada çalışmada Titrek kavak örneklerinde sırası ile ısıl işlem görmemiş, TW_1 ve TW_2 varyasyonlarında olmak üzere σ//B değeri 45.42, 47.95 ve 53.31 N/mm^2 olduğu belirlenmiştir (Aytin ve ark. 2022).

Çizelge 3'e göre en yüksek ve en düşük yoğunluk değerleri sırası ile CON_{54} ve $TW_{2,18}$'de olmak üzere 0.50 ve 0.43 gr/cm^3 olarak belirlenmiştir. Kriyojenik işlem yoğuluk değerlerini, kriyojenik işlem görmemiş Tirek kavak örneklerine göre artırmış olduğu görülmektedir. Titrek kavak örnekleri ile yapılan bir çalışmada kotrol örnekleri ile sadece ısıl işlem görmüş örneklerin (TW_1 ve TW_2) yoğunluk değerleri sırası ile olmak üzere 0.44, 0.42 ve 0.39 gr/cm^3 olarak bulunmuştur (Aytin ve ark. 2022).

SONUÇLAR

Çalışma sonuçlarına belli bir ısıl işlem sıcaklığında sığ kriyojenik işlem uygulayarak kontrol örneklerine göre daha yüksek liflere paralel basınç dayanımı elde etmek mümkündür. Çalışmada 52.86 N/mm^2 ile en yüksek σ//B değerinin görüldüğü $TW_{1,18}$ varyasyonda ile en düşük değerin 44.64 N/mm^2 ile görüldüğü CON_{54} varyasyonuna göre % 18.41 artış meydana gelmiştir. Öte yandan aynı varyasyon içinde sığ kriyojenik işlem süresi uzadıkça σ//B değerinin azaldığı görülmektedir. Aynı zamanda ısl işlem sıcaklığı arttıkça da σ//B değerinin azaldığı görülmektedir.

Sığ kriyojenik işlem ile birlikte Titrek kavak odununda yoğunluk değerleri artmış olduğu görülmektedir. Bu farklılığın kalıcı mı yoksa geçici mi olduğun konusunda çalışmaların yapılması, sığı kriyojenik işlemin yoğunluk değişimi mekanizması üzerine etkisini izah etmek

için önemli bulunmaktadır. Bununla birlikte yoğunluktaki artışın oldukça büyük ve önemsenecek boyutta olması da oldukça dikkat çekicidir. Sonuçların ısıl işlem görmüş Titrek kavak odununun değerlendirilmesinde yeni fırsatların ortaya çıkmasına yardımcı olabileceği düşünülmektedir.

Gerek liflere paralel basınç dayanımı gerek ise yoğunluk değerlerindeki değişimlerin kalıcılığı ve doğruluğunun daha çok malzeme üzerinde test edilmesi önemli bulunmaktadır. Kriyojenik işlemin ağaç malzeme sektöründe bilimsel çalışmalar bağlamında henüz yeni olması ve sınırlı sayıda malzeme üzerinde çalışma yapılması, gelecek çalışmalarda diğer ağaç türlerinin de kriyojenik çalışma kapsamına alınması gereksinimini doğurmaktadır. Literatür özetinde de görülecek olduğu üzere sığ ve derin kriyojenik işlem ile elde edilen sonuçların aynı yönlü ama büyüklük olarak farklılık arz etmesi konuyu daha da cazip hale getirmektedir.

Bu kapsamda sonraki adımlarda diğer ağaç türlerinin ısıl işlemdem sonra farklı sürelerde ve sıcaklıklarda kriyojenik işlemi, kriyojenik işlemden sonra da ağaç malzemenin fiziksel, mekanik ve kimyasal özellikleri üzerinde çalışm yapılması planlanmaktadır.

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A RARE CAUSE OF CORONARY ISCHEMIA: CORONARY SUBCLAVIAN STEAL SYNDROME

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Abstract

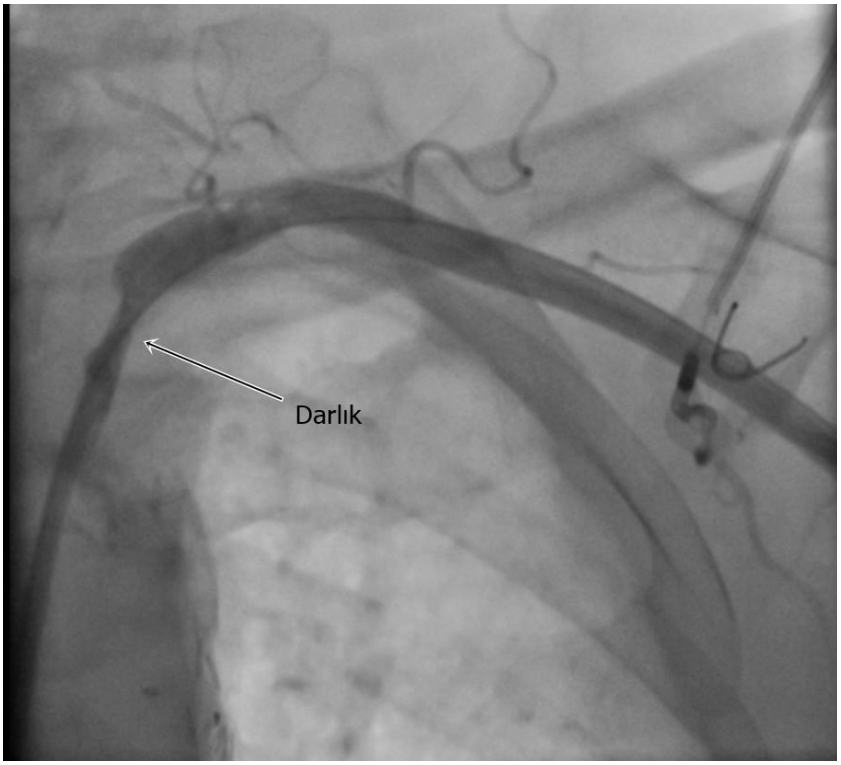
Introduction:Subclavian steal syndrome occurs due to stenosis or occlusion of the subclavian artery before the vertebral artery, leading to reversed blood flow. This report presents a rare case of coronary subclavian steal syndrome causing angina.

Object: A 56-year-old male with a history of coronary artery bypass grafting (CABG) presented with chest pain. His risk factors included hypertension, smoking, and diabetes. Physical examination revealed a blood pressure difference between the arms (140/80 mmHg in the right, 110/70 mmHg in the left). Electrocardiography was normal, and echocardiography showed an ejection fraction of 60% without segmental wall motion abnormalities. Elevated troponin levels led to a diagnosis of non-ST elevation myocardial infarction, and the patient was admitted to the coronary intensive care unit.

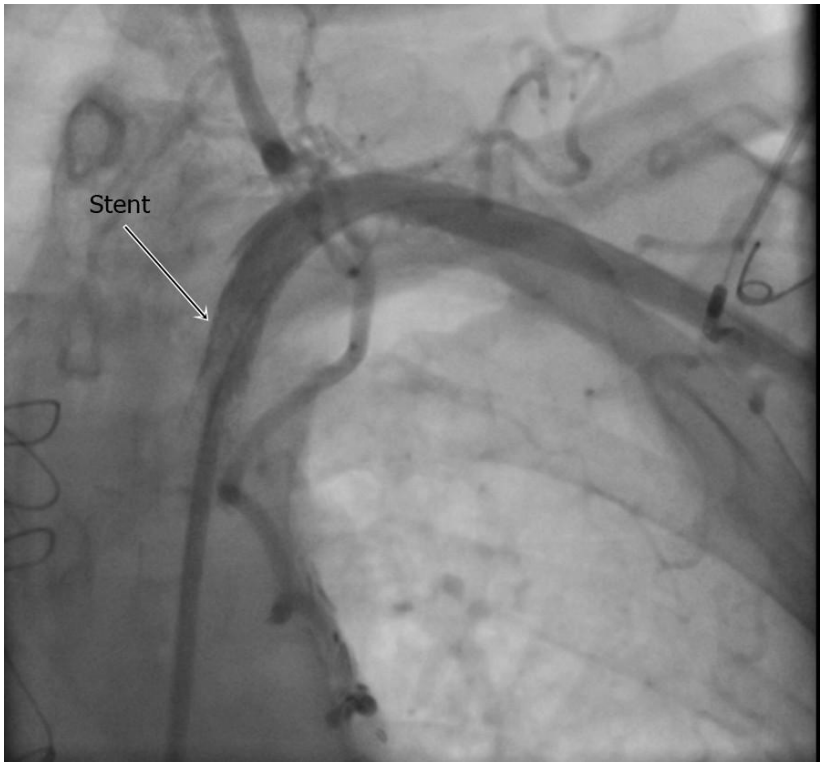
Coronary angiography showed retrograde flow in the left internal mammary artery (LIMA) to the left anterior descending artery (LAD) due to critical stenosis(Picture-1) in the proximal subclavian artery. A balloon angioplasty and stent placement successfully restored full patency (Picture-2). The patient's chest pain and exertional angina resolved after the procedure.

Discussion: Subclavian steal syndrome occurs in 0.2%–6.8% of CABG patients. It may cause arm and chest pain, dizziness, ataxia, visual disturbances, or weakness. A blood pressure difference of >20 mmHg between the arms may be the only sign. This condition should be considered in patients with unexplained chest or arm pain.

Keywords: Subclavian stenosis, myocardial infarction, coronary artery disease.



Picture-1: Subclavian stenosis-before stent



Picture-2: Subclavian stenosis-after stent

WHAT IS THE IMPACT OF ORTHOREXIA NERVOSA AND EATING ATTITUDES ON SOCIAL APPEARANCE ANXIETY IN YOUTH

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Abstract

Purpose: The aim of this study is to examine the relationship between orthorexia nervosa levels, eating attitudes, and social appearance anxiety among students studying at the Faculty of Sport Sciences in light of sociodemographic variables.

Methods: This cross-sectional and descriptive study was conducted with 833 students. Data were collected using a data collection form designed as an e-survey by the researchers, the ORTO-15 Scale, the Eating Attitudes Test, and the Social Appearance Anxiety Scale. Categorical measurements were presented as numbers and percentages, while continuous measurements were expressed as mean and standard deviation (with median and minimum-maximum values where necessary). For the analysis of two-group comparisons, an independent Student's t-test was used, while one-way ANOVA was applied for comparisons involving more than two groups. Post-hoc Bonferroni tests were performed as needed. The relationships between the scales were examined using Pearson correlation analysis.

Results: Of the participants, 53.2% were male, and 46.8% were female. While 96.2% of the participants did not follow a consistent diet, 3.8% reported adhering to a regular diet. The mean ORTO-15 Scale score was found to be 37.6±4.3, the mean Social Appearance Anxiety Scale (SAAS) score was 43.6±5.0, and the mean Eating Attitudes Test (EAT) score was 28.1±6.9. It was observed that 155 participants (18.6%) exhibited orthorexic tendencies. The Eating Attitudes Test indicated that 410 participants (49.2%) were at moderate risk, 299 (35.9%) were at high risk, and 124 (14.9%) were at low risk. When comparing scale scores by gender, the mean ORTO-15 score was 37.6±4.2 for males and 37.5±4.5 for females. The mean SAAS score was 43.5±5.0 for males and 43.6±5.0 for females. The mean EAT score was 28.3±7.1 for males and 27.9±6.8 for females. A weak negative correlation was observed between ORTO-15 and SAAS scores ($r=-0.096$; $p=0.006$). No significant relationships were found between other scale scores, as presented in Table 5 ($p>0.05$).

Conclusion: To prevent behavioral disorders such as orthorexia nervosa, it is crucial to expand psychological counseling services for students and increase awareness on this subject.

Keywords: Orthorexia Nervosa, Eating Attitudes, Social Appearance Anxiety,

Introduction

The term Orthorexia Nervosa (ON) originates from the Greek words "orthos" and "orexia," first introduced by Bratman and Knight in 1997 [1,2]. The word "orthos" means "correct" or "valid,"

while "orexis" translates to "hunger" or "appetite." Combining these terms, orthorexia nervosa refers to an "obsession with healthy and correct eating." It emphasizes a pathological focus on the consumption of appropriate and healthy foods. Over time, behaviors that may initially seem harmless, such as preventing chronic diseases, avoiding excessive consumption of fats, sugars, and sweeteners, and refraining from consuming foods with chemical additives, can potentially evolve into obsessions. These behaviors may lead individuals to develop an unhealthy fixation [3]. Although Orthorexia Nervosa (ON) is a relatively new term, it has gained increasing attention in recent years. ON is defined as an obsession with healthy eating, which may indicate the potential presence of a new type of eating disorder. It is characterized by an excessive focus on food quality, preparation, and nutritional content [4].

Individuals with orthorexia nervosa meticulously control every aspect of the food they consume. They exhibit an obsession with ensuring that the food is biologically pure, free from chemicals or artificial ingredients, and is both healthy and appropriate. Their focus tends to shift from portion size to the nutritional content of the food [5]. People exhibiting ON symptoms avoid consuming artificial products such as preservatives, genetically modified foods, color additives, food flavorings, pesticides, herbicides, and foods with excessive fat, sugar, or salt [6].

Individuals with orthorexia nervosa often prefer foods produced using organic methods. Additionally, they conduct extensive research on various aspects, such as the content of food packaging, the presence of substances that extend shelf life, the ingredients on product labels, the materials used in food preparation, and the impact of preparation techniques on nutritional values. They also investigate whether hormones were administered to the animals producing dairy products [2,7].

Maintaining a good physical appearance is generally a priority for individuals. In social settings, paying attention to physical appearance has become important to stay in the spotlight. The media often promotes specific physical standards for both men and women. Women are typically portrayed as attractive when thin, while men are depicted as appealing when muscular and well-built. Young adolescents, in particular, are driven by the desire to attain these idealized physical appearances. Individuals tend to compare their bodies to these societal standards and may strive to align themselves with these ideals, whether through positive or negative internal motivation [8]. Social appearance anxiety refers to the emotional reactions individuals experience when they feel their physical appearance is being evaluated by others [9].

Having a negative perception of one's own body can lead individuals to feel less attractive compared to others, experience discomfort with their body, or even feel ashamed. Such concerns about their physical appearance may cause individuals to avoid social settings or become excessively preoccupied with the body part(s) they perceive as flawed. Appearance anxiety and body image not only influence self-esteem but also affect eating attitudes and behaviors, sexual behaviors, social relationships, emotional states, and levels of social phobia [10].

Eating attitude is a concept that refers to individuals' eating habits, emotional and behavioral attitudes toward food, and thoughts related to eating. It encompasses behaviors toward eating, the way individuals select their foods, their eating patterns, and their feelings about food. Eating attitudes can be influenced by numerous factors, including cultural norms, personal beliefs, psychological states, family habits, and environmental factors.

An attitude is a combination of evaluations, thoughts, and emotions that an individual develops toward a particular object, person, situation, or event. It guides a person to exhibit either a positive or negative approach toward the object or situation in question. In psychological literature, attitude is defined as a tendency that shapes an individual's emotions, thoughts, and behaviors.

Among the primary factors influencing eating attitudes are gender and age. Young women, in particular, are reported to be more sensitive to body image and aesthetics compared to men. Other factors affecting eating attitudes include body mass index (BMI) and body dissatisfaction [11].

The aim of this study is to examine the relationship between the levels of orthorexia nervosa, eating attitudes, and social appearance anxiety among students at the Faculty of Sports Sciences in light of sociodemographic variables.

MATERIAL AND METHODS

The research was conducted as cross-sectional and descriptive.

The universe of the study consists of students studying at the Faculty of Sport Sciences of a State University in the 2021-2022 Academic Year. It was planned to reach the entire universe without selecting a sample in the study. The data were collected with students who volunteered to participate in the study. The study was completed with a total of 833 students. Before data collection, ethics committee approval was obtained with permission dated 20.04.2022 and numbered 32/37. In addition, institutional permission was obtained from the school administration and verbal informed consent was obtained from the students.

Data collection tools

Data were obtained using the e-survey data collection form (16 questions), ORTO-15 scale (15), Eating Attitudes Test (EAT-40) and Social Appearance Anxiety Scale (16) developed by the researchers. The socio-demographic data form includes 12 questions to determine the individual characteristics of the participants, 4 questions regarding dieting status and physical appearance attitude, totaling 16 questions.

ORTO-15 Scale: The ORTO-15 scale is a 15-item Likert-type questionnaire developed by Donini et al. in 2005, based on the questionnaire created by Bratman and Knight (2000) to assess tendencies toward orthorexia nervosa [12,13]. The Turkish version of the scale was prepared by Bağcı Bosi et al., and the validity and reliability study was conducted by Arusoğlu et al. (2008) [14,15]. The scale uses a 4-point Likert-type format, where individuals are asked to indicate how frequently they feel the way described in each statement, with the options “always,” “frequently,” “sometimes,” and “never.” The scale has a total score range of 15 to 60 points. Individuals scoring 33 points or below are classified as "orthorexic" according to the ORTO-15 scale [14].

Eating Attitudes Test (EAT-40): Developed by Garner and Garfinkel in 1979, the Turkish validity and reliability study was conducted by Savaşır and Erol in 1989 [16,17]. The test consists of 40 questions, with responses evaluated on a six-point Likert scale: always, very often, often, sometimes, rarely, and never. The cutoff score for the EAT-40 is 30 points.

Social Appearance Anxiety Scale (SAAS): Developed by Hart et al. in 2008, the SAAS was created to measure individuals' levels of social appearance anxiety[18]. The Turkish validity and reliability study was conducted by Doğan in 2010. The scale consists of 16 items and uses a 5-point Likert scale with responses ranging from 1 (not appropriate at all) to 5 (completely appropriate). The first item is reverse-coded, and higher scores on the scale indicate a higher level of social appearance anxiety [19].

Statistical Analysis

The statistical analysis of the data was conducted using the SPSS (Statistical Package for the Social Sciences) version 23.0 software. Categorical variables were summarized as frequencies and percentages, while continuous variables were summarized as means and standard deviations (with median and minimum-maximum values provided where necessary). To

determine whether the parameters in the study followed a normal distribution, the skewness and kurtosis values of the scale scores were examined. For normally distributed parameters, independent t-tests were used for binary group comparisons, and One-Way ANOVA was used for comparisons involving more than two groups. In cases with more than two groups, the Bonferroni test was applied to identify the source of differences between groups. Pearson correlation tests were used to assess relationships between the scales. A significance level of 0.05 was applied for all tests.

Results

The sociodemographic characteristics of the participants are shown in Table 1. Among the participants, 53.2% are male and 46.8% are female. While 96.2% of the participants do not follow a regular diet, 3.8% report following a regular diet. Additionally, 2.3% of the participants have a diagnosed medical condition and use medication. Furthermore, 48.3% of the participants reported being dissatisfied with their physical appearance.

Table 2 shows the results of the Skewness and Kurtosis tests to assess whether the scale scores followed a normal distribution. According to George and Mallery (2010), the skewness and kurtosis values should fall between +2 and -2. The skewness and kurtosis values obtained in our study align with the findings of George and Mallery's research [20]. In this context, it was determined that the scale scores used in the study exhibited a normal distribution (Table 2).

Table 1. Sociodemographic Characteristics of the Participants

Category	**Number (n)**	**Percentage (%)**
Gender		
Male	443	53.2%
Female	390	46.8%
Where do you currently live?		
With family	249	29.9%
Other	67	8.0%
At home	266	31.9%
Dormitory	251	30.1%
Family Income Level		
Very poor	32	3.8%
Poor	74	8.9%
Medium	302	36.3%
Good	282	33.9%
Very good	143	17.2%
Your Department		
Coaching	395	47.4%
Physical Education	238	28.6%
Sports Management	200	24.0%
What year are you in?		
1st year	194	23.3%
2nd year	217	26.1%
3rd year	215	25.8%
4th year	207	24.8%
Your mother's education level		
Primary school	220	26.4%
Secondary school	206	24.7%

Category	Number (n)	Percentage (%)
High school	277	33.3%
Associate degree	62	7.4%
Bachelor's and higher	68	8.2%
Your father's education level		
Primary school	200	24.0%
Secondary school	210	25.2%
High school	223	26.8%
Bachelor's degree	200	24.0%
Do you follow a specific diet?		
Yes	32	3.8%
No	801	96.2%
Do you have a diagnosed medical condition by a doctor?		
Yes	19	2.3%
No	814	97.7%
Are you undergoing regular medication treatment?		
Yes	19	2.3%
No	814	97.7%
Are you satisfied with your physical appearance?		
Yes	431	51.7%
No	402	48.3%
Height (Mean ± SD)	174.7±9.1	175 (160-190)
Weight (Mean ± SD)	70.6±12.1	71 (50-90)
Desired weight (Mean ± SD)	70.0±6.1	70 (60-80)

Table 2. Distribution of Participants' Scale Scores

Scale	Mean ± SD	(Median, Min-Max)	Skewness	Kurtosis
Orto15 Scale	37.6±4.3	38 (25-49)	-0.012	-0.316
Social Appearance Anxiety Scale	43.6±5.0	44 (28-59)	-0.198	-0.036
Eating Attitude Test Scale	28.1±6.9	28 (10-52)	0.358	0.038

Table 3 shows the categorical distribution of Orthorexia Nervosa and Eating Attitudes Test scores. It was observed that 155 (18.6%) of the participants were orthoectic. 410 (49.2%) of the EAT participants were found to be at medium risk, 299 (35.9%) at high risk, and 124 (14.9%) at low risk (Table 3).

Table 3. Categorical distributions of Orthorexia Nervosa and Eating Attitudes Test scores

Category	Number (n)	Percentage (%)
Orthorexia		
33 points or below (Orthorexic)	155	18.6%
Above 33 points (Normal)	678	81.4%
Eating Attitude Test (EAT)		
Low risk (<21)	124	14.9%
Moderate risk (21-30)	410	49.2%
High risk (>30)	299	35.9%

The comparison of the mean scale scores with the independent variables is shown in Table 4. A significant difference was found between the mean Social Appearance Anxiety score and the variable of where the participants currently live (p=0.044). When the source of the difference was examined with the Post Hoc Tukey test, it was determined that the Social Appearance Anxiety scale scores of those living with their families were higher than those who chose the other option (p=0.028).

Participants who answered yes to the question of whether they have a disease diagnosed by a doctor and whether they are taking regular medication had lower Social Appearance Anxiety scale mean scores, which was found to be statistically significant (p=0.019; p=0.017, respectively).

It was determined that there was a significant difference between the family income level and the Eating Attitudes Test scale score (p=0.003). When the source of the difference was examined with the Post Hoc Tukey test, it was determined that the Eating Attitudes Test scale score average in those with a very high family income level was lower than in other income level groups (p<0.05).

No significant difference was found between the scale scores and the other variables in Table 4 (p>0.05).

Table 4. Comparison of mean scale scores with independent variables

Category	**n**	**Orto15 Mean ± SD**	**Social Appearance Anxiety Scale (SAAS) Mean ± SD**	**Eating Attitude Test (EAT) Mean ± SD**
Gender				
Male	443	37.6 ± 4.2	43.5 ± 5.0	28.3 ± 7.1
Female	390	37.5 ± 4.5	43.6 ± 5.0	27.9 ± 6.8
t		0.283	-0,325	0,908
p		0.777	0,745	0,364
Where do you currently live?				
With family	249	37.5 ± 4.5	44.1 ± 4.9[a]	28.7 ± 6.9
Other	67	37.8 ± 4.8	42.4 ± 5.2[b]	28.1 ± 7.9
At home	266	37.4 ± 4.1	43.7 ± 4.9	27.8 ± 6.9
Dormitory	251	37.8 ± 4.2	43.2 ± 5.2	27.8 ± 6.9
f		0,606	2,711	0,949
p		0,611	0,044*	0,416
Family Income Level				
Low income level [+]	106	37.8 ± 4.3	43.3 ± 4.9	28.5 ± 7.3
Medium	302	37.6 ± 4.3	43.7 ± 5.0	28.7 ± 7.2
Good	282	37.5 ± 4.2	43.5 ± 5.1	28.3 ± 6.8
Very good	143	37.4 ± 4.5	43.8 ± 4.9	26.2 ± 6.2
f		0,186	0,303	4,676
p		0,906	0,823	0,003**
Your Department				
Coaching	395	37.6 ± 4.3	43.3 ± 5.1	28.3 ± 7.1
Physical Education	238	37.3 ± 4.4	43.7 ± 5.1	27.7 ± 7.3
Sports Management	200	37.8 ± 4.2	43.9 ± 4.9	28.3 ± 6.3
f		0,758	0,888	0,567
p		0,469	0,412	0,568
What year are you in?				

Category	n	Orto15 Mean ± SD	Social Appearance Anxiety Scale (SAAS) Mean ± SD	Eating Attitude Test (EAT) Mean ± SD
1st year	194	37.5 ± 3.9	43.8 ± 4.9	27.6 ± 6.6
2nd year	217	37.6 ± 4.3	43.3 ± 4.7	28.8 ± 7.2
3rd year	215	37.9 ± 4.5	44.2 ± 4.9	28.1 ± 7.3
4th year	207	37.2 ± 4.4	43.0 ± 5.6	27.9 ± 6.7
F		1,043	2,262	1,272
p		0,373	0,080	0,283
Mother's Education Level				
Primary school	220	37.7 ± 4.3	43.3 ± 4.9	28.7 ± 6.9
Secondary school	206	37.4 ± 4.6	43.6 ± 5.4	28.0 ± 7.6
High school	277	37.6 ± 4.3	43.8 ± 5.0	28.1 ± 6.6
Associate degree	62	37.5 ± 4.2	43.7 ± 5.1	27.1 ± 8.1
Bachelor's and higher	68	37.9 ± 3.9	43.4 ± 3.9	27.7 ± 5.5
f		0,325	0,351	0,757
p		0,862	0,844	0,553
Father's Education Level				
Primary school	200	37.9 ± 4.3	43.4 ± 5.2	28.4 ± 6.7
Secondary school	210	37.6 ± 4.4	43.6 ± 4.9	28.7 ± 6.9
High school	223	37.7 ± 4.1	43.3 ± 5.1	27.7 ± 7.1
Bachelor's degree	200	37.1 ± 4.5	44.1 ± 4.8	27.6 ± 7.1
f		1,558	1,022	1,108
p		0,198	0,382	0,345
Do you follow a specific diet?				
Yes	32	38.8 ± 3.9	43.8 ± 4.9	29.5 ± 7.7
No	801	37.5 ± 4.3	43.6 ± 5.0	28.1 ± 6.9
t		1,562	0,245	1,178
p		0,119	0,807	0,239
Do you have a diagnosed medical condition?				
Yes	19	36.4 ± 2.9	40.8 ± 5.3	30.6 ± 6.8
No	814	37.6 ± 4.3	43.6 ± 5.0	28.1 ± 6.9
t		-1,238	-2,400	1,599
p		0,221	0,019*	0,112
Are you undergoing regular medication treatment?				
Yes	19	36.4 ± 2.9	40.8 ± 5.3	30.6 ± 6.8
No	814	37.6 ± 4.3	43.6 ± 5.0	28.1 ± 6.9
t		-1,238	-2,400	1,599
p		0,216	0,017*	0,110
Are you satisfied with your physical appearance?				
Yes	431	37.7 ± 4.2	43.6 ± 4.9	28.1 ± 6.9
No	402	37.5 ± 4.4	43.5 ± 5.1	28.2 ± 6.9
t		0,587	0,183	-0,165
p		0,558	0,855	0,869
Height				

Category	n	Orto15 Mean ± SD	Social Appearance Anxiety Scale (SAAS) Mean ± SD	Eating Attitude Test (EAT) Mean ± SD
r		0,009	0,046	-0,034
p		0,796	0,181	0,324
Weight				
r		0,043	-0,014	0,031
p		0,220	0,677	0,375
Desired weight				
r		0,027	-0,043	0,016
p		0,429	0,216	0,648

*p<0.05, **p<0.01, t: Independent student t-test, F: Oneway ANOVA, r: Pearson correlation.

In Table 5, a weak negative (inverse) relationship was found between the Orto15 scale score and the SAAS scale score (r=-0.096; p=0.006). No significant relationship was found between the other scale scores in Table 5 (p>0.05).

Table 5. Relationship between scale scores

Variables	Orto15		SAAS	
	r	p	r	p
SAAS	-0.096**	0.006		
EAT	0.031	0.833	0.009	0.795

DISCUSSION

In this study, the level of orthorexia nervosa, eating attitudes, and social appearance anxiety of students studying at the Faculty of Sports Sciences were examined in relation to sociodemographic variables.

53.2% of the participants were male, and 46.8% were female. 96.2% of the participants did not follow a regular diet, while 3.8% followed a regular diet. 2.3% of the participants had a diagnosed illness and used medication, as diagnosed by a doctor. 48.3% of the participants reported that they were not satisfied with their physical appearance. In a study by Bulut et al. (2023), it was also reported that 91.3% of the students did not follow a regular diet, 37.9% were not satisfied with their physical appearance, 97.1% did not have a chronic illness, and 8.7% used medication regularly [21].

The average score of the participants on the Orto 15 Scale was 37.6±4.3, the average score on the Social Appearance Anxiety Scale (SAAS) was 43.6±5.0, and the average score on the Eating Attitude Test Scale (EAT) was 28.1±6.9. It was observed that 155 participants (18.6%) were orthorectic. The Eating Attitude Test revealed that 410 participants (49.2%) were at moderate risk, 299 participants (35.9%) were at high risk, and 124 participants (14.9%) were at low risk. When looking at the scale scores by gender, the average Orto 15 score for males and females was 37.6±4.2 and 37.5±4.5, respectively; the average SAAS score was 43.5±5.0 and 43.6±5.0; and the average EAT score was 28.3±7.1 and 27.9±6.8, respectively.

In the study by Bulut et al. (2023), the total score of the SAAS was reported as 37.54±13.15, and the total score of the Orto15 was reported as 15.34±8.55 [21]. In the study by Çakaroğlu et al. (2020), the average SAAS score of students studying at the Faculty of Physical Education

and Sports was found to be 28.29, while the average EAT score was 17.19 [22]. In the study by Şengönül et al. (2023), the average SAAS score was 43.84±10.7, and the EAT score was 23.47±11.83 [23]. Looking at studies in the literature, in the study by Arslantaş et al. (2017), it was reported that 84.5% of students were at risk according to the EAT-40 [24]. In another study, it was found that 10.9% of students were at risk for eating disorders based on the EAT-40 score [25]. In the study by Duran et al. (2016), it was found that 31.8% of students had a EAT score ≥30, indicating a higher likelihood of eating disorders, with the total EAT score averaging 26.5±14 (min. 0 - max. 120) [26]. In the study by Oğur et al. (2016), based on the evaluation of the EAT-40 scale, it was reported that 13.3% of students (n=39) had a score ≥30, indicating a susceptibility to eating behavior disorders [27]. The average Eating Attitude Test score in this study shows similarity to the studies in the literature.

In the study by Hyrnik et al. conducted in Poland with 1899 students, the average ORTO-15 score was found to be 39.2 ± 3.6 points, with no gender difference [28].

In the 2022 study by Paludo et al., which used the ORTO-15 questionnaire to examine the orthorexia risk profile in athletes, it was reported that the ORTO-15 score ranged from 38 to 35, and no significant difference was found between the orthorexic scores of men and women [29].

In a study conducted in Italy with 2130 students, the average ORTO-15 score in the general sample was found to be 36.93 ± 4.22 [30].

In the study by Kuzu et al. (2023), it was reported that 25.7% of the participants were orthorectic [31]. In a study conducted with Portuguese fitness participants, no significant difference was found between orthorexic tendencies and gender, but it was determined that 51.8% of the participants had orthorexia nervosa [32].

In another study, it was reported that 19% of the participants had tendencies toward orthorexia (ON), with no significant difference between genders, and the average ORTO-15 test score was found to be 41.0 ± 2.6 [33]. In the study by Demir et al. (2022) conducted with students from the Faculty of Sports Sciences, the average ORTO-15 score of the students was found to be 36.57 ± 4.50. In the same study, no significant difference was observed between genders in the ORTO-15 scores [34]. Our study shows similarities with studies in the literature.

In the study by Pehlivan et al. (2019) with university students, it was determined that 12.2% were orthorexic according to the ORTO-15 scale. In the same study, when examining the frequency of orthorexia by gender, 12.6% of men were found to be orthorexic, while the rate for women was 12% [35]. Studies on orthorexia nervosa have reported that orthorexic tendencies are higher among healthcare professionals, athletes, performing artists, and dietitians [25,36-38].

The high rate of orthorexia in our study may be attributed to the fact that the participant population consisted of students from the Faculty of Sports Sciences. It is believed that the identity of being an athlete, as well as the aspiration to become a physical education teacher or coach in the future, might lead them to pay more attention to their appearance. It is also thought that they might prioritize their physical appearance due to the importance it holds for their professional careers, which could explain the higher orthorexia scores.

In our study, a significant difference was found between the Social Appearance Anxiety (SAAS) scores and the participants' current living situation. It was determined that those who lived with their families had higher Social Appearance Anxiety scale scores compared to those who selected other options. The Social Appearance Anxiety scale scores of patients diagnosed by a doctor and those on regular medication were found to be significantly lower (p=0.019; p=0.017). There was no significant difference in scale scores between genders. In a study by Çetintürk, M. (2021), no significant difference was found between gender and the Eating Attitudes Test (EAT) and Social Appearance Anxiety (SAAS) scales [39].

A significant difference was found between the family income level and the Eating Attitudes Test (EAT) scale scores (p=0.003). When the source of this difference was examined using the Post Hoc Tukey test, it was determined that individuals from families with a "very good" income level had lower Eating Attitudes Test scale scores compared to other income groups (p<0.05). In Çetintürk, M.'s (2021) study, a significant difference was found in the eating attitude scale based on monthly income levels (p<0.05). Our study shows similarities with the literature in this regard [39].

There is no significant difference in scale scores between genders. In the study by Kadıoğlu and Ergün, although they found that the average EAT score was higher in females compared to males, they did not find a significant difference [40]. Büyüköztürk et al. reported that gender and place of residence did not affect eating attitudes [41]. Anderson et al. (2016) did not find a significant relationship between gender and eating awareness in university students [42]. In Çetintürk, M.'s (2021) study, no significant difference was found in eating attitudes and social appearance anxiety scores between genders (p>0.05) [39]. Our study is similar to those in the literature. However, contrary to our study, there are studies in the literature that found a significant difference between EAT scores and gender [43,44]. This difference is likely due to population differences.

In our study, a weak negative relationship was found between the Orto15 scale score and the SAAS scale score (r=-0.096; p=0.006). No significant relationship was found between the other scale scores in Table 5 (p>0.05). In the study by Çakaroğlu et al. (2020), when they examined the relationship between the EAT-40 score and the SAAS score, they reported a significant positive relationship [22]. No significant relationship was found between the EAT scale and the SAAS scale. In Çetintürk, M.'s (2021) study on individuals attending fitness centers, no significant difference was found between the social anxiety levels of those showing normal eating attitudes and those with eating disorders [39].

Conclusion and Recommendations

53.2% of the participants are male, and 46.8% are female. 48.3% of the participants reported that they were not satisfied with their physical appearance. The mean score for the Orto 15 Scale was 37.6±4.3, the mean score for the Social Appearance Anxiety Scale (SAAS) was 43.6±5.0, and the mean score for the Eating Attitude Test (EAT) was 28.1±6.9. It was observed that 155 participants (18.6%) were orthorectic. In the Eating Attitude Test, 410 participants (49.2%) were in the moderate risk group, 299 participants (35.9%) were in the high-risk group, and 124 participants (14.9%) were in the low-risk group. In our study, a weak negative relationship was found between the Orto15 scale score and the SAAS scale score (r=-0.096; p=0.006). These results suggest that students need more support in healthy eating behaviors and body perceptions. Awareness-raising training on eating attitudes and social appearance anxiety should be organized for students in the Faculty of Sports Sciences. To prevent behavioral disorders such as orthorexia nervosa, it is important to expand psychological counseling services for students. Orthorexia nervosa is a serious condition that arises as a result of excessive focus on healthy eating, and it can reach levels that endanger individuals' overall health. Understanding such conditions better is essential for developing effective treatment methods. This research emphasizes the need to raise awareness about orthorexia nervosa. Nutrition and psychological support programs are considered to be effective in preventing and treating this condition.

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PRODUCTION AND MANAGEMENT OF RENTAL HOUSING: AN ASSESSMENT OF THE APPLICABILITY OF THE BUILT-TO-RENT MODEL IN TÜRKİYE

KİRALIK KONUT ÜRETİMİ VE YÖNETİMİ: "BUILT TO RENT" MODELİNİN TÜRKİYE'DE UYGULANABİLİRLİĞİNİN DEĞERLENDİRİLMESİ

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ÖZET

Son yıllarda, dünya genelinde konut sektöründe yeni bir model olarak öne çıkan "Built to Rent" (BtR), kiralık konut üretiminin profesyonel yatırımcılar tarafından planlanması ve yönetilmesini ifade etmektedir. Bu model, özellikle büyük şehirlerde konut arzının yetersiz olduğu ve kiralık konut talebinin arttığı durumlarda, ekonomik ve sosyal sürdürülebilirliği artırma amacını taşımaktadır. BtR, gayrimenkul geliştiricilerinin, konutları kiralamak için inşa etmelerini ve bu süreçte uzun vadeli yatırımlar yapmalarını teşvik ederken, kiracılara daha kaliteli yaşam alanları sunmayı da amaçlamaktadır. Uluslararası uygulamalarda, BtR modeli farklı yasal düzenlemeler ve politikalarla şekillenmiştir. Örneğin, Birleşik Krallık'ta BtR projelerine yönelik vergi teşvikleri ve inşaat standartlarına ilişkin düzenlemeler, bu tür yatırımların artmasını sağlamıştır. Amerika Birleşik Devletleri'nde ise, bazı eyaletlerde özel olarak kiralık konut projelerine ayrılan arazi tahsisi, yatırımcılar için önemli bir avantaj sunmaktadır. Avustralya ve Kanada gibi diğer gelişmiş ülkelerde, BtR projelerine yönelik özel yasal çerçeveler, kiracı haklarının korunması, yönetim standartlarının belirlenmesi ve yatırımcılara yönelik vergi indirimleri gibi faktörlerle desteklenmektedir. Çalışma kapsamında, BtR projelerinin farklı ülkelerde nasıl şekillendiğini ve başarısını etkileyen yasal düzenlemeler, teşvik mekanizmaları ve piyasa dinamikleri üzerine kapsamlı bir literatür taraması gerçekleştirilmiştir. Özellikle Birleşik Krallık, Amerika Birleşik Devletleri, Kanada ve Avustralya gibi ülkelerde BtR modelinin gelişimine katkı sağlayan mevzuat, vergi teşvikleri, kira düzenlemeleri ve yatırımcı politikaları incelenmiş ve bu faktörlerin Türkiye'ye nasıl uyarlanabileceği üzerine karşılaştırmalı bir analiz yapılmıştır. Elde edilen bulguların yerel ve ulusal düzeyde politika önerileri geliştirilmesi için bir temel oluşturması hedeflenmiştir. Türkiye'de konut sektörü, artan nüfus ve kentsel dönüşüm süreçleriyle birlikte hızlı bir gelişim göstermektedir. Ancak, BtR modelinin, yani kiralamaya yönelik inşa edilen konut projelerinin henüz gelişmiş bir pazar yapısına sahip olmadığı tespit edilmiştir. BtR modelinin Türkiye'de yaygınlaşmamasının önündeki başlıca engellerin, mevcut kira düzenlemelerinin uzun vadeli yatırımcıyı teşvik edici nitelikte olmaması, yatırım teşvik mekanizmalarındaki eksiklikler, vergi indirimi düzenlemelerinin bulunmaması, BtR projelerine özel planlama (arazi tahsisi, inşaat

izinleri, vb.) süreçlerine yönelik düzenlemelerin bulunmaması olduğu tespit edilmiştir. Türkiye'de, konut sektörüyle ilgili düzenlemeler, kiracılık ve mülkiyet yasaları, gayrimenkul yatırımcıları için çeşitli fırsatlar ve zorluklar yaratmaktadır. Bu kapsamda, Türkiye'de BtR modeline yönelik olası yasal değişiklikler ve düzenlemeler tartışılarak, kira sözleşmeleri, vergi teşvikleri, tesis yönetimi ve inşaat izinleri gibi konularda politika önerileri sunulmaktadır.

Anahtar Kelimeler: Kiralama Amaçlı Konut Üretimi, BtR, Kiralık Konut, Konut Sektörü

ABSTRACT

"Built to Rent" (BtR), which has emerged as a new model in the global housing sector in recent years, refers to professional investors' planning and management of rental housing production. This model aims to increase economic and social sustainability, especially in large cities with insufficient housing supply and growing demand for rental housing. BtR encourages real estate developers to build housing for rent and make long-term investments while providing tenants with better-quality living spaces. In international practice, the BtR model has been shaped by different legal regulations and policies. For example, in the United Kingdom, tax incentives for BtR projects and regulations on construction standards have led to an increase in such investments. In the United States, allocating land in some states specifically for rental housing projects offers a significant advantage for investors. In other developed countries, such as Australia and Canada, specific legal frameworks for BtR projects are supported by protecting tenants' rights and setting management standards and tax breaks for investors. As part of the study, a comprehensive literature review was conducted on how BtR projects have developed in different countries and the legal regulations, incentive mechanisms, and market dynamics that influence their success. In particular, the legislation, tax incentives, rental restrictions, and investor policies that have contributed to the growth of the BtR model in countries such as the United Kingdom, the United States, Canada, and Australia were examined, and a comparative analysis was carried out to assess how these factors could be adapted to Türkiye. The findings aim to serve as a foundation for developing policy recommendations at both local and national levels. The housing sector in Türkiye has been rapidly expanding due to increasing population and urban transformation processes. However, it has been determined that the BtR model, which refers to housing projects explicitly built for rental purposes, has not yet developed into a well-established market. The main obstacles to the widespread adoption of the BtR model in Türkiye include the lack of long-term investor-friendly rental regulations, deficiencies in investment incentive mechanisms, the absence of tax reduction regulations, and the lack of specific planning regulations (such as land allocation and construction permits) for BtR projects. In Türkiye, regulations on the housing sector, as well as tenancy and ownership laws, create various opportunities and challenges for real estate investors. In this context, possible legal changes and regulations for the BtR model in Türkiye are discussed, and policy recommendations are presented on issues such as lease agreements, tax incentives, facility management and construction permits.

Key Words: Rental Housing Production, BtR, Rental Housing, Housing Sector

GİRİŞ

Son yıllarda konut piyasasında yaşanan dönüşümler, yeni barınma modellerinin gelişimini teşvik etmiş ve özellikle Built to Rent (BtR), diğer bir ifade ile "kiralama amaçlı konut üretimi" modeli, birçok ülkede konut arzını artıran önemli bir strateji haline gelmiştir (Oxley & Smith, 2018). Geleneksel mülkiyet odaklı konut politikalarının aksine, BtR modeli uzun vadeli kiralama odaklı olup, yatırımcıların sürdürülebilir kira gelirleri elde etmesine ve kiracıların daha güvenli barınma koşullarına erişmesine olanak tanımaktadır (Pomeroy, 2020). BtR modelinin gelişimini destekleyen unsurlar arasında mevzuat düzenlemeleri, vergi teşvikleri,

kira kontrol mekanizmaları ve yatırımcı politikaları önemli rol oynamaktadır. Birçok ülkede bu faktörler, özel sektör yatırımlarını teşvik etmek ve konut arzını artırmak amacıyla farklı şekillerde tasarlanmıştır (Scanlon, Whitehead & Blanc, 2021). Örneğin, BtR pazarının en hızlı büyüdüğü ülkelerden biri olan İngiltere'de hükümet tarafından sağlanan vergi teşvikleri ve imar düzenlemeleri, BtR projelerinin hızla yaygınlaşmasını sağlamıştır (Gallent & Gilmour, 2019). Benzer şekilde, uzun vadeli kiralama kültürünün bulunduğu Almanya'da kira düzenlemeleri ve uzun vadeli kiracıyı koruma politikaları, BtR sektörünün istikrarlı bir şekilde büyümesine katkıda bulunmuştur (Kemp, 2015).

Bu çalışmada, BtR modelinin gelişimini destekleyen mevzuat, vergi teşvikleri, kira düzenlemeleri ve yatırımcı politikaları incelenerek, bu faktörlerin Türkiye'ye nasıl uyarlanabileceği konusunda bir tartışma yapılmaktadır. Konut piyasasının mevcut durumu, kira piyasasındaki dalgalanmalar ve yatırımcı beklentileri dikkate alınarak BtR modelinin uygulanabilirliği değerlendirilmektedir. Çalışmanın temel amacı, elde edilen bulguların yerel ve ulusal düzeyde politika önerilerinin geliştirilmesi için bir temel oluşturmak ve Türkiye'de sürdürülebilir kiralama politikalarının oluşturulmasına katkı sağlamaktır.

LİTERATÜR ARAŞTIRMASI VE KAVRAMSAL ÇERÇEVE

Kiralama amaçlı konut üretiminin temelleri Sanayi Devrimi'ne dayanmaktadır. Sanayileşmeyle birlikte kentsel alanlarda nüfus artmış ve apartman inşaatları yaygınlaşmaya başlamıştır. Bazı araştırmacılar, bu sürecin kiralık konut üretimi anlayışının temelini oluşturduğunu ileri sürmektedir (Abidoye vd., 2022). 20. yüzyılın ortalarına gelindiğinde, apartmanlar kiralama amacıyla özel olarak geliştirilmeye başlanmış ve bu durum sektörde önemli bir değişimin yaratmıştır (Hilary, 2023). Son on yılda ise, Amerika Birleşik Devletleri ve Birleşik Krallık dahil olmak üzere birçok ülkede BtR modeli büyük ilgi görmüştür (Muoneke, 2024). Londra başta olmak üzere birçok şehirde uygulanan BtR projeleri, büyük ölçüde ABD'deki örnek uygulamalardan esinlenmiştir (Brill & Durrant, 2021). BtR sektöründeki gelişmelerin hızlı olmasındaki nedenler arasında satılık konutlara erişimin zorlaşması, düşür gelir seviyeleri ve arz-talep dengesizliği gibi faktörler yer almaktadır (Carvalho vd., 2023).

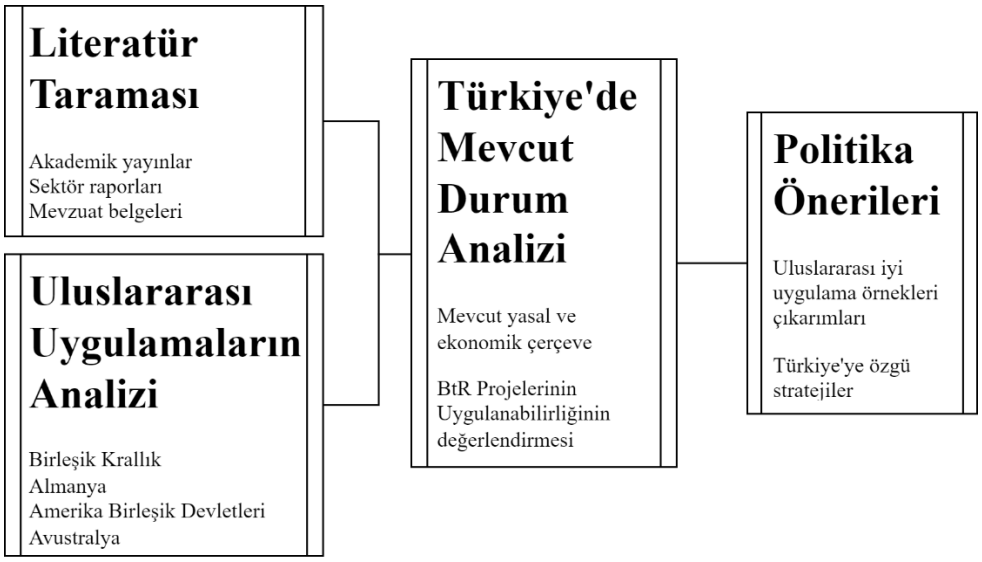
Küresel nüfusun artmasıyla birlikte, konut ihtiyacı da giderek büyümektedir. Birçok büyük şehrinde konut erişilebilirliği önemli bir kentsel sorun olarak kabul edilmektedir (Fields & Hodkinson, 2018). BtR modeli, satış yerine uzun vadeli kiralama için geliştirilen konut projelerini ifade etmektedir (Nethercote, 2020). Bazı araştırmacılar, söz konusu modelin geleneksel konut sahipliğinden uzaklaşarak daha esnek ve melez bir yaşam biçimini teşvik ettiğini belirtmektedir (Muoneke, 2024). BTR uygulamaları, kentsel alanlarda konut arzına yönelik etkili bir çözüm olarak öne çıkmakta olup, kiracılara uzun vadeli kira güvencesi sağlarken, yatırımcılara da istikrarlı gelir akışları sunmaktadır (Acheampong ve Earl, 2020). Bu nedenle hem kiracılar hem de yatırımcılar açısından avantajlı bir model olarak değelrendirilmektedir (Herbert vd., 2013; Nethercote, 2020).

Literatür taraması, BtR modelinin konut piyasasında farklı dinamikler ile birlikte şekillendiğini ve ülkelerin kendi iç dinamiklerine göre değişen uygulamalara sahip olduğunu göstermektedir. Akademik çalışmalar, modelin ekonomik faktörlerin yanı sıra sosyal ve politik faktörler ile de birlikte ele alınması gerektiğini ortaya koymaktadır. BtR modelinde, yatırımcılara sağlanan istikrarlı kira getirisi ve ölçek ekonomisi avantajlarının, uzun vadeli konut politikaları ile desteklenmesi durumunda modelin sürdürülebilir olabileceği belirtilmektedir (Acheampong ve Earl, 2020; Nethercote, 2020). Bununla birlikte, çalışmalarda kiracılar açısından model ile sağlanan esneklik ve uzun vadeli konut güvencesi sisteminin, geleneksel mülkiyet anlayışından farklı bir yaklaşım oluşturduğu vurgulanmaktadır. Ancak, BtR modelinin konut krizi oluşması durumuna kalıcı bir çözüm sunup sunamayacağı, konut erişilebilirliği üzerindeki etkisi ve piyasada yaratabileceği olası dengesizlikler açısından daha fazla araştırma yapılması gerektiği belirtilmelidir. Mevcut literatür, BtR'nin avantajlarını öne çıkarırken, piyasa dinamikleri,

regülasyonlar ve toplumsal kabul düzeyi gibi faktörlerin, modelin uzun vadeli başarısını belirleyeceğini ortaya koymaktadır.

METODOLOJİ

Bu çalışma, BtR modelinin farklı ülkelerdeki uygulamalarını nasıl şekillendiğini ve Türkiye'de uygulanabilir olup olmadığını hangi faktörlerin belirlediğini incelemektedir. Araştırma, nitel araştırma yöntemlerine dayalı olup, literatür taraması, mevzuat analizi ve karşılaştırmalı politika incelemeleri gibi yaklaşımları kapsamaktadır. Çalışma kapsamında, BtR modeline ilişkin akademik yayınlar, sektör raporları, ulusal ve uluslararası mevzuat belgeleri incelenmiştir (Şekil 1).



Şekil 1. Çalışma çerçevesi

Araştırmada öncelikle dünyadaki BtR uygulamalarının gelişimi, ekonomik ve hukuki altyapısı detaylı şekilde ele alınmıştır. BtR uygulamalarının hızlı gelişme gösterdiği ve BtR piyasasının giderek yaygın hale geldiği Birleşik Krallık, Almanya, Amerika Birleşik Devletleri ve Avustralya'daki mevzuat düzenlemeler arasındaki temel farklılıklar ve ortak noktalar belirlenmiştir. Ayrıca, yatırım teşvikleri, vergi avantajları ve kira düzenlemeleri gibi politika araçları karşılaştırılarak, Türkiye'deki mevcut durum analiz edilmiştir. Bu karşılaştırmalar doğrultusunda, uluslararası iyi uygulama örnekleri temel alınarak, Türkiye'ye özgü politika önerileri geliştirilmiştir. Çalışma, ikincil veri kaynaklarına dayanmaktadır. Türkiye'de BtR modeline ilişkin sınırlı sayıda uygulama bulunması nedeni ile, ampirik veriye dayalı derinlemesine bir analiz yapılamamıştır. Ancak, mevcut yasal ve ekonomik çerçevenin değerlendirilmesi ve uluslararası uygulamalarla karşılaştırma yapılması, politika geliştirme sürecine katkı sağlamaktadır.

FARKLI ÜLKELERDEKİ BtR UYGULAMALARI VE İLGİLİ DÜZENLEMELERİN DEĞERLENDİRİLMESİ

Konut piyasasında yaşanan arz-talep dengesizlikleri ve artan konut fiyatları, birçok ülkede BtR modelinin gelişimini hızlandırmıştır. BtR modeli, uzun vadeli kiralamaya uygun, kurumsal yatırımcılar tarafından inşa edilen ve yönetilen konut projelerini ifade etmektedir (Scanlon, Whitehead & Blanc, 2021). Bu modelin yaygınlaşmasını teşvik eden faktörler arasında mevzuat düzenlemeleri, vergi teşvikleri, kira kontrol mekanizmaları ve yatırımcı politikaları yer almaktadır. Bu kapsamda, farklı ülkelerde uygulanan teşvikler ve yasal düzenlemeler

incelendiğinde, her ülkenin kendi konut piyasası dinamiklerine uygun çeşitli stratejiler geliştirdiği görülmektedir (Tablo 1).

Birleşik Krallık, BtR modelini teşvik eden ülkeler arasında özellikle öne çıkmaktadır. İngiltere'de hükümet, 2012 yılında Montague Raporu ile BtR modelini desteklemek amacıyla özel sektör yatırımlarını teşvik eden düzenlemeler önermiştir (Montague, 2012). Buna ek olarak, 2017 yılında yürürlüğe giren Build to Rent Planning Policy kapsamında, BtR projelerinin imar planlarında öncelikli olarak değerlendirilmesi sağlanmış, yerel yönetimlere uzun vadeli kira sözleşmelerini destekleyici politikalar oluşturma yetkisi verilmiştir (Gallent & Gilmour, 2019). Bunun yanı sıra, Kurumsal Gayrimenkul Yatırım Fonları (Real Estate Investment Trusts - REITs) üzerinden yapılan BtR yatırımları için vergi avantajları sağlanmış, damga vergisi (Stamp Duty Land Tax - SDLT) oranları düşürülmüştür (Scanlon vd., 2021). BtR projelerinde kira piyasasından %20 civarında daha uygun fiyatlı konut birimlerinin inşa edilmesi planlama aşamasından itibaren teşvik edilmekte ve "Affordable Homes Programme" kapsamında bu tür karma projeler ayrı bir fon ile desteklenmektedir (Khan, 2025). Ayrıca, 2018 yılında Housing Infrastructure Fund (HIF) ile BtR projelerine yönelik altyapı finansmanı desteklenmiş ve uzun vadeli kira piyasasının istikrarlı bir şekilde büyümesine katkıda bulunulmuştur.

Almanya'da BtR modeli, uzun vadeli kira piyasasına yönelik güçlü düzenlemeler çerçevesinde gelişmektedir. Özellikle, Mietpreisbremse (Kira Freni) politikası kapsamında, büyük şehirlerde kira artışlarının sınırlanması, kiracıların korunmasını ve uzun vadeli yatırımcıların piyasaya güven duymasını sağlamaktadır (Kemp, 2015). Ayrıca, Almanya'daki kurumsal yatırımcılar, BtR projelerinde yerel yönetimlerle iş birliği yaparak sosyal konut projelerine entegre çözümler sunmaktadır. Wohnraumförderungsgesetz (WFG) kapsamında, düşük gelirli gruplara yönelik konut arzını artırmak için yatırımcılara düşük faizli krediler ve vergi indirimleri sağlanmaktadır (Haffner, Hoekstra & Oxley, 2020).

ABD'de BtR modeli, özellikle büyük metropollerde yaygınlaşmıştır. Federal düzeyde BtR projeleri için doğrudan bir teşvik mekanizması olmamakla birlikte, Kurumsal Gayrimenkul Yatırım Fonları (Real Estate Investment Trusts - REITs) üzerinden yatırım yapan firmalara vergi avantajları sunulmaktadır (Pomeroy, 2020). Özellikle, Low-Income Housing Tax Credit (LIHTC) gibi programlar aracılığıyla, düşük ve orta gelir grubuna yönelik BtR projelerine yönelik vergi kredileri sağlanmaktadır. Ayrıca, Opportunity Zones Programı, belirli bölgelerde BtR yatırımlarını teşvik etmek amacıyla sermaye kazancı vergisi muafiyetleri sunmaktadır (Gyourko & Molloy, 2015).

Avustralya, BtR modelinin gelişimini desteklemek amacıyla çeşitli mali teşvikler sunmaktadır. National Rental Affordability Scheme (NRAS) programı, uygun fiyatlı kiralık konut arzını artırmak için yatırımcılara doğrudan sübvansiyonlar sağlamıştır (Pawson, Milligan & Yates, 2020). Ayrıca, 2021 yılında Victoria ve New South Wales eyaletlerinde yürürlüğe giren Build-to-Rent Tax Concessions, BtR projeleri için damga vergisi indirimleri ve emlak vergisi avantajları getirmiştir. Bu düzenlemeler, kurumsal yatırımcıların BtR sektörüne ilgisini artırarak uzun vadeli kira piyasasının büyümesine katkıda bulunmuştur (Hulse, Reynolds & Parkinson, 2019).

Tablo 1. BtR modelinin ülkeler üzerinden karşılaştırması

Faktörler	İngiltere	ABD	Almanya	Avustralya
Mevzuat ve Regülasyonlar	Serbest piyasa Kira kontrolü yok Teşvikler mevcut	Eyalet bazlı farklılıklar Genellikle serbest piyasa	Kiracıyı koruyan düzenlemeler Yeni projeler kontrolsüz	Yeni gelişen sektör Eyalet bazlı teşvikler mevcut
Piyasa Büyüklüğü ve Talep	BtR projelerinde hızlı gelişme Toplam kiralık stokun %2'si	Kapsamlı ve oturmuş bir BtR pazarı Büyük ölçekli yatırımlar	Yüksek kiracı oranı (%50) Uzun vadeli kiralama yaygın	Henüz küçük pazar, ancak hızla büyüyor
Finansman ve Teşvikler	Özel yatırımcılar Devlet teşvikleri Emeklilik fonları	Mortgage REIT'leri Devlet destekli kredi kuruluşları	Düşük faizli kamu kredileri Vergi teşvikleri	Vergi indirimleri Yabancı yatırım teşvikleri
Geliştirme ve Operasyon Modelleri	Özel sektör liderliği Uzun vadeli kiralama	Özel sektör hakimiyeti Çok daireli apartmanlar ve tek aile için müstakil yapılar için BtR	Kamu-özel ortaklıkları Belediye konut işletmeleri aktif	İlk projeler yabancı yatırımcılarla Yönetim gelişmekte

Farklı ülkelerde BtR modelinin gelişimini teşvik eden mevzuat ve yatırım politikaları, piyasanın ihtiyaçlarına göre şekillendirilmiştir. İngiltere, planlama reformları ve vergi teşvikleri ile BtR modelini desteklerken, Almanya kiracı hakları ve kira kontrollerine dayalı bir sistem benimsemiştir. ABD'de kurumsal yatırımcı destekleri öne çıkarken, Avustralya doğrudan vergi teşvikleri ve sübvansiyonlarla BtR projelerini teşvik etmektedir. Türkiye'de BtR modelinin uygulanabilirliği açısından, bu uluslararası deneyimlerden faydalanarak uygun mevzuat düzenlemeleri, vergi teşvikleri ve yatırım politikaları geliştirilmelidir. Özellikle, kurumsal yatırımcıları teşvik edecek vergi avantajları ve uzun vadeli kira sözleşmelerini güvence altına alacak düzenlemeler, BtR modelinin Türkiye'de başarılı bir şekilde uygulanmasını sağlayabilecektir.

BtR Modelinin Yönetim Açısından Değerlendirilmesi

Geleneksel satılık konutlardan farklı olarak, bu mülklerin tamamı tek bir yönetici veya yatırımcı tarafından işletilmekte ve profesyonel yönetim hizmetleri sunulmaktadır. BTR gayrimenkulleri genellikle profesyonel tesis yönetim şirketleri tarafından yönetilmektedir ve bu şirketler tarafından bakım, kiracı ilişkileri, güvenlik ve ek hizmetler gibi farklı seçenekler sunulmaktadır. Bu projeler çoğunlukla otel benzeri hizmetler ve paylaşımlı alanlarla donatılmıştır. Spor salonları, çalışma alanları, ortak sosyal alanlar gibi hizmetler, kiracıların uzun süreli konforunu artırmaya yöneliktir (Nethercote, 2020). Geleneksel kiralık konutlarda ise bu tür merkezi hizmetler genellikle bulunmaz veya çok sınırlıdır (Tablo 2).

Tablo 2. BtR ve diğer konut modellerinin yönetim açısından temel farklılıkları

Özellik	Built-to-Rent (BTR)	Geleneksel Konut Yönetimi
Yönetim Türü	Profesyonel yönetim şirketleri	Bireysel ev sahipleri veya profesyonel olmayan yöneticiler
Yatırım Stratejisi	Uzun vadeli kira getirisi odaklı	Genellikle gayrimenkulde değer artışı odaklı
Bakım ve Onarım	Düzenli ve planlı	Ev sahibinin bütçesine bağlı olarak değişken
Kiracı Deneyimi	Hizmet odaklı, müşteri memnuniyeti yüksek	Standart
Ek Hizmetler	Güvenlik, sosyal alanlar, ortak kullanım alanları	Genellikle mevcut değildir

Genel çerçevede değerlendirildiğinde BtR'lerde sunulan yönetim hizmetleri diğer projelere oranla müşteri memnuniyetine çok daha fazla odaklanmaktadır. Hizmet çeşitliği özellikle büyük şehirlerde uzun mesailerde çalışanlar, yeni taşınanlar ve yalnız yaşayanlar için çok daha cazip olmaktadır. Türkiye'de ise profesyonel tesis yönetimi anlayışı henüz tam anlamıyla

yerleşmemiştir (Keskin vd., 2023a). Yönetim hizmetleri Kat Mülkiyeti Kanunu çerçevesinde kat malikleri tarafından gerçekleştirilmektedir ancak bu yönetim anlayışının hizmet sunumu ve kalitesi açısıdan bazı dezavantajları bulunmaktadır. Türkiye'de ekonomik şartlar da dikkate alındığında aidatların düşük olması öncelikler arasında çoğunlukla ilk sırada gelldiğinden, sunulan hizmet çeşitliliği ve kalitesi ikinci planda kalmaktadır. Diğer yandan profesyonelleşme ve eğitim konusundaki eksiklikler nedeniyle birçok konutta yönetime ilişkin eleştiriler olduğu görülmektedir (Keskin vd., 2023b). BtR'nin Türkiye'de uygulanması ile birlikte hizmet çeşitliliği ve kalitesi açısından önemli bir avantaj sağlayacağı düşünülmektedir.

TÜRKİYE'DE MEVCUT DURUM İNCELEMESİ VE ÖNERİLER

Dünyada birçok ülke, Built to Rent (BtR) modelini konut arzını artırmak, kira piyasasını istikrara kavuşturmak ve uzun vadeli yatırımcıları teşvik etmek amacıyla benimsemiştir. Türkiye'de ise BtR modeli henüz kurumsal bir çerçevede gelişim göstermemiş olup, konut piyasası daha çok bireysel gayrimenkul sahipliği ve kısa vadeli kira kontratlarına dayanmaktadır. Ancak, artan konut fiyatları, uzun vadeli kiralama ihtiyacının yükselmesi ve kurumsal yatırımcıların piyasaya ilgisinin artmasıyla birlikte BtR modelinin Türkiye'de uygulanabilirliği giderek daha fazla gündeme gelmektedir. Türkiye'de konut piyasası ağırlıklı olarak satın alma odaklıdır ve kiralık konut sektörü, bireysel gayrimenkul sahiplerinin hakimiyetinde bulunmaktadır. Türkiye'de hane halkının yaklaşık %57'si ev sahibi iken, %26'sı kiracı olarak yaşamaktadır (TÜİK, 2023). Ancak, özellikle büyükşehirlerde konut fiyatlarının hızla yükselmesi, konut satın alma oranlarını düşürmekte ve kiralama ihtiyacını artırmaktadır (Erol & Kaya, 2021). Bununla birlikte, Türkiye'de kira piyasası düzensiz fiyat dalgalanmalarına ve sınırlı kiracı korumasına sahiptir. 2022 yılında getirilen %25 kira artış sınırı, kısa vadede kiracıları korumayı amaçlasa da uzun vadede yatırımcıları caydırıcı etkiler yaratabileceği öne sürülmektedir (KPMG, 2023). Bu durum, BtR gibi uzun vadeli, kurumsal kira modellerine yönelik bir düzenleme ihtiyacını ortaya çıkarmaktadır.

Türkiye'de BtR modelinin uygulanabilmesi için mevcut kira mevzuatı, gayrimenkul yatırım düzenlemeleri ve imar politikaları incelenmelidir (Tablo 3). 6098 sayılı Türk Borçlar Kanunu, kira sözleşmelerini düzenlemekte ancak kurumsal BtR projelerine özgü bir hukuki çerçeve sunmamaktadır. Ayrıca, 6306 sayılı Afet Riski Altındaki Alanların Dönüştürülmesi Hakkında Kanun kapsamında dönüşüm projelerine yönelik teşvikler sunulsa da bunlar BtR'ye özgü değildir. Birleşik Krallık, Almanya ve ABD gibi ülkelerde olduğu gibi, Türkiye'de de BtR projeleri için özel kira düzenlemeleri getirilmesi, uzun vadeli kiralama piyasasını güvence altına alabilir. Örneğin, Almanya'daki Mietpreisbremse (Kira Freni) benzeri bir uygulama ile kira artışları uzun vadede düzenlenerek yatırımcılar için öngörülebilir bir piyasa ortamı oluşturulabilir (Kemp, 2015).

Tablo 3. Türkiye'de BtR modelinin uygulanabilmesi için geliştirilen öneriler

Kategori	Öneri
Mevzuat ve Hukuki Düzenlemeler	BtR projeleri için özel bir yönetmelik hazırlanmalı
	İmar planlarında BtR için özel alanlar tanımlanmalı
	Kiracı haklarını koruyacak ancak yatırımcıları caydırmayacak düzenlemeler getirilmeli
	Uzun vadeli kira kontratları 5-10 yıl gibi standart hale getirilmeli
	Tahliye ve kira tahsilatı süreçleri hızlandırılarak yatırımcı güvenliği artırılmalı
Vergi ve Finansal Teşvikler	BtR yatırımları için KDV oranları düşürülmeli
	Emlak vergisi muafiyeti sağlanmalı
	Uzun vadeli kira gelirleri için vergi avantajları getirilmeli
	Devlet destekli konut kredileri ve düşük faizli finansman modelleri oluşturulmalı
	Gayrimenkul yatırım ortaklıkları (GYO'lar) BtR projelerine yönlendirilmeli
	Kira getirisine dayalı gayrimenkul fonları oluşturulmalı
Yatırımcı Çekmek İçin Teşvikler	Yabancı yatırımcılar için oturma izni veya vatandaşlık avantajları sağlanmalı
	BtR projelerine yönelik kamu-özel sektör iş birlikleri kurulmalı
	Belediyeler altyapı destek fonları sağlayarak yatırımcılar için cazip alanlar oluşturmalı
	Türkiye Varlık Fonu veya kamu bankaları aracılığıyla BtR projelerine uzun vadeli düşük faizli kredi sağlanmalı
	Gayrimenkul yatırımcılarının BtR'ye yönelmesi için devlet garantili projeler teşvik edilmeli
Piyasada Güven Oluşturulmalı	Kira sözleşmelerinin hukuki güvence altına alınması sağlanmalı
	Profesyonel yönetim firmalarının BtR projelerini yönetmesi teşvik edilmeli
	Şeffaf ve öngörülebilir piyasa koşulları sağlanarak yatırımcı ve kiracı güveni oluşturulmalı

Türkiye'de BtR modelinin gelişimini desteklemek amacıyla vergi teşvikleri ve yatırım politikaları önem taşımaktadır. Mevcut durumda Gayrimenkul Yatırım Ortaklıkları (GYO'lar) konut sektöründe faaliyet gösterebilmekte, ancak kira getirisine dayalı büyük ölçekli BtR projeleri henüz yaygınlaşmamıştır. Birleşik Krallık'ta uygulanan damga vergisi muafiyetleri ve altyapı destek fonları, Türkiye'de de BtR projeleri için uygulanabilir. KDV oranlarının düşürülmesi, emlak vergisi indirimleri ve uzun vadeli kira gelirlerine yönelik vergi avantajları sağlanması, BtR modelinin cazibesini artırabilir (Tablo 3).

SONUÇ

Build-to-Rent (BtR) modeli, incelenen dört ülkede de konut arzını artırma, kiracılara nitelikli ve profesyonel hizmet sunma ve yatırımcılara uzun vadeli istikrarlı getiri sağlama potansiyeli ile öne çıkmaktadır. Konut piyasalarında yaygın olarak gözlemlenen arz yetersizliği, erişilebilir konut eksikliği ve standartlaşmamış kalite gibi yapısal sorunlar karşısında, BtR sektörü hükümetler tarafından konut politikalarının önemli bir bileşeni olarak değerlendirilmektedir. Ülkeler arasındaki mevzuat farklılıkları ve piyasa dinamiklerine rağmen, BtR projeleri küresel ölçekte giderek daha fazla benimsenen bir yatırım modeli haline gelmiştir. Modelin sunduğu güvenli, sürdürülebilir ve kaliteli yaşam alanları kiracılar açısından cazip bir alternatif sunarken, uzun vadeli ve öngörülebilir getiri yapısı ise yatırımcılar için önemli bir avantaj oluşturmaktadır. Bu ortak dinamikler, BtR modelinin uluslararası konut piyasalarında büyümesini ve yaygınlaşmasını teşvik eden temel unsurlar arasında yer almaktadır.

Türkiye'de BtR modelinin uygulanmasının hem yatırımcılar hem de kiracılar açısından çeşitli avantajlar sağlayacağı düşünülmektedir. Kurumsal projeler ani fiyat dalgalanmalarını azaltarak daha öngörülebilir bir kira piyasası oluşturmaya yardımcı olabilecekken, büyük ölçekli yatırımcılar için de sürdürülebilir gelir kaynağı yaratacaktır. Ayrıca kiracıların haklarının korunması açısından da önemli görülmektedir. Ancak, avantajlarının yanında bazı dezavantajları da bulunmaktadır. İlk olarak mevcut bireysel mülkiyet yapısının güçlü olması, kiralık konut piyasasının gelişimini sınırlayabilir. Ekonomideki ve siyasetteki belirsizlik ve

dalgalanmalar yatırımcılar için caydırıcı olabilir zira BtR yatırımları uzun vadeli yatırımlar olduğundan istikrar diğer projelere göre daha önemlidir. Kira kontrol politikalarının net olmaması da BtR projelerinin sürdürülebilirliği konusunda riskler yaratabilecektir.

Türkiye'de BtR modelinin uygulanabilmesi için, mevzuat, teşvik mekanizmaları ve yatırımcı politikaları açısından yeni düzenlemeler gerekmektedir. Öncelikle uzun vadeli kira sözleşmelerini teşvik edecek özel düzenlemeler getirilmelidir. Diğer yandan KDV, damga vergisi ve emlak vergisi muafiyetleri sunulmalıdır. Yabancı ve yerli yatırımcıların BtR projelerine ilgisini artıracak uzun vadeli finansman ve teşvik paketleri oluşturularak büyükşehirlerden başlamak üzere BtR projeleri için kamu-özel sektör iş birlikleri teşvik edilmelidir. Türkiye'de BtR modelinin gelişimi, konut arzını artırarak kira piyasasını dengeleyerek yatırımcılar için uzun vadeli sürdürülebilir gelir fırsatları sunabilir. Ancak, bunun için hukuki ve mali altyapının güçlendirilmesi gerekmektedir. Gelecekte BtR modeline yönelik kapsamlı düzenlemelerin, Türkiye konut piyasasında yeni bir dönüşüm yaratabileceği düşünülmektedir.

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TEXTURAL PROPERTIES OF METEORITES AS AN INDICATION OF THEIR SOURCE: AN EXAMPLE FROM KIRŞEHİR, TÜRKİYE

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ABSTRACT

Meteorites exhibit a variety of microscopic textural types, which can provide valuable information about their origins and the processes they have undergone. Meteorites serve as tangible remnants of the solar system's formative processes, offering a valuable insight into the origin and evolution of planetary bodies. Based on their compositions, structure, and origin, detailing the three primary classes: stony meteorites, iron meteorites, and stony-iron meteorites. The textural types provides insight into the meteorite's history, including its formation, thermal history, and the conditions present in the early solar system. Understanding these textures helps scientists reconstruct events in the solar system's evolution. The meteorites may have generally six textural features under the microscope. These are chondritic, nodular, granular, layered, porphyritic, breasted and metallic Texture. The meteorite which obtained from Kırşehir city (Türkiye) has granular texture under the polarizing microscope. The Kırşehir meteorite mainly composed of olivine, ringwoodite, augite with rare amount of chromite and magnetite. The Kırşehir meteorite classify as stony meteorite.

Key Words: Meteorite, Raman spectroscopy, Ringwoodite, Kırşehir

Introduction and Purpose: Meteorites are preserved fragments of extraterrestrial materials that have survived their passage through the Earth's atmosphere. They are classified based on their chemical and mineralogical composition, providing astronomers and planetary scientists clues about the formation and evolution of the solar system (Mason, 1963). Stony meteorites contain clues about primitive and volatile-rich materials, while iron meteorites chronicle the core formation and thermal evolution of their parent bodies. Stony-iron meteorites stand at the crossroads of both groups, representing mixed processes leading to planetesimal differentiation (Folco et al., 2006; Rochette et al., 2003).. Additionally, the isotopic studies of meteorites lend insights into the isotopic ratios of elements, revealing processes such as nucleosynthesis and the conditions present in the early solar system. Studies on organic compounds found in carbonaceous chondrites have also expanded our understanding of the potential for life and the distribution of organic matter in the universe.

Materials and Methods: The textural features are examined through the polarizing and ore microscopy. The detail mineral identification are analyzed vial high-resolution Raman microscope of the Kırşehir meteorite. The detail chemical composition of the whole meteorite is analyzed by Ped X-Ray Fluorescence. The mineral chemistry of the olivine and pyroxene are analyzed using Electron Probe Micro Analysis (EPMA) method.

Results: The mineralogy of meteorites varies significantly based on their classification. The mineral assemblage provides information about the thermal and petrogenetic history of the parent body. As a silicate the olivine, pyroxene, and feldspar are common in chondrites and

achondrites. The olivine is ringwoodite, forsterite and rarely fayalite in composition (Figure 1 and Figure 2). The metaphases mostly represent by Iron-nickel alloys such as kamacite and taenite are predominant in iron meteorites, revealing insights into the cooling history and crystallization processes within their parent bodies. Minerals like spinel, zircon, and apatite represent the accessory mineral compositions of the meteorites.

Discussion and Conclusion: Meteorites mostly confused with the term of meteor, and meteorid. Meteor; is a small body of matter from outer space that enters the earth's atmosphere, becoming incandescent as a result of friction and appearing as a streak of light.

The Meteroid is a small body moving in the solar system that would become a meteor if it entered the earth's atmosphere. However; The meteorite is a piece of rock or metal that has fallen to the earth's surface from outer space like a meteor. Over 90 per cent of meteorites are of rock while the remainder consist wholly or partly of iron and nickel.

The classification of meteorites plays a crucial role in understanding their origin, composition, and the processes that shaped them. By categorizing these space rocks into different groups based on their chemical, mineralogical, and isotopic characteristics, scientists can draw meaningful conclusions about the processes that have shaped our solar system and our planet. One of the most common classifications of meteorites is based on their composition. Broadly speaking, meteorites can be categorized into three main groups: stony meteorites, iron meteorites, and stony-iron meteorites. Each of these categories has its own unique features and provides valuable insights into different aspects of our solar system.

Stony meteorites, as the name suggests, are predominantly composed of rocky material. These meteorites are further divided into two subgroups: chondrites and achondrites. Chondrites are the most common type of meteorite and are believed to be remnants of the earliest materials formed in our solar system. They contain small spherical structures called chondrules, which are often composed of minerals like olivine and pyroxene. Chondrites provide valuable clues about the conditions that existed when our solar system was just beginning to take shape.

On the other hand, achondrites are meteorites that lack chondrules and show evidence of igneous processes. They are often composed of minerals like feldspar, pyroxene, and olivine, similar to those found on Earth. Achondrites are believed to originate from larger celestial bodies such as the Moon, Mars, and asteroids, which have undergone significant geological activity. Studying achondrites helps scientists understand the geological processes that have shaped these bodies in the past.

Another major group of meteorites is known as iron meteorites. These meteorites are composed primarily of iron and nickel, with minor amounts of other elements such as cobalt and sulphur. Iron meteorites are believed to originate from the cores of small differentiated bodies that were once part of a larger parent asteroid. Their unique composition provides valuable information about the metallic cores of these ancient celestial bodies. By studying iron meteorites, scientists can gain insights into the processes of planetary differentiation and the formation of metal-rich planetary cores.

The third category of meteorites is stony-iron meteorites, which as the name suggests, are composed of a mixture of rocky material and metal. These meteorites are rare and are thought to originate from the boundary region between a parent body's core and its mantle or crust. Stony-iron meteorites are composed of a matrix of silicate minerals surrounding metal-rich regions known as Widmanstätten patterns. These unique patterns are caused by the slow cooling of metal within the meteorite, resulting in a distinctive crystalline structure.

In addition to these main classifications, meteorites can also be further categorized based on their isotopic compositions and mineralogy. Isotopic studies allow scientists to investigate the origin and history of meteorites by analysing the ratios of different isotopes of elements within the meteorite. This provides valuable information about the sources of meteoritic material and

the processes that have affected them.

Mineralogical studies of meteorites involve analysing their mineral compositions and structures, which can reveal important clues about the conditions under which they formed. For example, specific mineral phases can indicate the temperatures and pressures that were present during their formation. By studying the mineralogy of meteorites, scientists can gain insights into the geologic processes that have shaped celestial bodies throughout the history of our solar system. The chemical analysis results the olivine are Ferro-Hortonolit in compositions (Figure 3).

the classification of meteorites is a critical field of study that allows scientists to unlock the secrets of our solar system's formation and evolution. By categorizing these extra-terrestrial objects based on their composition, isotopic compositions, and mineralogy, scientists can gain valuable insights into the processes that have shaped our solar system and our planet Earth. The study of meteorites provides a unique opportunity to unravel the mysteries of the universe and understand our place within it.

Meteorites, as remnants of our solar system’s formation and evolutionary history, play a critical role in advancing our understanding of planetary science. The categorization of meteorites into stony, iron, and stony-iron types, along with their respective subcategories, enables researchers to glean insights into the processes that shaped our celestial neighborhood. Whether it is through the study of chondrites that preserve the early solar system’s materials or iron meteorites that reveal the thermodynamic paths of their parent bodies, each meteorite contributes to a more comprehensive understanding of planetary formation and the processes that govern it.

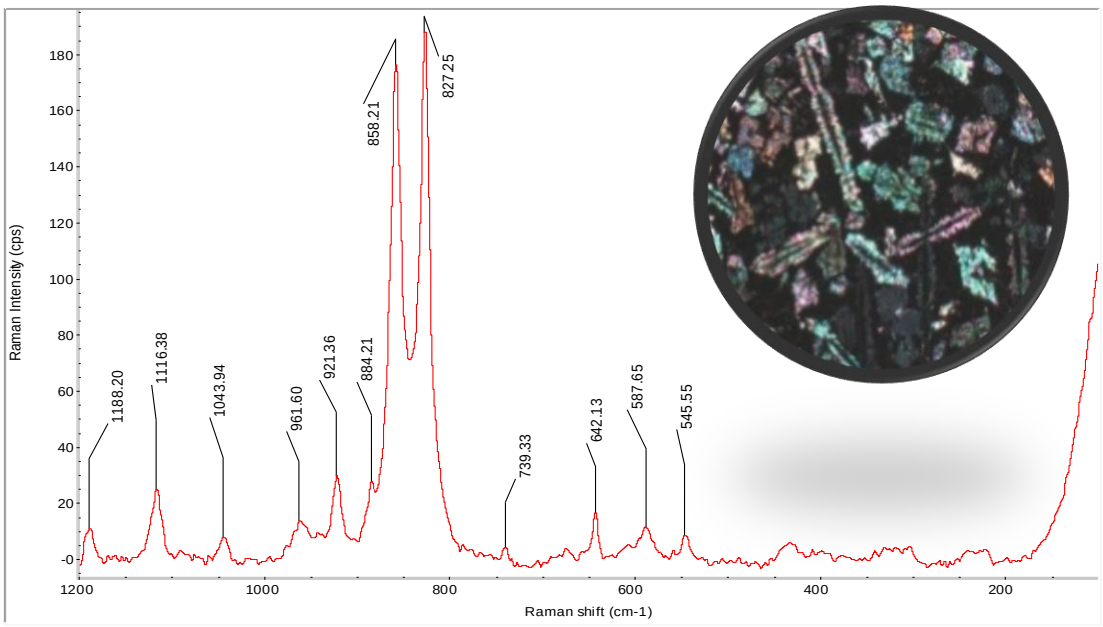

Figure-1 Raman Spectra of olivine (Ringwodite) within meteorite of Kırşehir (Türkiye).

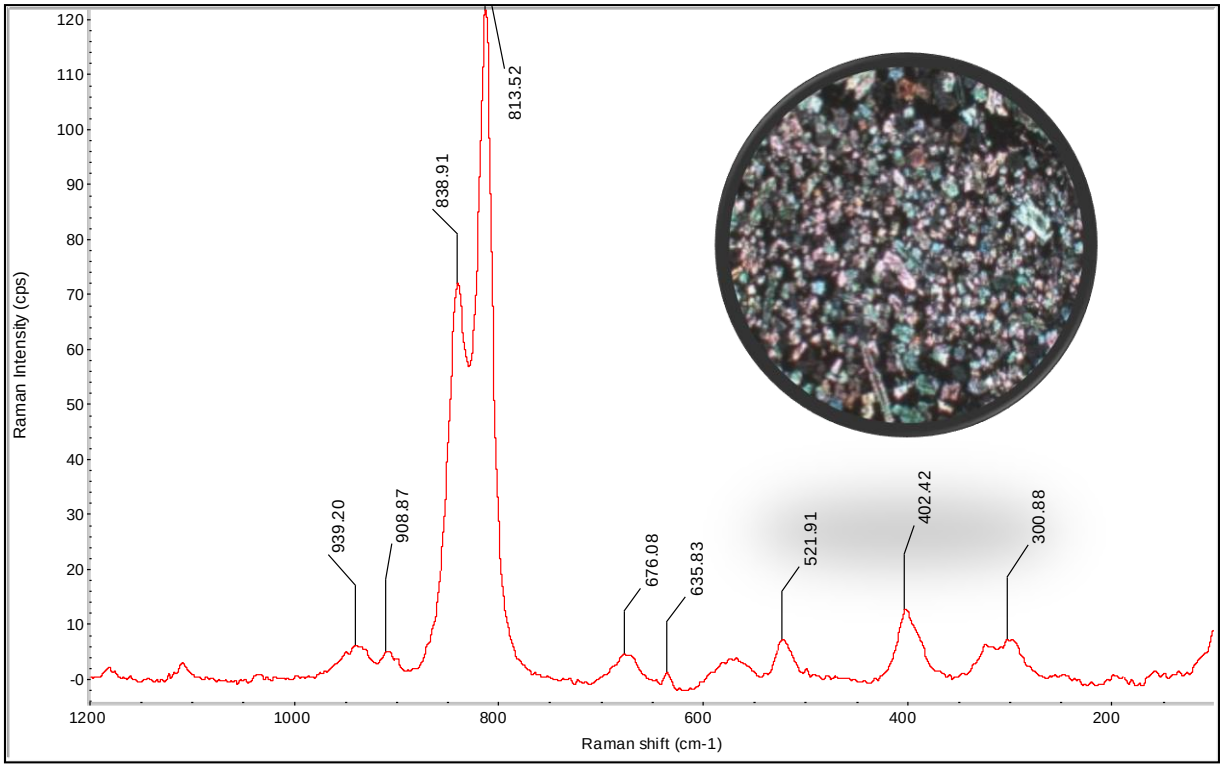

Figure 2 Raman Spectra of forsterite within meteorite of Kırşehir (Türkiye).

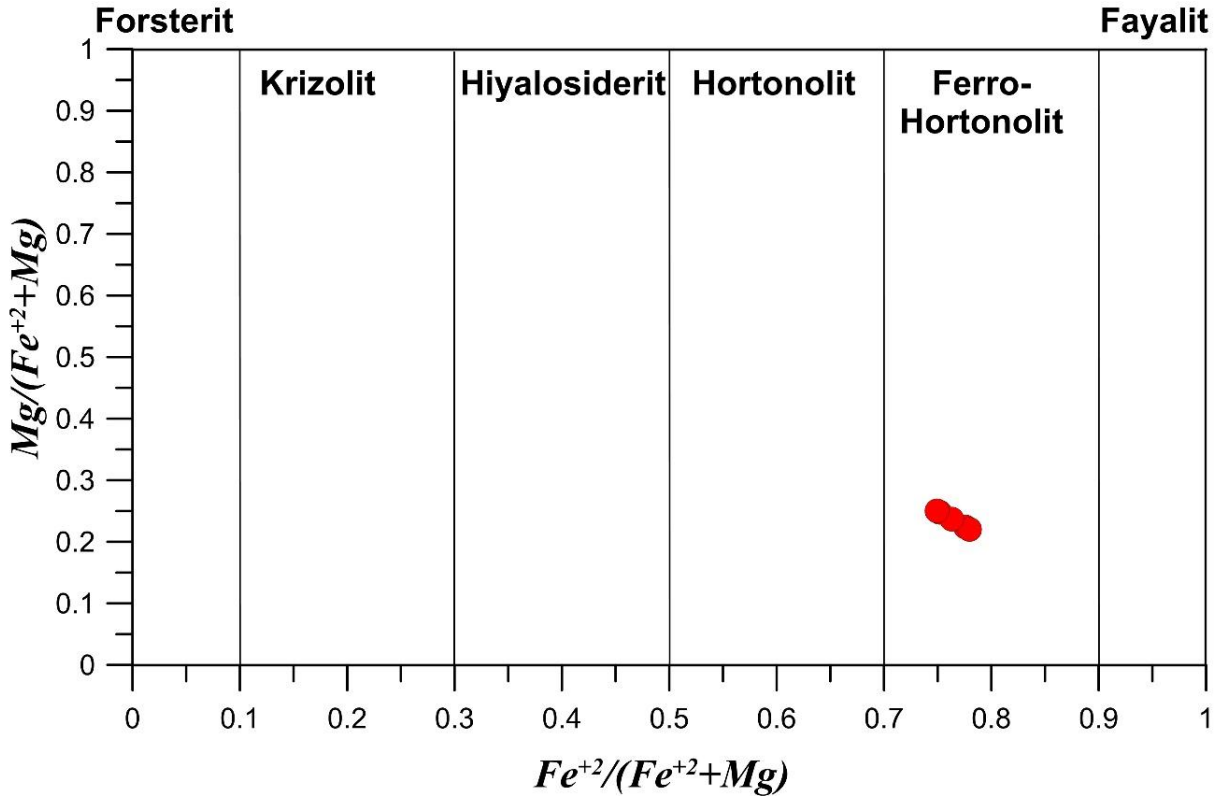

Figure 3 Mineral chemical classification of the meteorite of Kırşehir (Türkiye). They are mainly plot on the Ferro-Hortonolit area.

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SAMSUN TOURISM: THE PEARL OF THE BLACK SEA WITH ITS STRENGTHS AND WEAKNESSES

KARADENİZ'İN İNCİSİ, EKSİLERİ ARTILARIYLA SAMSUN TURİZMİ

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ÖZET

Samsun'un turizm potansiyeli, şehrin zengin coğrafi ve kültürel kaynakları ile paralel olarak büyük fırsatlar sunmaktadır. Ancak, altyapı eksiklikleri, mevsimsel turizme bağımlılık ve çevresel sorunlar gibi zorluklar, bu potansiyelin etkin bir şekilde kullanılmasını engellemektedir. Özellikle deniz, sağlık, yayla ve ekoturizm gibi alanlarda Samsun, yıl boyu sürdürülebilir turizm faaliyetleri geliştirme fırsatına sahiptir. Çevre dostu altyapı yatırımları, yerel halkın turizme katılımının sağlanması ve doğal ile kültürel mirasın korunması gibi stratejik çözümlerle, şehrin turizm sektöründeki potansiyelinin en üst düzeye çıkarılması mümkündür. Turizm sektörünü değerlendirmede sıklıkla kullanılan SWOT analizi, güçlü ve zayıf yönlerin belirlenmesi, fırsatlar ve tehditlerin analiz edilmesi açısından önemli bir stratejik araçtır. Ancak, mevcut literatürde Samsun'un turizm potansiyelini SWOT analizi çerçevesinde detaylı bir şekilde ele alan akademik çalışmaya rastlanılamamıştır. Bu eksiklik, Samsun'un turizmdeki güçlü yönlerini öne çıkaracak ve gelişim alanlarını belirleyecek bilimsel bir değerlendirme ihtiyacını ortaya koymaktadır. Buradan hareketle, bu çalışmanın amacı Samsun turizmini SWOT analizi ile ele alarak, "Karadeniz'in İncisi" olarak anılan Samsun'un turizm potansiyeline yönelik farkındalık yaratmak ve sürdürülebilir gelişim için stratejik öneriler sunmaktır.

Anahtar Kelimeler: Samsun, SWOT Analizi, Samsun Turizm Çeşitleri, Çevre Dostu Strateji Önerileri

ABSTRACT

Samsun's tourism potential presents significant opportunities, aligned with the city's rich geographical and cultural resources. However, challenges such as infrastructure deficiencies, dependence on seasonal tourism, and environmental issues hinder the effective utilization of this potential. Particularly in the fields of marine, health, highland, and ecotourism, Samsun has the opportunity to develop sustainable tourism activities throughout the year. Strategic solutions, including environmentally friendly infrastructure investments, local community engagement in tourism, and the preservation of natural and cultural heritage, can maximize the city's tourism sector potential. SWOT analysis, a commonly used tool in tourism sector

evaluation, is crucial for identifying strengths and weaknesses while analyzing opportunities and threats. However, a comprehensive academic study examining Samsun's tourism potential within the framework of SWOT analysis has not been identified in the existing literature. This gap highlights the need for a scientific assessment that emphasizes Samsun's strengths in tourism and identifies areas for improvement. Therefore, this study aims to analyze Samsun's tourism sector using SWOT analysis, raising awareness of the city's potential which is referred to as the "Pearl of the Black Sea" and providing strategic recommendations for sustainable development.

Keywords: Samsun, SWOT Analysis, Samsun Tourism Types, Environmentally Friendly Strategy Proposals

Giriş

Karadeniz Bölgesi, Türkiye'nin zengin doğal güzellikleri, tarihi mirası ve kültürel çeşitliliği sayesinde ulusal ve uluslararası turizmde önemli bir yer edinmiştir (Demir, 2017; Yılmaz, 2020). Bölgenin stratejik konumunda yer alan Samsun, tarihsel süreçte Karadeniz'in en önemli liman kentlerinden biri olarak öne çıkmakla birlikte, günümüzde gelişen turizm altyapısı ve çeşitliliği ile dikkat çekmektedir. Samsun, doğusunda Ordu, batısında Sinop, güneyinde Amasya ve Tokat ile çevrilidir; ayrıca kuzeyinde geniş bir Karadeniz kıyı şeridine sahiptir (Hekimoğlu vd., 2007). Bu coğrafi özellik, şehre deniz turizmi açısından büyük bir avantaj sağlamakta ve turizm potansiyelini artırmaktadır. Samsun, ılıman iklimi, kıyı ekosistemi, ormanları, yaylaları ve termal kaynakları sayesinde deniz, kültürel, doğa, yayla ve sağlık turizmi gibi farklı turizm türlerine ev sahipliği yapabilecek niteliktedir. Özellikle Atakum, İlkadım ve Canik gibi merkez ilçeler deniz ve kültürel turizme; Ayvacık ve Vezirköprü ilçeleri doğa ve yayla turizmine; Havza ise termal turizme odaklanmaktadır (Şahin ve Yılmaz, 2009). Bu çeşitlilik, bölgenin bölgesel kalkınmadaki stratejik önemini artırırken, sürdürülebilir turizm politikaları gerektiren dinamik bir yapıyı ortaya koymaktadır.

Turizm destinasyonlarının sürdürülebilir kalkınma süreçlerinde, doğal ve kültürel kaynakların yanı sıra altyapı eksiklikleri, mevsimsel turizm baskıları ve yetersiz tanıtım stratejilerinin önemli bir engel teşkil ettiğin görülmüştür. Örneğin, Şahin ve Yılmaz (2009) Samsun ilinde doğal kaynaklara dayalı turizm çekiciliğinin planlı bir şekilde kullanılmadığını ve yerel düzeyde plansız turizm hareketlerinin mevcut olduğunu belirtmişlerdir. Benzer şekilde, Özışık Yapıcı (2021), Samsun'un sağlık turizmi potansiyeline rağmen tanıtım eksiklikleri ve altyapı yetersizliklerinin bu potansiyeli sınırladığını vurgulamıştır. Ayrıca, Gedik ve arkadaşları (2019) Karadeniz Bölgesi'nde turizm arz kaynaklarının yetersizliği ile planlama ve tanıtım hizmetlerindeki eksiklikleri dile getirmiştir.

Yapılan bu çalışmalar ışığında, Samsun özelinde de benzer sorunların mevcut olduğu, dolayısıyla turizm potansiyelinin etkin bir şekilde değerlendirilebilmesi için stratejik, planlı ve sürdürülebilir politikaların geliştirilmesinin gerekliliği ortaya çıkmıştır. Mevcut eksiklikler hem yerel ekonomiye hem de bölgesel kalkınmaya olumsuz yansımakta; dolayısıyla konunun akademik ve pratik öneminin altı çizilmektedir. Bu kapsamda, araştırmanın temel amacı, Samsun'un aktif turizm çeşitlerini SWOT analizi çerçevesinde değerlendirerek, destinasyonun güçlü ve zayıf yönleri, fırsatlarını ve tehditlerini belirlemek ve bu doğrultuda sürdürülebilir turizm politikalarına yönelik stratejik öneriler sunmaktır. Ayrıca bu çalışmayı önemli kılan husus daha önce ulusal literatür kapsamında Samsun'u genel hatlarıyla turizm açısından SWOT analizi ile ele alan herhangi bir çalışmaya rastlanılamamış olmasıdır. Buradan hareketle çalışmanın şehrin turizm stratejilerinin geliştirilmesine olanak sağlayacağından ayrıca önemli olduğu düşünülmektedir.

Samsun'da Turizm

Karadeniz Bölgesi, Türkiye'nin kuzeyinde yer alan ve kıyı boyunca uzanan doğal güzellikleri, tarihi mirası ve zengin kültürel dokusuyla dikkat çeken bir bölgedir. Trabzon, tarihi Sümela Manastırı ve Uzungöl'ü ile öne çıkarken, Rize çay tarlaları ve yaylalarıyla tanınır. Ordu doğal güzellikleri ve fındık üretimiyle bilinirken, Sinop tarihi cezaevi ve doğal koylarıyla ziyaretçileri cezbeder. Bölgenin en büyük şehri olan Samsun ise Karadeniz'in önemli bir liman kenti olup, zengin turizm çeşitliliği ve tarihi mirası ile dikkat çekmektedir (Oğan ve Büyükyılmaz, 2020; Denk, 2021; Kement,2022).

Samsun'da sağlık turizmi, etkin biçimde uygulanmaktadır, sağlık turizmi açısından termal kaynakları, rehabilitasyon merkezleri ve modern sağlık tesisleri ile önemli bir potansiyele sahiptir. Havza ve Ladik bölgelerindeki termal kaplıcalar, romatizmal hastalıklar ve kas-iskelet sistemi rahatsızlıkları için tedavi edici özellikler sunmaktadır. Ayrıca, şehirdeki özel hastaneler ve tıp merkezleri, medikal turizm kapsamında estetik cerrahi, diş tedavileri ve organ nakli gibi alanlarda uluslararası hastalara hizmet vermektedir. (Karagöz ve Öztürk, 2019; Akbaş, 2016; Demir ve Sağlık, 2020; Özışık Yapıcı, 2021). Deniz turizmi kapsamında, Samsun'un uzun sahil şeridi, temiz plajları ve Atakum gibi turistik bölgeleri, deniz, kum ve güneş aktivitelerinin yanı sıra kano, dalış, yat turları ve su sporları gibi etkinliklerin gerçekleştirilmesine olanak sağlamaktadır (Efe ve Gözet, 2021). Bölgenin doğal güzelliklerinin ön plana çıkarılması amacıyla, gastronomi turizmi de önemli bir yer tutmakta; yerel mutfağın özgün tatları ve deniz ürünleri, ziyaretçilere bölgesel lezzet deneyimleri sunmaktadır (Bayrak, 2024). Kış sporları da, özellikle kış aylarında bölgedeki uygun coğrafi koşullar çerçevesinde, kayak ve snowboard gibi faaliyetlerle desteklenerek turistik faaliyetler arasına entegre edilmekte, böylece mevsimsel turizm çeşitliliği sağlanmaktadır (Kadıoğlu, 2017). Ek olarak, düzenlenen festivaller, yerel kültürün ve sanatın tanıtılmasına yönelik etkinlikler arasında yer almakta, turistlere kültürel ve sosyal etkileşim alanları sunmaktadır (Çalışkan, 2019).

Ekoturizm alanında ise, Samsun'un biyolojik çeşitliliğe sahip doğal alanları, özellikle Kızılırmak Deltası, ormanlık bölgeler ve yaylalar, doğa yürüyüşleri, trekking, kampçılık ve kuş gözlemciliği gibi çevre dostu aktivitelerin gerçekleştirilmesine uygun ortamlar sunmaktadır (Kadıoğlu ve Aydın, 2018). Kültürel turizm perspektifinde, Samsun'un tarihsel ve kültürel mirası; antik kalıntılar, müzeler, tarihi yapılar ve düzenlenen kültürel etkinlikler aracılığıyla turistlere sunulmaktadır. Şehir, tarih boyunca birçok medeniyete ev sahipliği yapmış olması nedeniyle, Bandırma Vapuru, Kurtuluş Yolu, Amisos Tepesi ve Roma Hamamı gibi sembolik alanlarda gerçekleştirilen turlar ve sergilerle zengin bir kültürel deneyim sağlamaktadır (Tan, 2013; Bağcı ve Şahin, 2018; Kuvvetli vd., 2024).

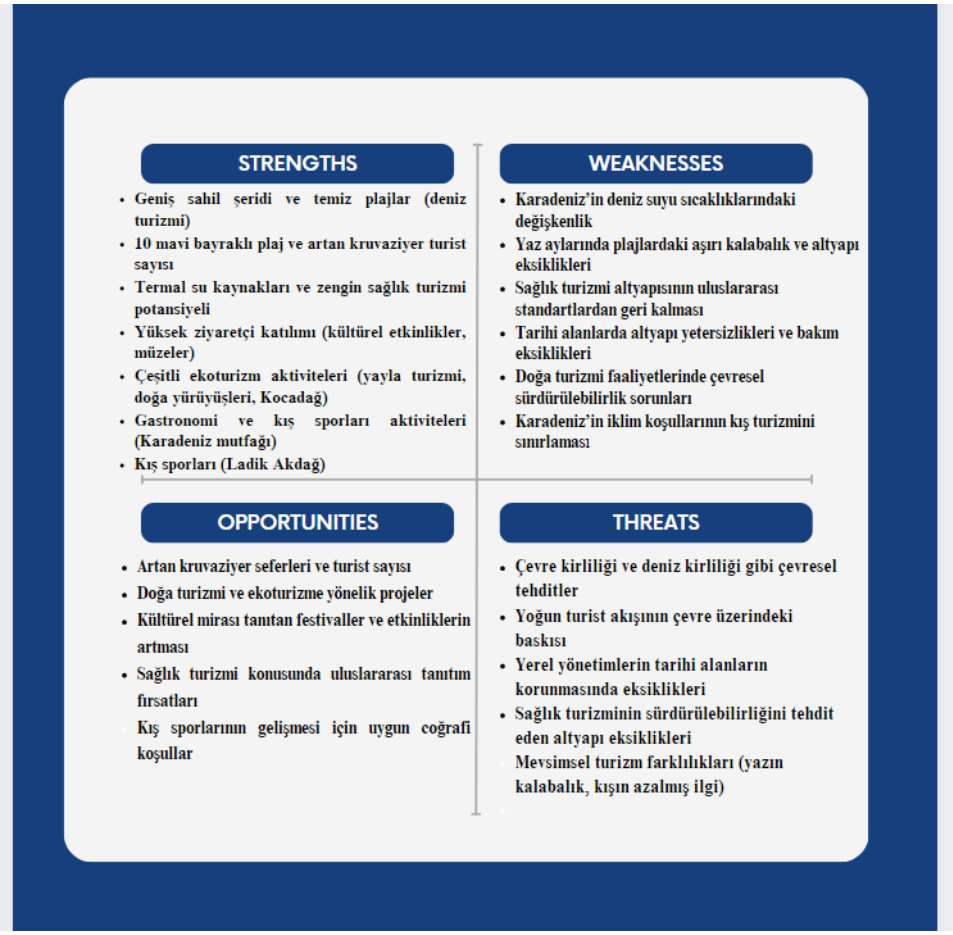
Samsun'un mevcut turizm çeşitliliği; deniz turizmi, ekoturizm, kültürel turizm, sağlık turizmi, gastronomi, kış sporları ve festivaller gibi alanlarda gerçekleştirilen çeşitli aktivitelerle desteklenmekte, böylece hem bölgesel ekonomiye katkı sağlanmakta hem de sürdürülebilir kalkınma hedeflerine ulaşılmasına zemin hazırlanmaktadır. Bu çok boyutlu turizm yaklaşımının, Samsun'un ulusal ve uluslararası turizm pazarındaki rekabet gücünü artırırken, ziyaretçilere de zengin ve farklı deneyimler sunduğu düşünülmektedir (Balaban ve Şimşek, 2019; Yıldırım ve Kıran, 2021; Yeşiltaş, 2009; Hakkıtanır ve Bulut, 2021; Canbolat ve Çakıroğlu, 2020).

Samsun Turizmine Yönelik SWOT Analizi

Samsun, Karadeniz Bölgesi'nin en büyük ve stratejik şehirlerinden biri olarak, doğal ve kültürel zenginlikleri ile turizmde önemli avantajlara sahiptir. Ancak, turizm altyapısındaki eksiklikler, mevsimsel bağımlılık ve çevresel sorunlar gibi faktörler, sektörün gelişimini sınırlayabilmektedir. Bu doğrultuda, Samsun'un turizm potansiyelini SWOT analizi çerçevesinde değerlendirmek, sürdürülebilir stratejiler geliştirmek için önemli bir adımdır.

SWOT analizi, bir bölgenin, işletmenin veya sektörün mevcut durumunu değerlendirmek için kullanılan stratejik bir analiz yöntemidir. Bu analiz, Strengths (Güçlü Yönler), Weaknesses (Zayıf Yönler), Opportunities (Fırsatlar) ve Threats (Tehditler) olmak üzere dört temel bileşenden oluşur. Güçlü yönler, rekabet avantajı sağlayan unsurları; zayıf yönler, gelişime açık alanları; fırsatlar, büyüme ve gelişme potansiyelini; tehditler ise dış faktörlerden kaynaklanan riskleri ifade eder (Özan vd., 2015; Durgun, 2007; Bozca vd., 2017).

Tablo 1: Samsun'un Turizm Potansiyeli



Kaynakça: Yazarlar Tarafından Akademik Literatür Çerçevesindeki Çalışmalar, Yerel Haber Kayakları ve Yetkili Devlet Kurum Raporlarından Yola Çıkılarak Oluşturulmuştur.

Samsun, sahip olduğu doğal ve kültürel zenginlikleri ile farklı turizm türlerini etkili bir şekilde barındıran bir destinasyon olma potansiyeline sahiptir. Şehir, deniz turizminden ekoturizme, kültürel turizmden sağlık turizmine kadar geniş bir yelpazede çeşitli turistik aktiviteler sunmaktadır. Ancak, bu çeşitliliğin sunduğu fırsatlar ve karşılaşılan zorluklar, Samsun'un turizm potansiyelinin daha verimli kullanılabilmesi için dikkatle ele alınması gereken unsurlar arasında yer almaktadır.

Güçlü Yönler ve Fırsatlar

Bu değerlendirmeler, turizm üzerine yapılan çeşitli çalışmaların sonuç ve öneri bölümlerinden, devlet kurumlarının raporlarından elde edilmiştir. Samsun'un en belirgin güçlü yönlerinden biri, sahip olduğu uzun sahil şeridi ve temiz plajlar ile deniz turizmi açısından sağladığı cazip fırsatlardır. 10 mavi bayraklı plajın varlığı, şehrin deniz turizminin sürdürülebilirliğini artıran

önemli bir avantajdır. Ayrıca, artan kruvaziyer turist sayısı ve sağlık turizmi alanındaki potansiyel, Samsun'un ekonomik kalkınma ve turizm gelirlerini artırma açısından önemli fırsatlar sunmaktadır. Şehirdeki ekoturizm alanları, doğal zenginlikler ve biyolojik çeşitlilik gibi unsurlar, doğa sever turistler için cazip fırsatlar yaratmaktadır. Kültürel ve tarihi mirasta, Samsun'un turistlere sunduğu zenginliklerin başında gelmektedir. Özellikle UNESCO Dünya Mirası Geçici Listesi'ne aday gösterilen Amisos Tepesi ve çevresi gibi alanlar, Samsun'un kültürel turizmdeki potansiyelini artırmaktadır. Ayrıca, kültürel etkinlikler ve festivaller, şehre gelen turistlerin ilgisini çeken önemli unsurlar arasında yer almaktadır (Aylar vd, 2022; Yeşiltaş, 2009; Tan, 2013; Gül ve Yılmaz, 2019; Samsun İl Tarım ve Orman Müdürlüğü, 2022; Kapadokya Üniversitesi, 2024).

Zayıf Yönler ve Tehditler

Bu değerlendirmeler, turizm üzerine yapılan çeşitli çalışmaların sonuç ve öneri bölümlerinden, devlet kurumlarının raporlarından ve yerel haber kaynaklarının analizlerinden elde edilmiştir. Samsun'un turizm alanındaki zayıf yönleri, özellikle altyapı eksiklikleri ve çevre yönetimi konusundaki yetersizliklerle öne çıkmaktadır. Karadeniz'in iklim koşulları ve deniz suyu sıcaklıklarındaki mevsimsel değişkenlik, kış turizmi ve su sporları gibi deniz turizmi faaliyetlerinin sınırlı kalmasına neden olmaktadır. Yaz aylarında artan turist yoğunluğu ise plajlarda aşırı kalabalığa yol açarak mevcut altyapının yetersiz kalmasına sebep olmaktadır. Doğa turizmi faaliyetlerinin yoğunlaşması, bazı ekosistemlerin sürdürülebilirliğini tehdit ederken aşırı kullanım doğal alanların bozulmasına neden olabilmektedir. Sağlık turizmi açısından Samsun, uluslararası tanınırlığını artırabilecek önemli bir potansiyele sahip olmasına rağmen, altyapı eksiklikleri bu gelişimi kısıtlamaktadır. Ayrıca, yerel yönetimlerin tarihi ve kültürel mirasın korunması konusundaki eksiklikleri, kültürel turizmin sürdürülebilirliğini tehlikeye atmaktadır (Demir ve Sağlık, 2020; Tekbalkan, 2017; Bulut ve Tankuş, 2022; Keleş vd., 2020; Samsun İl Valiliği, 2024; Samsun İl Valiliği, 2025; Anadolu Ajansı, 2023a; Anadolu Ajansı, 2023b).

Samsun, sahip olduğu turizm çeşitliliği ve doğal güzellikleri ile büyük bir potansiyele sahip olsa da, bu potansiyeli en verimli şekilde kullanabilmek için sürdürülebilir altyapı yatırımlarına ve çevresel yönetim stratejilerine ihtiyaç duymaktadır. Ayrıca, yerel halkın turizm faaliyetlerine dahil edilmesi ve kültürel mirasın korunmasına yönelik daha fazla çaba gösterilmesi, Samsun'un uzun vadede turizmdeki başarısını pekiştirecektir. Bu bağlamda, hem yerel yönetimler hem de turizm paydaşları, şehirdeki turizm potansiyelini sürdürülebilir bir şekilde geliştirmek adına stratejik planlamalar yapmalıdır.

Sonuç ve Öneriler

Samsun'un turizm potansiyeli, şehrin coğrafi ve kültürel zenginlikleriyle paralel olarak büyük fırsatlar sunmaktadır. Karadeniz'in sahil şeridi boyunca uzanan plajlar, yaylalar, tarihi ve kültürel miras gibi doğal ve kültürel kaynakları, şehri hem yerli hem de yabancı turistler için cazip bir destinasyon haline getirmektedir fakat Karadeniz Bölgesinde yer alan Samsun'un karşılaştığı bazı zorluklar, şehirdeki turizm sektörünün sürdürülebilir gelişimini engellemektedir.

Altyapı eksiklikleri, mevsimsel turizme dayalı faaliyetler ve çevresel sorunlar bunlardan birkaçıdır. Samsun'daki deniz turizmi, genellikle yaz aylarına odaklanmakta olup, iklim değişikliklerinin etkisiyle bu dönemin kısalması turizmin sürdürülebilirliğini tehdit etmektedir. Bu bağlamda, mevsimsel turizmin çeşitlendirilmesi ve yıl boyu sürecek etkinliklerin teşvik edilmesi önem kazanmaktadır. Yayla turizmi, ekoturizm, sağlık turizmi ve kış sporları gibi alanlar, şehri dört mevsim cazip kılabilir. Özellikle termal turizm ve sağlık turizmi, Samsun için büyük bir fırsat sunmaktadır; ancak bu alanlardaki tanıtım eksikliği ve yatırım azlığı bir

diğer tehdit oluşturan unsurlardır. Yatırımların artması, sürdürülebilir kalkınmaya katkı sağlayabilir.

Şehirdeki çevresel sorunların, özellikle deniz kirliliği ve restorasyon eksikliklerinin de dikkate alınarak, çevre dostu altyapı yatırımlarına öncelik verilmesi gerekmektedir. Mavi bayraklı plajların sayısının artırılması, sürdürülebilir turizm uygulamalarının yaygınlaştırılması, atık yönetimi ve enerji verimliliği gibi çevre dostu uygulamalarla şehrin turizm altyapısının güçlendirilmesi önemlidir. Ayrıca, yerel halkın turizm faaliyetlerine aktif katılımını sağlamak, turizmin ekonomik faydalarından doğrudan yararlanmalarını sağlamak için yerel el sanatları, gastronomi ve kültürel miras gibi unsurların tanıtılmasına yönelik stratejiler geliştirilebilir. Bu, aynı zamanda yerel halkın turizme karşı olan kaygılarını da azaltarak, sosyal uyumun sağlanmasına yardımcı olabilir. Samsunda gerçekleştirilen çeşitli festivaller için de özellikle daha fazla tanıtım yapılması gerekmektedir, eğer yeterli tanıtım yapılırsa Samsun daha fazla tanınmış olacak ve şehre bakış açısı farklılık kazanacaktır.

Aşağıda mevcut sürdürülebilir turizm politikalarına ek iyileştirme önerileri sunulmuştur;

- Enerji tasarrufu, atık yönetimi ve sürdürülebilir ulaşım gibi daha fazla çevreci projelerle turizm bölgelerinin ekolojik dengesini korumak.
- Deniz ve yaz turizmine ek olarak, doğa yürüyüşleri, sağlık turizmi ve kış sporları gibi alternatiflerin de varlığına dikkat çekerek tek sezon bağımlılığını azaltmak.
- Yerel halkın gastronomi, el sanatları ve tarım turizmi gibi alanlarda aktif rol almasını teşvik ederek ekonomik kalkınmayı desteklemek.
- Yerel halkı bilinçlendiren atölye, kampanya ve eğitim programlarıyla turizm alışkanlıkları kazandırmak.
- Müzeler, arkeolojik alanlar ve geleneksel mimari yapıların restorasyonunun iyileştirilmesi ve alan koruması ile kültürel mirası canlandırmak.
- Şehir otelleri yerine, organik tarım çiftlikleri, doğayla uyumlu bungalovlar ile şehirdeki yoğunlaşmayı azaltarak dikkati minimal çevre dostu seçeneklere yönlendirmek.

Samsun'un turizm stratejilerinin uzun vadeli bir perspektifle planlanması ve yerel yönetimlerin, kamu kurumlarının ve özel sektörün ortak hareket etmesi gerekmektedir. Çevre dostu turizm politikalarının geliştirilmesi ve uygulanması, sürdürülebilir turizmin temel unsurlarından biri olarak değerlendirilmelidir. Ayrıca, turizm sektöründe nitelikli insan kaynağı yetiştirilmesine yönelik eğitim programlarının arttırılması, hem hizmet kalitesini yükseltecek hem de istihdam olanaklarını genişletecektir.

Öte yandan, Samsun'un turizmdeki rekabet gücünü artırabilmesi için dijital pazarlama stratejilerine ve uluslararası tanıtım faaliyetlerine de ağırlık verilmelidir. Kültürel mirasın korunması ve turizm amaçlı kullanımı konusunda yenilikçi projeler geliştirilerek, ziyaretçi deneyimi iyileştirilebilir. Bunun yanı sıra, yerel halkın turizme aktif katılımını sağlamak amacıyla girişimcilik destekleri artırılmalı ve yerel ürünlerin turistik değer kazanması teşvik edilmelidir.

Sonuç olarak, önerilerin hayata geçirilmesi hem yerel halkın yaşam kalitesini artıracağı hem de Samsun'un turizmdeki büyüme potansiyelini en üst düzeye çıkaracağı öngörülmektedir. Çalışma alanının gelişimi açısından daha fazla akademik araştırmaya ihtiyaç duyulmaktadır, çünkü Samsun ilini kendi içerisinde tüm yönleriyle turizme yönelik SWOT analizi çerçevesinde ele alan herhangi bir akademik çalışmaya rastlanılamamıştır. Bu durum, mevcut çalışmanın önemini bir kez daha vurgulamaktadır. Samsun'un turizm sektöründe sürdürülebilir bir büyüme yakalayabilmesi için altyapı yatırımlarından tanıtım stratejilerine, çevre politikalarından insan kaynağına kadar kapsamlı bir planlama gerekmektedir. Tüm bu unsurların dikkate alınması,

Samsun'u dört mevsim boyunca cazip bir turizm destinasyonu haline getirecek ve kentin ekonomik kalkınmasına önemli katkılar sağlayacaktır.

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AS A FOOD SOURCE: *CAMELLIA OLEIFERA*

GIDA KAYNAĞI OLARAK: *CAMELLİA OLEİFERA*

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ÖZET

Camellia oleifera, Theaceae familyasının en büyük cinsine ait olan *C. oleifera,* zeytin (*Olea europaea* L.), palmiye yağı (*Elaeis guineensis J.)* ve Hindistan cevizi(*Cocos nucifera L.*) ile birlikte dünyanın dört büyük odunsu yağ mahsulünden biri olarak bilinmektedir. *C. oleifera,* kamelya, yabani kamelya ve beyaz çiçek kamelya olarakta bilinen, kullanım değeri yüksek, ekonomik açıdan önemli, küçük, yaprak dökmeyen bir ağaç türüdür. *C. oleifera'nın* dünyadaki kökeni ve en büyük üreticisi, 2300 yıldan fazla bir süredir yetiştirildiği ve küresel üretimin %90'ını oluşturduğu Çin'dir. *C. oleifera'dan* elde edilen ana ürün *Camellia oleifera* yağıdır ve Güney Çin'de yaygın olarak kullanılan yüksek besin değerine sahip doğal bir bitkisel yağdır. Zeytinyağıyla son derece benzer fizikokimyasal özellikleri ve yağ asidi profilleri nedeniyle *C. oleifera* yağı, "Doğu Zeytinyağı" olarak anılmaktadır. Doymamış yağ asitleri açısından zengin olan bu yağ, insan sağlığı için önemli biyolojik işlevlere sahiptir. Yapılan çalışmalar, bu yağın antioksidan, anti-inflamatuar, antibakteriyel, antikanser, antidiyabetik ve kardiyovasküler koruyucu etkiler sunduğunu göstermektedir. *Camellia oleifera* yağı, başlıca vitamin E, saponinler, polifenoller, steroller, skualen ve flavonoidler gibi biyoaktif bileşenler içermektedir. Bu bileşenler, serbest radikallerin temizlenmesi, bağışıklık sisteminin desteklenmesi ve iltihaplanmanın azaltılması gibi birçok faydalı etkiye sahiptir. Ekstraksiyon işlemi, *C. oleifera* yağının yüksek kalitesini ve verimini elde etmek için çok önemlidir. *C. oleifera* yağının ana geleneksel yöntemleri, sıcak presleme ekstraksiyonu, soğuk presleme ekstraksiyonu ve geleneksel solvent ekstraksiyonunu içeriyordu. Son yıllarda, kritik altı ekstraksiyon, süperkritik ekstraksiyon, sulu enzimatik ekstraksiyon, ultrasonik ekstraksiyon ve diğer teknolojilerin geliştirilmesi ve uygulanması, *C.oleifera* yağının verimliliğini ve kalitesini etkili bir şekilde iyileştirmiştir. Bu derleme, *C. oleifera* yağının bileşimi, biyoaktif bileşenleri, ektraksiyon yöntemleri, biyolojik işlevi üzerine ele alınmıştır.

Anahtar Kelimeler: *Camellia oleifera*, biyoaktif bileşenler, yağ bileşimi

ABSTRACT

*Camellia oleifera***,** belonging to the largest genus of the Theaceae family, is known as one of the world's four major woody oil crops, along with olive (*Olea europaea* L.), oil palm (*Elaeis*

guineensis J.), and coconut (*Cocos nucifera* L.). Also referred to as camellia, wild camellia, or white-flowered camellia, *C. oleifera* is a small, evergreen tree species with high utility value and significant economic importance. China is both the origin and the largest producer of *C. oleifera*, where it has been cultivated for over 2300 years, accounting for 90% of global production. The primary product derived from *C. oleifera* is *Camellia oleifera* oil, a natural vegetable oil with high nutritional value that is widely used in southern China. Due to its highly similar physicochemical properties and fatty acid profile to olive oil, *C. oleifera* oil is often referred to as the "Eastern Olive Oil."Rich in unsaturated fatty acids, this oil offers important biological functions for human health. Studies have shown that *C. oleifera* oil possesses antioxidant, anti-inflammatory, antibacterial, anticancer, antidiabetic, and cardiovascular protective effects. It primarily contains bioactive compounds such as vitamin E, saponins, polyphenols, sterols, squalene, and flavonoids. These components contribute to numerous beneficial effects, including free radical scavenging, immune system support, and inflammation reduction. The extraction process is crucial for obtaining high-quality and high-yield *C. oleifera* oil. Traditional extraction methods include hot-press extraction, cold-press extraction, and conventional solvent extraction. In recent years, the development and application of advanced technologies such as subcritical extraction, supercritical extraction, aqueous enzymatic extraction, and ultrasonic extraction have significantly improved the efficiency and quality of *C. oleifera* oil. This review discusses the composition, bioactive components, extraction methods, and biological functions of *C. oleifera* oil.

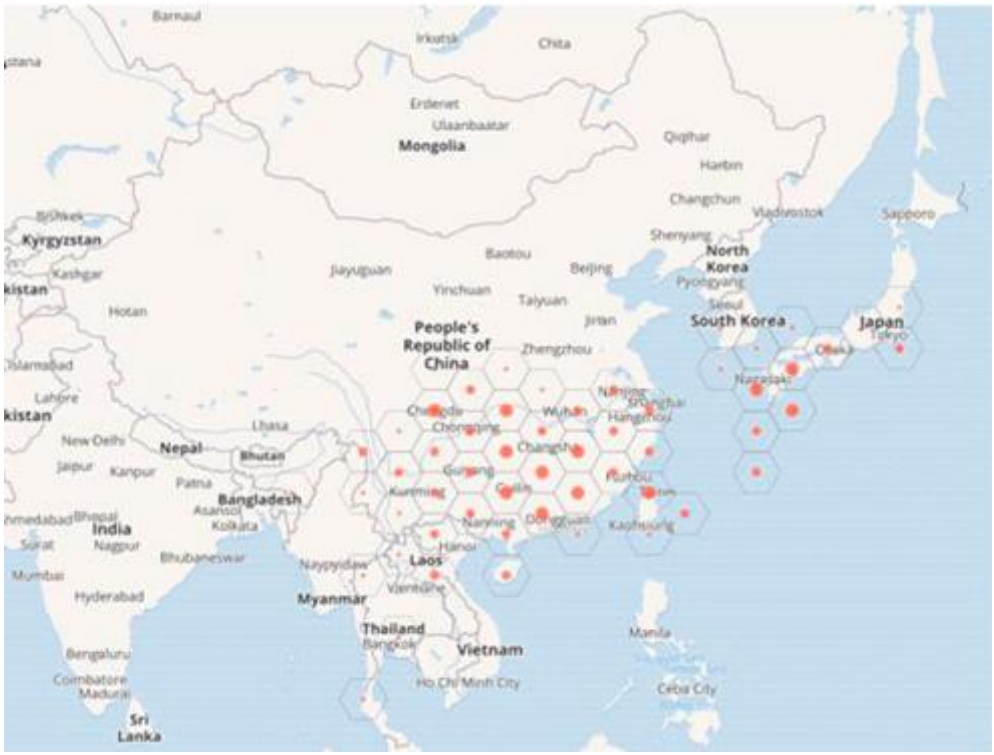
Keywords: *Camellia oleifera*, bioactive compounds, oil composition

GİRİŞ

Theaceae familyasının en büyük cinsine ait olan *Camellia oleifera,* zeytin (*Olea europaea* L.), palmiye yağı (*Elaeis guineensis J.)* ve Hindistan cevizi (*Cocos nucifera* L.) ile birlikte dünyanın dört büyük odunsu yağ mahsulünden biridir (Quan ve ark., 2022; Gao ve ark., 2024). *C. oleifera* (Şekil 1), kamelya, yabani kamelya ve beyaz çiçek kamelya olarak da bilinmektedir (Qin ve ark., 2024).

Şekil 1. C. oleifera'nın farklı kısımları; (A) ağacı, (B) gövdesi, (C) meyvesi, (D) yaprakları, *(E)* çiçekleri (Luan ve ark., 2020)

C. oleifera'nın 2300 yıldan fazla bir süredir yetiştirildiği ülke Çin'dir. Çin, küresel üretimin% 90'ını karşılamaktadır (Şekil 2). Çin dışında, Japonya, Vietnam, Tayland ve diğer Asya ülkelerinde de yetiştirilmektedir. Bu ülkelerdeki *C. oleifera* çeşitleri ağırlıklı olarak Çin kökenlidir (Gao ve ark., 2024).



Şekil 2. *C. oleifera*'nın dağılımı (Quan ve ark., 2022).

C. oleifera yaprak dökmeyen bir ağaçtır. Ağacın yüksekliği genellikle 2-4 m, taban çapı 20-80 cm olup yaşı 100-200 yıla kadar ulaşabilir (Dun-Yuan ark., 2009). Gübresiz çorak topraklarda büyüyebilir. Ekimden itibaren sekiz yılda meyve vermeye başlar (Yang ve ark., 2016). *C. oleifera* genellikle meyve vermek için böcekler tarafından tozlaştırılması gereken büyük, ağır, yapışkan polen taneleri ile kendi kendine çiçek açan steril bir ağaç türüdür (Yuan ark., 2009). *C. oleifera* her yılın Ekim ayında çiçek açar ve bir sonraki yılın Şubat ayına kadar çiçeklenme sürer. Meyveler Şubat ayında olgunlaşır ve genellikle Ekim ayında hasat edilir (Li ve ark., 2022a).

C. *oleifera* güneş ışığına ihtiyaç duyar. Aksi takdirde yalnız dallar ve yapraklar büyür, meyve verimi azalır, yağ oranı düşer. Yetişmesi için sıcaklık ihtiyacı yıllık ortalama 16-18 °C, çiçeklenme döneminde ise 12-13 °C'dir. Su ihtiyacı yüksektir. Yıllık yağış ihtiyacı genellikle 1000 mm'nin üzerindedir. Büyüme için toprak eğiminin hafif, erozyonun zayıf olması gerekir. Genellikle yetişmesi için derin asidik topraklar uygundur. Taşlık ve sert topraklar uygun değildir (Dun-Yuan ve ark., 2009).

C. *oleifera*'nın tohum yağı, Ming Hanedanlığı döneminde (1518–1593) Shizhen Li tarafından derlenen ünlü klasik Çin Materia Medica kitabı "Bencao Gangmu"da kayıt altına alınmıştır. Çin Materia Medica sözlüğüne göre, bu bitkinin tohumları, yaprakları, kökleri, tomurcukları, meyve ve kabukları uzun yıllardır geleneksel Çin tıbbında kullanılmaktadır (Luan ve ark., 2022).

CAMELLIA OLEIFERA TOHUMLARININ BİLEŞİMİ

Olgunlaşmış *C. oleifera* meyvesinin şekli küresel veya asferiktir. Tohumları siyah sert bir kabuk ve sarı bir çekirdekten oluşmaktadır (Zeng ve Endo, 2019). *C. oleifera*'nın meyvesinden elde

edilen tohumlar, meyvenin kabuğu ile kaplıdır. Tohumlar, taze meyvenin %38-40'ını oluşturur ve doğal güneşte kurutma, manuel ayıklama yoluyla veya meyvenin mekanik olarak ayıklama yoluyla elde edilebilir. *C. oleifera* tohumu bir kabuk ve çekirdekten oluşur ve çekirdek tüm tohumun %66-72'sini oluşturur (Şekil 3) (Li ve ark., 2022b). Çekirdekler yaklaşık %8.65-10.14 su, %43.56-44.24 yağ, %8.96-9.38 protein, %8.10-8.65 çay saponinleri ve diğer bileşenleri içerir (Tablo 1) (Zhu ve ark., 2020).

Şekil 3. *C. oleifera* meyvesinin kısımları (Quan ve ark., 2022).

Tablo 1. *Camellia oleifera* tohum çekirdeğinin bileşimi (Zhu ve ark., 2020)

Bileşen	**Miktar (%)**
Su	8.65-10.14
Yağ	43.56-44.24
Protein	8.66-9.38
Ham lif	3.26-4.91
Saponin	8.10-8.65
Tanen	0.50-0.57
Kül	2.39-2.59
Azotsuz özüt	23.80-24.63

Tablodan görüldüğü gibi tohumlar yağ açısından zengindir. Yetiştiği ortama bağlı olarak yağ içeriği %40 ile %60 arasında değişmektedir. Bunun için C. oleifera tohumları yenilebilir yağ üretiminde kullanılabilir (Zhang ve ark., 2022). Yağ kalıntıları, *C. oleifera* tohumunun hücre duvarı tarafından hapsedilir. Lipitler genellikle lipoproteinler veya lipopolisakkaritler formundadır yani proteinler veya polisakkaritler ile bağlıdır. Bu ağlar, yağların hareketliliğini kısıtlar ve ekstraksiyon işlemi sırasında *C. oleifera* tohumlarından yağların ve diğer fitokimyasalların salınmasını engeller (Li ve ark., 2022b).

C. oleifera bitkisinin tohumlarından elde edilen yağ, tıbbi ve besin değeri yüksek olup yenilebilir bir bitkisel yağdır (Qin ve ark., 2024). Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO) tarafından yüksek kaliteli bir yemeklik yağ olarak önerilmiş olup dünya çapında yaygın olarak kullanılmaktadır (Li ve ark., 2022b). Zeytinyağıyla son derece benzer fizikokimyasal özelliklere (Tablo 2) ve yağ asidi profiline (Tablo 3) sahiptir. Bu nedenle "Doğu zeytinyağı" olarak anılmaktadır (Zhang ve ark., 2022).

Tablo 2. *C. oleifera* yağının fizikokimyasal özellikleri (Gao ve ark., 2024)

Özellikler	**Değer**
Asit değeri, mg/g	0.1–0.5
Peroksit değeri, mEq/kg	2.64–17.8
İyot değeri, I_2/100 g	83.9–86.30 g
Sabunlaşma değeri, mg KOH/g	193.28–194.05
25 °C'de yoğunluk, g/cm^3	0.920
20 °C'de kırılma indisi	1.466

Trigliseridler, farklı zincir uzunluklarına ve doygunluk seviyelerine sahip üç yağ asidi kalıntısına bağlı gliserol moleküllerinin bir karışımıdır. Çay tohumu yağındaki yağ asitlerinin spesifik bileşimi, kökene ve olgunluğa bağlı olarak biraz değişir. Palmitik (C16:0), stearik (C18:0), oleik (C18:1) ve linoleik (C18:2) asitler, çay tohumu yağındaki dört ana yağ asididir ve genel yağ asidi profilinin %97-98'ini oluştururlar. Zeytinyağına benzer şekilde, doymamış yağ asitleri (UFA'lar), çay tohumu yağının ana bileşenleridir (% >85), tekli doymamış bir yağ asidi olan oleik asit içeriğince zengindir (Li ve ark., 2022b).

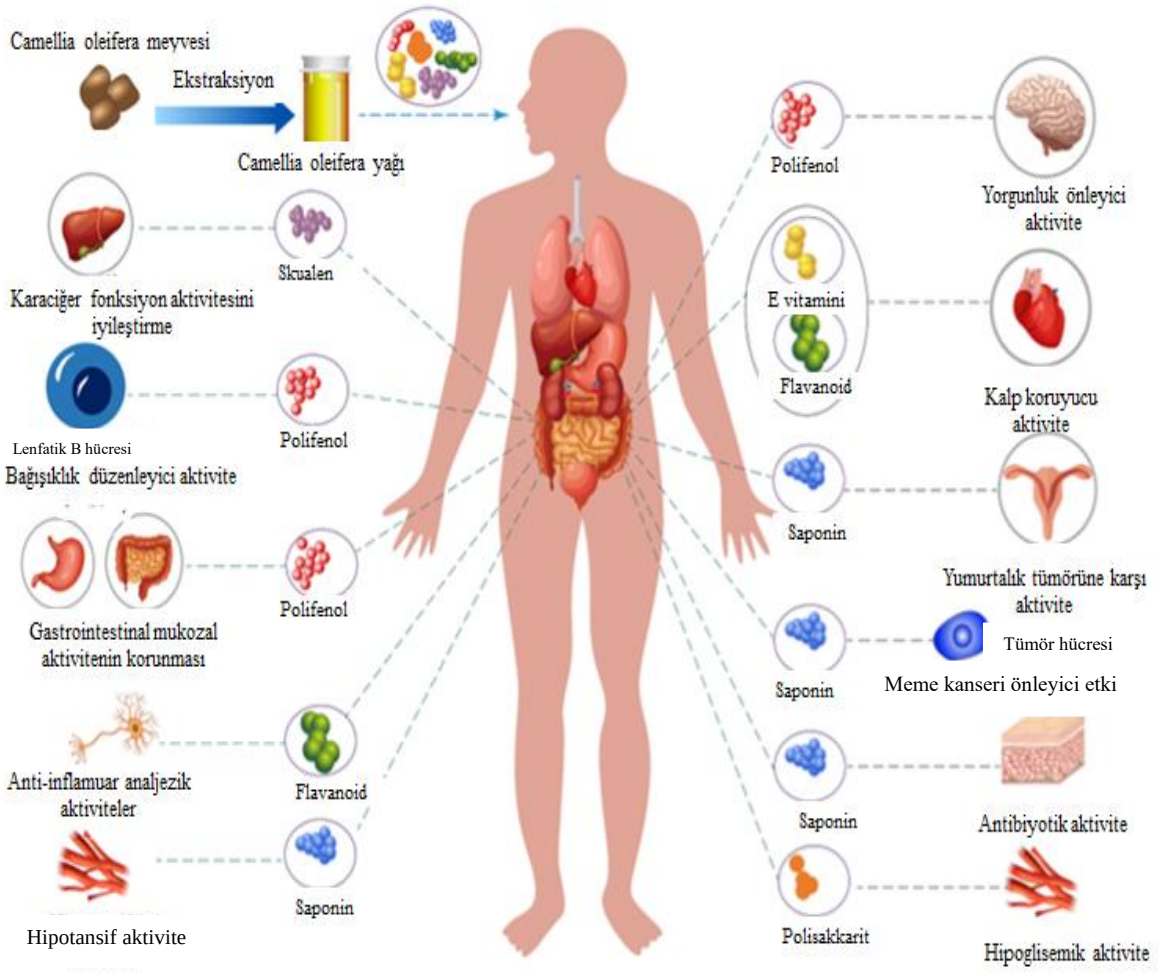
Tablo 3. *C. oleifera* yağının yağ asidi bileşimi (Li ve ark., 2022b)

Yağ asidi	**Dağılımı (%)**
Tridekanoik asit (C13:0)	0.0048–0.0066
Miristik asit (C14:0)	0.0297–0.0617
Pentadekanoik asit (C15:0)	0.0072–0.0140
Palmitik asit (C16:0)	7.4541–9.0572
Margarik asit (C17:0)	0.0635–0.0791
Stearik asit (C18:0)	1.8946–3.5695
Araşidik asit (C20:0)	0.0446–0.0987
Behenik asit (C22:0)	0.0160–0.0307
Trikosanoik asit (C23:0)	0.0150–0.0510
Lignoserik asit (C24:0)	0.0305–0.0746
Palmitoleik asit (C16:1)	0.1200–0.1821
Margaroleik asit (C17:1)	0.0553–0.0847
Oleik asit (C18:1n9)	**75.9724–79.4949**
Asklepik asit (C18:1n11)	0.5284–1.0959
Gadoleik asit (C20:1)	0.5268–0.6065
Erusik asit (C22:1)	0.0259–0.0383
Linoleik asit (C18:2n6)	**7.4679–10.2809**
Eikosadienoik asit (C20:2)	0.0144–0.0213
α-Linolenik asit (C18:3n3)	0.1869–0.3860
γ-Linolenik asit (C18:3n6)	0.0356–0.0687
Dokosaheksaenoik asit (C22:6n3)	0.0561–0.1047
Doymuş yağ asidi (SFA)	9.8917–12.4011
Tekli doymamış yağ asidi (MUFA)	77.2590–81.1909
Çoklu doymamış yağ asidi (PUFA)	7.8677–10.7537

C. oleifera yağı yerel tüketiciler tarafından kendine has aroması nedeniyle tercih edilmektedir. Bir çalışma sonuçlarına göre, *C. oleifera* yağında bulunan başlıca uçucu bileşenler arasında hidrokarbonlar, aldehitler, ketonlar, alkoller, asitler, esterler ve heterosiklikler bulunmaktadır. Aldehitler ve alkoller baskın uçucu aroma bileşenleridir ve toplam içeriğin %74'ünden fazlasını oluştururlar. Aroma çalışmaları, aldehitlerin, esterlerin, asitlerin ve heterosiklik bileşiklerin çiğ *C. oleifera* tohumu yağının aroma profiline önemli ölçüde katkıda bulunduğunu göstermiştir (Li ve ark., 2022b).

CAMELLIA OLEIFERA'NIN BİYOAKTİF BİLEŞENLERİ VE SAĞLIK ÜZERİNE ETKİLERİ

C. oleifera polifenoller, doymamış yağ asitleri, skualen, E vitamini, fitosteroller ve saponinler gibi çok sayıda biyoaktif madde içermektedir. Bu biyoaktif maddeler, kolesterol düşürme, kardiyovasküler hastalık önleme, karaciğer koruma, anti-inflamatuar, antibakteriyel, anti-tümör ve antioksidan aktiviteler dahil olmak üzere çeşitli farmakolojik aktiviteler gösterir (Şekil 4) (Li ve ark., 2022a).



Şekil 4. *Camellia oleifera* bileşenleri ve aktiviteleri (Qin ve ark., 2024)

E vitamini, birçok bitkide bulunan ve bitki tohumlarında bol miktarda bulunan yağda çözünen bir vitamindir. Bitki tohumlarının tohum kabuğunda ve embriyosunda yüksek oranda konsantre şekilde bulunur (Qin ve ark., 2024). E vitamini, dört tokoferol (α, β-, γ- ve δ-tokoferoller) ve dört tokotrienolün (α-, β-, γ- ve δ-tokotrienoller) ortak adı olan en önemli antioksidanlardan biridir. *C. oleifera* yağı, E vitamini açısından zengindir (Tablo 4) ve α-tokoferol (153-771 mg/kg) çay tohumu yağındaki ana tokoferoldür. *C.oleifera* yağının farklı işleme süreçleri E vitamini içeriği üzerinde önemli bir etkiye sahip olabilir (Gao ve ark., 2024). Yapılan çalışmalar, tokoferolün antioksidan, anti-inflamatuar, anti-tümör ve kardiyovasküler hastalıkları önleme yeteneğine sahip olduğu göstermiştir (Qin ve ark., 2024)

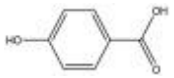
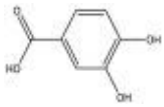
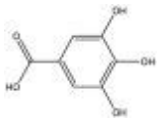
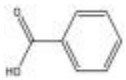
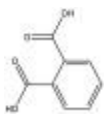
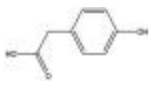
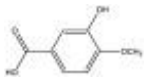
Tablo 4. *Camellia oleifera* yağındaki E vitamini içeriği (Qin ve ark., 2024)

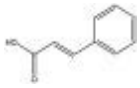
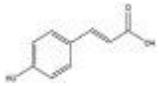
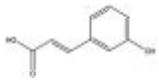
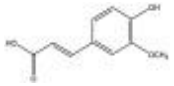
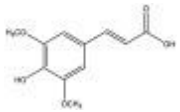
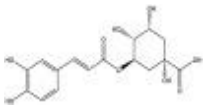
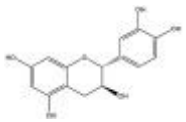
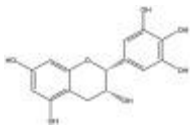
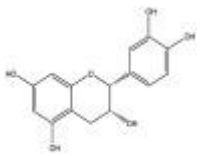
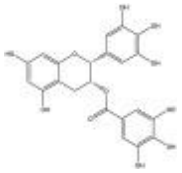
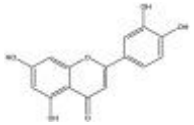
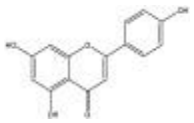
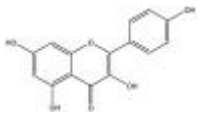
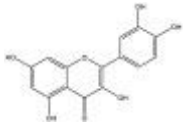
Biyoaktif Bileşenler	İçerik (mg/kg)
α-tokoferol	153-771
γ-tokoferol	223
δ-tokoferol	197

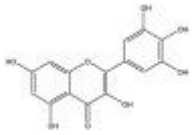
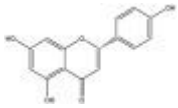
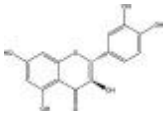
Saponinler, birçok bitki türünde bulunan steroidlerin, steroid alkaloidlerin (nitrojen fonksiyonlu steroidler) veya triterpenlerin glikozitleridir. Saponinler, anti-inflamatuar ve anti-sitotoksik aktivite, anti-trombotik yetenek, hemolitik, antifungal aktivite, antelmintik aktivite ve antioksidan aktiviteye sahip olduğu bildirilmiştir (Hu ve ark., 2012). Özellikle triterpenler, kolesterol ve lipid düşürücü etkiye sahiptir. Araştırmalar sonucunda, saponinlerin gastrointestinal sistemin düzenlenmesinde rol oynayabileceği düşünülmektedir. Yapılan bir çalışma, saponinlerin kanser hücreleriyle mücadeledeki potansiyelini ortaya koymuştur. Bununla birlikte, saponin türevlerinin anti-tümör mekanizması hakkında sınırlı araştırma bulunmaktadır. Triterpenoid saponinler ayrıca diyabet için potansiyel bir tedavi olarak umut vaat etmektedir (Qin ve ark., 2024). *C. oleifera* tohumlarından yağ ekstraksiyonundan sonra kalan küspe, saponinler açısından zengindir (Hu ve ark., 2012). Bu küspenin az kısmı, balık havuzlarını temizlemede ve gübre olarak kullanılsa da çoğu atılır (Yu ve ark., 2022a). Küspe, oleanan triterpenoid saponinler içerir. Bu bileşikler, emülsifiye edici özellikleri, özellikle mükemmel bir köpürme stabilizatörü olarak bilinir. Bir çalışmada, çay tohumlarındaki saponin içeriği 3.70 mg/100 g konsantrasyonda bulunmuştur (Qin ve ark., 2024).

Polifenoller, geniş biyolojik özellikler sergileyen ikincil metabolitlerdir. Yapısına göre fenolik asitler ve flavonoidler olarak sınıflandırılır. *C. oleifera* tohumu yağının polifenol içeriği 20.56-88.56 mg/kg arasında değişmektedir. Diğer yağlardan farklı olarak bu yağ, kamferol, kersetin gibi fenolik bileşiklere sahiptir (Gao ve ark., 2024). Polifenoller, antioksidan özelliklerinin yanı sıra alerjiyi hafifletme ve vücudu detoksifiye etme gibi çeşitli fizyolojik işlevlere sahiptirler (Qin ve ark., 2024). *C. oleifera'*da saptanan fenolik bileşikler Tablo 5'te gösterilmiştir.

Tablo 5. *C. oleifera*'nın fenolik madde içeriği (Wang ve ark., 2017; Li ve ark., 2022a)

Bileşikler	Kimyasal yapı	Moleküler Formül	İçerik (μg/g)
p-Hidroksi benzoik asit		$C_7H_6O_3$	0.1005–4.4000
Protokatekuik asit		$C_7H_6O_4$	2.2658–4.7972
Gallik asit		$C_7H_6O_5$	0.4640–1.5580
Benzoik asit		$C_7H_6O_2$	2.9457–12.1903
Ftalik asit		$C_8H_6O_4$	0.2214–0.8897
p-Hidroksifenil-asetik asit		$C_8H_8O_3$	1.3346–3.0780
Vanilik asit		$C_8H_8O_4$	1.6269–5.6877

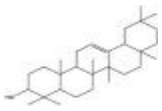
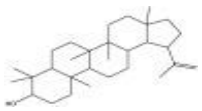
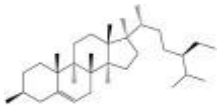
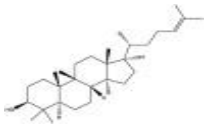
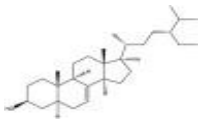
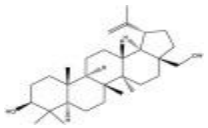
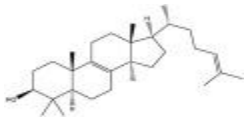
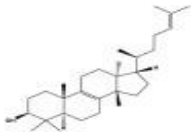
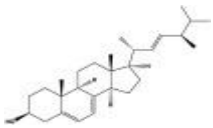
Bileşikler	**Kimyasal yapı**	**Moleküler Formül**	**İçerik (µg/g)**
Sinnamik asit		$C_9H_8O_2$	3.7156–10.6329
p -Kumarik asit		$C_9H_8O_3$	0.5171–1.0837
Kafeik asit		$C_9H_8O_4$	0.0106–0.0696
Ferulik asit		$C_{10}H_{10}O_4$	0.0455–0.1728
Sinapik asit		$C_{11}H_{12}O_5$	0.0462–0.2649
Klorojenik asit		$C_{16}H_{18}O_9$	ND~0.2031
Kateşin		$C_{15}H_{14}O_6$	0.6236–2.1696
Epigallokateşin		$C_{15}H_{14}O_7$	0.0459–0.5343
Epikateşin		$C_{15}H_{14}O_6$	0.1363–0.3393
Epigallokateşin gallat		$C_{22}H_{18}O_{11}$	0.1078–1.0243
Luteolin		$C_{15}H_{10}O_6$	NQ
Apigenin		$C_{15}H_{10}O_5$	0.0592–0.5594
Kemferol		$C_{15}H_{10}O_6$	ND~0.1602
Kuersetin		$C_{15}H_{10}O_7$	0.2262–1.4062

Bileşikler	Kimyasal yapı	Moleküler Formül	İçerik (μg/g)
Mirisetin		$C_{15}H_{10}O_8$	NQ
Naringenin		$C_{15}H_{12}O_5$	0.1554–1.8182
Taksifolin		$C_{15}H_{10}O_8$	ND~0.0092

Bitkiler aleminde yaygın bulunan flavonoidler antioksidasyon, antibakteriyel, antiviral, kanser, kardiyovasküler hastalıklar ve iltihaplanma gibi birçok hastalıktan koruyucu etkiler gösterir (Liu ve ark., 2014). Yapılan bir çalışmada, 40 farklı *C. oleifera* yağında toplam flavonoid içeriği %2.84 ile %8.68 saptanmıştır (Yu ve ark., 2022b). Flavonoidler kanser riskini, yaşlanmanın etkilerini ve kardiyovasküler hastalık riskini azaltan güçlü doğal antioksidanlardır (Chen ve ark., 2009). Beyin dokusunda inflamatuar faktörlerin ekspresyonunu engelleyerek oksidatif stresin neden olduğu hasarı azaltabilir, nöral hasar proteinlerini temizleyebilir ve nöronal apoptozu inhibe ederek yaşa bağlı bilişsel bozuklukları iyileştirebilirler (Chu ve ark., 2023). Bunun yanı sıra, serbest radikal temizleyiciler, indirgeyici ajanlar, lipid peroksidasyonuna karşı koruyucular ve reaktif oksijen türlerinin (ROS) söndürücüsü olarak önemli roller üstlenirler (Chen ve ark., 2009). Ayrıca mide koruması, anti-helicobacter pylori aktivitesi, antidiyabetik ve antioksidan etkiler de sergileyerek çok yönlü sağlık yararları sunarlar (Qin ve ark., 2024).

Fitosteroller, kolesterole benzer yapıya sahip doğal aktif maddelerdir. Birçok ülkedeki güncel diyet kılavuzları, kardiyovasküler hastalıkları önlemek için günlük en az 1.5–3 g fitosterol tüketilmesini önermektedir. Ancak standart bir diyet, önerilen eşik değerinin altında olan günde 200 ile 450 mg fitosterol içerir. Bu nedenle, *C. oleifera* içeren veya bundan türetilen gıda ürünleri gibi fitosterol açısından zengin gıdaların alımı, kardiyovasküler hastalıkların önlenmesine yardımcı olabilir. *C. oleifera*'nın fitosterol içeriği ve kompozisyonu, kaynak, çeşit, ekstraksiyon yöntemleri, ağaçların *büyüme koşulları ve tohumların* hasat zamanına bağlı olarak değişebilmektedir (Tablo 6) (Li ve ark., 2022a). Fitosteroller, vücuttaki kolesterol seviyelerini düşürmede çok önemlidir. Ayrıca, steroller antioksidan özellikler sergiler ve büyümenin teşviki, bağışıklık düzenlemesi ve hormon düzenlemesi gibi temel fizyolojik işlevlerde çok önemli roller oynarlar. Fitosteroller, kanserin önlenmesi ve tedavisi için ilaç olma potansiyelleri nedeniyle "yaşamın anahtarı" olarak etiketlenmiştir (Qin ve ark., 2024).

Tablo 6. *C. oleifera*'nın fitosterol içeriği ve kompozisyonu (Li ve ark., 2022a)

Bileşikler	Kimyasal yapı	Moleküler Formülü	İçerik (mg/kg)
β-amirin		$C_{29}H_{48}O$	607.24–913.35
Lupeol		$C_{30}H_{50}O$	121.00–381.17
β-sitosterol		$C_{30}H_{52}O$	ND~240.12
Kanofilol		$C_{30}H_{50}O_2$	110.66–174.97
Sikloartenol		$C_{30}H_{50}O$	164.00–1093.67
Stigmast-7-en-3-ol		$C_{29}H_{50}O$	269,73–493,55
Betülin		$C_{30}H_{50}O_2$	165,57–330,56
Lanosterol		$C_{30}H_{50}O$	715.19–1202.80
Tirukalol		$C_{30}H_{50}O$	73.00
Ergosterol		$C_{28}H_{44}O$	82.00

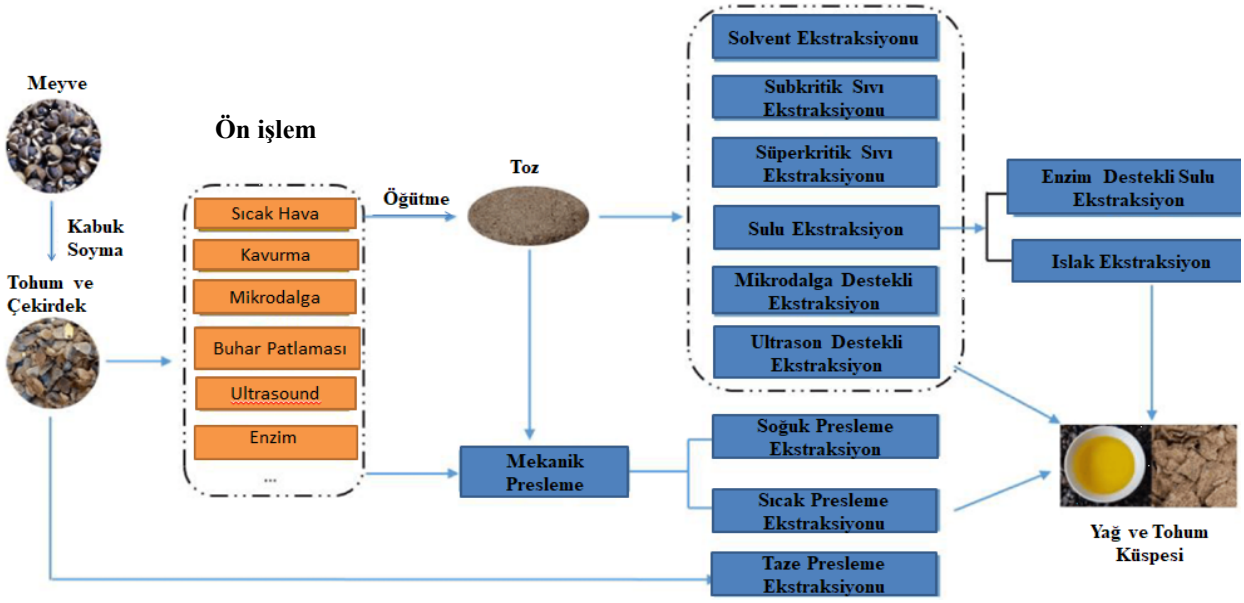
Skualen, çeşitli hayvan ve bitkilerde doğal olarak bulunan bir triterpenoid alifatik hidrokarbondur (Qin ve ark., 2024). Skualen, anabolik steroidler, D vitamini ve triterpenoidlerin sentezi için bir öncüdür. Süperoksit Dismutaz (SOD) aktivitesini arttırmak, vücut bağışıklığını arttırmak, cinsel fonksiyonu iyileştirmek, yaşlanma karşıtı, anti-yorgunluk ve anti-tümör gibi çeşitli fizyolojik işlevlere sahiptir (Gao ve ark., 2024). Çalışmalar, skualenin T lenfosit ve dendritik hücreler üzerindeki sistemik etkileri, gelişmiş bağışıklık bariyeri fonksiyonu, anti-inflamatuar etkiler ve potansiyel otoimmün yan etkiler dahil olmak üzere bağışıklık sistemi üzerindeki çeşitli biyolojik etkilerini göstermiştir (Qin ve ark., 2024).

Yapılan bir çalışmada *C. oleifera* yağındaki skualen içeriği 159.76-2083 mg/kg arasında saptanmıştır. Ek olarak, karakteristik triterpenoidler olarak az miktarda spinasterol (21.94-43.11 mg / kg) ve 24-metilen-sikloartan (126.60-266.26 mg / kg) içerdiği saptanmıştır (Gao ve ark., 2024).

Son çalışmalar, *C. oleifera*'dan saflaştırılmış monomer bileşikler ve polisakkaritler gibi bileşenlerin, antikanser, antioksidan, antienflamatuar, antimikrobiyal, anti-melanogenez, nöroprotektif, kardiyo koruyucu, hepatoprotektif, gastroprotektif, hipoglisemik, immünoregülatör, hipolipidemik, anti-hipertansif ve gibi geniş farmakolojik özelliklere sahip olduğunu göstermiştir (Luan ve ark., 2022).

CAMELLIA OLEIFERA YAĞININ EKSTRAKSİYON YÖNTEMLERİ

C. oleifera yağının verimini ve kalitesini artırmak için genellikle uygun ön işlem prosedürlerine ihtiyaç vardır. Başlıca ön işlemler; temizleme, kabuk soyma, kabuk ayırma, kurutma ve boyut küçültme (öğütme, kırma vb.) aşamalarını içerir (Şekil 5). Sonraki ekstraksiyon teknolojisine bağlı olarak, ön işlem işlemi farklı adımlardan oluşabilir. Ön işlem için enzimler kullanılabilir. Ön işlemin ana amaçları, nem içeriğinin modülasyonu, hücresel yapının bozulması, yağ hareketliliğinin iyileştirilmesi ve aroma bileşiklerinin oluşumudur. Sıcak hava işlemi, kavurma, fırınlama ve pişirme gibi geleneksel ön işlem yöntemleri, genellikle aşırı ısınma ve istenmeyen kimyasal reaksiyonlar riski olan termal işlemleri içerir. Kızılötesi ve mikrodalga ısıtma ve buhar patlaması gibi yenilikçi ön işlem yöntemleri genellikle ya termal olmayan ya da yüksek sıcaklıkta kısa süreli işlemlerdir (Li ve ark., 2022b).



Şekil 5. *C. oleifera* yağının ekstraksiyon yöntemleri (Li ve ark., 2022b).

Ön işlem teknolojileri, çay tohumu yağının kalitesi ve verimi üzerinde karmaşık etkilere sahiptir. Uygulanan enerji, yağlı tohumların hücre yapısını parçalayabilir ve çay tohumu yağlarının verimini ve kalitesini artırabilir. Bununla birlikte, aşırı ısıl işlem besin maddelerini bozabilir ve zararlı maddelere dönüştürebilir. Yenilikçi ön arıtma yöntemleri, düşük enerji tüketimi ve yüksek verimlilik gibi avantajlar sunar, ancak ekonomik ve teknik fizibiliteleri daha fazla araştırma yapmak gerekir (Li ve ark., 2022b).

Ekstraksiyon, yağın kalitesini ve verimini etkileyen en önemli işlemdir. *C. oleifera* yağı eldesinde ana geleneksel yöntemler; sıcak presleme, soğuk presleme ve geleneksel solvent ekstraksiyonunu içerirken son yıllarda, subkritik ekstraksiyon, süperkritik ekstraksiyon, sulu enzimatik ekstraksiyon, ultrasonik ekstraksiyon ve kombine ekstraksiyon yöntemleri uygulanmaktadır Kullanılan her ekstraksiyon tekniğinin birbirine göre avantaj ve dezavantajları vardır (Tablo 7). Yönteme bağlı olarak yağın verimi ve kalitesi değişmektedir. (Gao ve ark., 2024).

Tablo 7. *C. oleifera* yağı eldesinde kullanılan ekstraksiyon tekniklerinin avantaj ve dezavantajları (Li ve ark., 2022b).

Ekstraksiyon Yöntemi	Avantajları	Dezavantajları
Sıcak presleme (HPE)	Düşük yatırım maliyeti ve kolay kullanım	Yüksek işlem sıcaklığı, düşük yağ ve tohum kalitesi ve karmaşık arıtma işlemi gerektirir
Soğuk presleme (CPE)	Kolay kullanım, HPE'ye kıyasla daha iyi yağ ve tohum kalitesi ve daha basit rafinasyon	Düşük verim
Taze presleme (FPE)	Yüksek verim ve üstün kalite, birden fazla bileşenin aynı anda geri kazanılmasına olanak tanır	Artan yatırım maliyeti, ek ve sıkıcı operasyonlar gerekiyor
Solvent ekstraksiyonu (SE)	Düşük yatırım maliyeti ve yüksek verim	Yüksek işleme sıcaklığının yanı sıra tehlikeli solvent tüketimi ve kalıntısı, düşük yağ ve tohum kalitesine neden olur ve karmaşık bir arıtma işlemi gerektirir
Sulu ekstraksiyon (AE)	SE ile karşılaştırıldığında daha iyi yağ kalitesi, daha az solvent tüketimi ve daha az rafinasyon ve birden fazla bileşenin aynı anda geri kazanılmasına olanak tanır	Düşük verim ve uzun ekstraksiyon süresi, artan yatırım maliyetinin yanı sıra ıslak koşullarda karmaşık çalışma ve atık su deşarjı
Islak ekstraksiyon (WE)	Önemli ölçüde azaltılmış su tüketimi ile AE'den geliştirilmiştir	Birden fazla bileşenin aynı anda alıkonması için uygun değil
Enzim destekli sulu Ekstraksiyon (EAE)	Gelişmiş ekstraksiyon verimliliği ve özgüllüğü ve daha hafif çalışma koşulu ile AE'den geliştirilmiştir	Yüksek enzim maliyeti
Süperkritik akışkan ekstraksiyonu (SCFE)	Yüksek verim ve üstün kalite, çevre dostu ve hafif işleme koşulları	Yüksek basınç, yüksek sermaye ve işletme maliyeti ve düşük verim
Subkritik akışkan ekstraksiyonu (SFE)	SE ile karşılaştırıldığında daha iyi yağ kalitesi, AE'den daha yüksek verim, daha az işlem süresi ve solvent kullanımı	Yüksek sıcaklık ve artan basınç, yüksek sermaye ve işletme maliyeti
N-bütan kullanarak subkritik sıvı ekstraksiyonu (SFE)	SE ile karşılaştırıldığında daha iyi yağ ve tohum kalitesi, yüksek verim, azaltılmış işlem süresi ve hafif işleme koşulu	Artan basınç, yüksek sermaye ve işletme maliyeti, ek güvenlik yönetimi gerektirir
Mikrodalga destekli ekstraksiyon (MAE)	Geliştirilmiş verim ve azaltılmış işleme süresi	Yüksek sıcaklıklar ve ekstra enerji gereksinimleri

Mikrodalga, biyolojik enzim, ultrasonik ve süper/alt kritik sıvı ekstraksiyonu gibi giderek daha fazla gelişmiş modern teknolojiler, çay tohumu yağı çalışmalarında dikkat çekici sonuçlar elde etmek için uygulanmıştır. Yeni teknolojiler, çay tohumu yağının yalnız geleneksel ekstraksiyon yöntemiyle çıkarıldığı uzun süredir var olan tek tip modeli değiştirmede etkili olmuştur ve *C. oleifera* yağ üretim yöntemi, modern endüstriyel üretim sürecine girmiştir. Bu da gelecekte *C. oleifera* yağ endüstrisinin büyük ölçekli gelişimi ve canlanması için temel oluşturmuştur (Gao ve ark., 2024).

SONUÇ

C. oleifera yağı, Çin'in güneyinde binlerce yıldır yemeklik olarak yaygın kullanılan saf ve doğal yüksek kaliteli bir üründür. Doymamış yağ asitleri bakımından zenginliği ve yüksek besin

değeri nedeniyle Dünya sağlık örgütü tarafından yüksek kaliteli bir yemeklik yağ olarak önerilmiştir. Doymamış yağ asitlerine ek olarak, C. *oleifera* yağı, antioksidan, antibakteriyel, antienflamatuar, antidiyabetik, antikanser, nöroprotektif ve kardiyovasküler koruyucu özelliklerine katkıda bulunan fonksiyonel bileşikler içermektedir. C. *oleifera* yağı ve biyoaktif bileşenleri hakkında bilgi fazlayken özellikle modern ekstraksiyon yöntemlerinin uygulanışına ilişkin çalışma sayısı azdır. Ülkemizde yetiştirilmeyen bu çay çeşidinin tanıtılması konusunda çalışmalar yapılmalıdır.

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AN APPROACH TO USING RAMAN SPECTRUM TO DISTINGUISH QUARTZ MINERALS OF DIFFERENT COLORS

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ABSTRACT

Quartz is an essential mineral of rock-forming component of the earth. It appears in different colours depending on the trace element content and with different shapes due to their highly variable chemical structure. This study aims to determine the Raman characteristics of different quartz minerals depending on their colour changes, detected by Confocal Raman Spectrometry (CRS).

This study performed Raman measurements on the five different quartz samples. These are Smoky Quartz, Rose Quartz, Citrine, Pure transparent Crystal and Amethyst. The Raman spectra were recorded in the range of 100–1000 cm^{-1}, focusing on characteristic vibrational modes associated with quartz structure.

The Raman spectrum of quartz typically shows prominent Raman peaks at certain Raman shift wavelengths, these are around 464 cm^{-1} (Si-O symmetric stretching mode) and 798 cm^{-1} (Si-O bending mode). The obtained Raman spectra, the main 6 Raman peaks of quartz minerals can be continuity detected around 134 cm^{-1}, 211 cm^{-1}, 270 cm^{-1}, 360 cm^{-1}, 400 cm^{-1} and 470 cm^{-1}.

When the Confocal Raman spectra of Citrine and Pure transparent Crystal were examined, the presence of another peak around 515 cm^{-1} shift, which was not present in the other samples, was detected. Confocal Raman Spectrometry of Pure transparent Crystal, can be identified as Carnelian, which is a distinct microcrystalline quartz variety. The results of this study reveal that variations in Raman shift wavelengths provide a reliable approach to identifying different quartz types and their compositional differences. With the help of Confocal Raman Spectrometer, different colors of quartz can be identified using minor peaks of Raman spectra.

Key Words: Quartz, Confocal Raman Spectroscopy, Carnelian

INTRODUCTION

Quartz varieties appear in different colours and are valued as items of beauty. Quartz is also decorative and used in carvings as a jewellery stone. Depending on their environment and chemical composition, quartz colour type changes.

The most plentiful quartz in nature is rock crystal, which is colourless and transparent. Although there are excess amounts of colourful quartz, such as rose quartz, citrine, smoky quartz, amethyst, and blue quartz found in natural and synthetic forms, these are highly valuable in the jewellery market (Nassau 1980, 1983; Ballman 1961).

The colour of quartz changes depending on its trace element content. An amethyst's violet colour was observed because of the unusual charge state of Fe^{4+} in the structural sites of quartz; however, this conclusion is still inconclusive about the amethyst colour (Di Benedetto et al. 2010). Citrine's yellow to brown colours are due to ferric iron and Fe^{3+}- Fe^{2+} charge transfer. Most citrines come from heated amethyst specimens, and this process is irreversible. Although the citrine colour is not proven, Fe^{3+} inclusions of oxides and hydroxides are highly believed to be responsible (Lehmann, 1977). Smoky quartz is coloured by Al^{3+} instead of Si^{4+}, which forms $[A1O_4]^{4-}$. Alkali metal ions are also introduced (Pankrath, 1991). According to Holden (1924a, 1924b), the rose quartz colour is due to Mn^{3+} pigmentation. Later, other researchers found that the colour of the rose quartz may depend on the presence of Ti^{3+} (Wright et al. 1963; Lehmann, 1969; Cohen and Makar, 1984).

Quartz mineral has two different microstructures. The difference between the two types is crystal visibility. The first one is microcrystalline, where varieties are made of tiny crystal grains that are visible within an optical microscope, and the second is macrocrystalline, where varieties develop visible crystals or are made of large intergrown crystals.

During Raman scattering, the energy of the scattered light interacts with the molecule according to that of the light interacting with it. The energy differences between the vibrational energy levels of the molecule interacting with the light are calculated. For this reason, information about the vibrational energy levels of molecules can be obtained by spectroscopic examination of Raman scattering and this spectroscopic method is called Raman spectroscopy (Akçe, M. A., Kadıoğlu Y. K, 2020)

This study aims to find the changes in the quartz colour varieties depending on the Confocal Raman Spectrometry (CRS) technique. The CRS method is determined for the vibrational modes of the sample and provides chemical, physical, and structural insight. The CRS technique could determine the quartz varieties and show their Raman shifts, which are expected at the low-frequency levels (50 – 1200 cm^{-1}).

METHODOLOGY

The thin sections were made at the Ankara University Earth Sciences Application and Research Center (YEBİM) Laboratory, and Confocal Raman Spectrometry analysis is also carried out at the YEBİM Laboratory utilizing an analytical confocal microscope, specifically the Thermo DXR model confocal Raman spectrometer, with Labspec 4.02 software as the analysis method. Analysis carried out at the laser wavelength of 633nm at the laser power of 8mW with 25 μm slit confocal hole, and spectra were obtained using a CCD detector.

CONCLUSION AND DISCUSSION

The quartz minerals on Earth appear in different colours. The quartz we used in this study is Smokey Quartz, Rose Quartz, Citrine, Pure transparent Quartz, and Amethysts. With these samples, we conclude the Raman Spectrum experiments.

Obtained Raman spectrum from quartz minerals is divided into two different quartz crystalline forms. Macrocrystalline group of quartz (visible crystals or are made of large intergrown crystals) are Amethyst identified as Amethyst, Citrine identified as Citrine, Rose Quartz identified as Quartz, and Smoky Quartz identified as Quartz. The microcrystalline group of quartz (visible with the help of an optical microscope) is Pure transparent quartz, which is identified as Carnelian.

When obtained, Raman shifts of quartz minerals examined Pure transparent quartz, which was identified as Carnelian, showed an extra peak around 515cm$^{-1,}$ which is not seen at the other samples. On the contrary, the Microcrystalline group of quartz shows an extra pick, which is not observed with the Macrocrystalline. At the range of 100-1200cm^{-1}, obtained Raman shifts made it into a tabulated form and examined identified main peak at between 465-475cm^{-1} with the highest Raman intensity, remaining supportive peaks are between 120-135cm^{-1}, 200-210cm^{-1}, 350-365 cm^{-1} and two symmetric peaks between 390-410cm^{-1}. Raman shifts of 150-200cm^{-1} and 300-350cm^{-1} did not detect any peaks. There are six prominent Raman peaks observed in quartz.

Table 1 *Quartz samples peaks the green shaded are is main peak and yellow shaded area extra peak of carnelian.*

	Citrine	Pure Transparent Crystal	Smoky Quartz	Rose Quartz	Amethyst
100-150	125,81	134,98	134,36	134,98	127,67
150-200	NO PEAKS DETECTED				
200-250	203,82	213,61	211,75	214,23	206,92
250-300		271,19	269,95	270,57	263,26
300-350	NO PEAKS DETECTED				
350-400	353,65	361,58	360,96	360,96	353,65
350-400	390,18	399,97	399,35	399,97	390,8
398-450	398,23	408,63	408,01	408,01	402,56
450-500	462,62	471,78	469,93	471,17	462,62
500-550		515,74			
800+	803,76	814,16	813,54		808,71

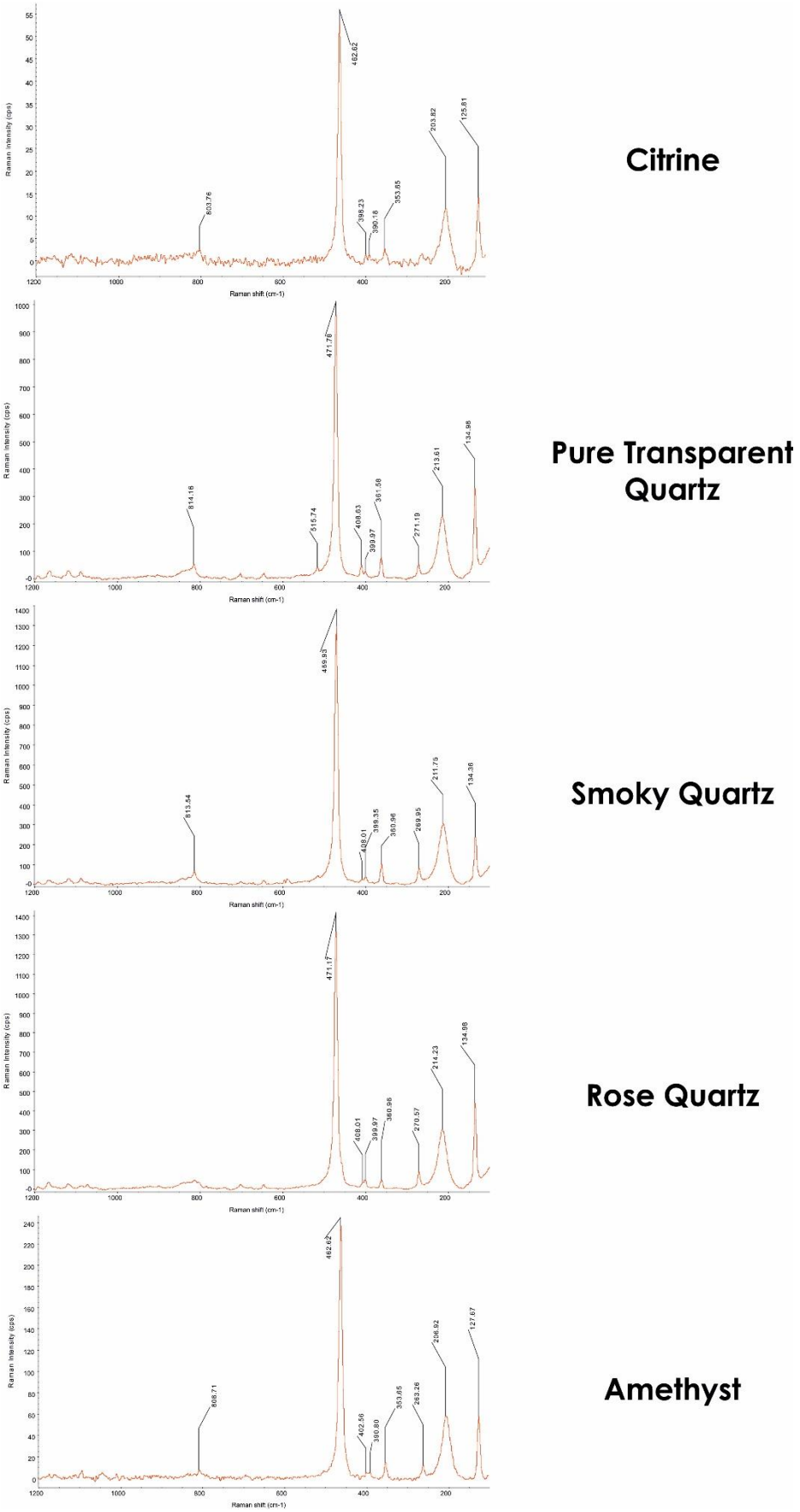

Figure 1 *The Raman Spectra of the analyzed Quartz samples*

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INVESTIGATION OF DENSITY, THERMAL, AND CHEMICAL PROPERTIES OF HAZELNUT SHELL FLOUR-FILLED EPOXY COMPOSITES

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ABSTRACT

The most significant challenges associated with epoxy utilisation worldwide pertain to the environmental sustainability of prevalent epoxy formulations and their tendency to exhibit an unnatural colouration. This study explores the integration of hazelnut shell flour (HSF) into epoxy resin, with the objective of developing eco-friendly and natural-looking composite materials. HSF was incorporated into epoxy resin in varying proportions, utilising a manual approach with a glass rod for agitation. Subsequent to this, a hardener was added to the mixture, followed by a further manual mixing process. The resultant mixtures were then transferred into silicone moulds and left to set for a period of 24 hours at room temperature. Epoxy composites with diverse HSF content were meticulously prepared and subjected to rigorous analysis to assess their density, thermal properties, and chemical interactions. The FTIR spectrum of HSF is analogous to that of natural fibres as documented in extant literature. Variations in the thermal properties, with a magnitude of approximately 1 to 2°C, were observed in the region of the glass transition temperature and T(max). In regard to the optimal content, 20% HSF was identified as providing the optimal density and thermal stability. FTIR analysis of the HSF-epoxy composite confirmed the strong chemical bond between the epoxy resin and HSF, thereby suggesting an improvement in interfacial adhesion. Conversely, increased weight losses and ash content during thermal degradation were observed with higher HSF content (over 20%), indicating a decrease in thermal stability.

Key Words: Hazelnut shell flour, Epoxy composites, Sustainable materials, Thermal stability, Lightweight materials

INTRODUCTION

Research on composite materials containing natural fillers has been stimulated by a heightened interest in the use of sustainable materials, especially in areas of agricultural waste like hazelnut shells (HS). Traditionally, these have been potential fillers for property enhancement in epoxy resins with added advantages of their minimal environmental impact owing to their high cellulose, hemicellulose, and lignin. The chemical constituents of the hazelnut shell potential, including approx. 43% lignin, 26% cellulose, and 30% hemicellulose, allow them to act as reinforcing fillers in composite materials (Cruz-Lopes et al., 2024). Thus, not only do they impart strength, but they also make the composites more environmental-friendly, emphasizing the current trend of growing attention toward sustainable materials in different sections of the industry (Ceraulo et al., 2022).

It has been observed that addition of hazelnut shell flour (HSF) in epoxy matrices tends to positively alter the mechanical and thermal properties of the composites. It has been shown that the incorporation of natural fillers improves tensile strength and thermal stability; however, achieving effective interfacial adhesion between the filler and the matrix is still a challenge (Bahrami et al., 2020; Sienkiewicz et al., 2022). Other factors, such as the type of filler, the type of matrix material and processing conditions will play vital part in influencing the

mechanical properties of composites (Gargol et al., 2021). In addition, it is shown that interaction of the epoxy resin with natural fillers can lead to performance properties being improved; the research showed that the addition of organic fillers can improve the thermal and mechanical properties of epoxy composites (Li et al., 2019). Furthermore, the objective is divided into two distinct aims: firstly, to reduce the unit cost of the composite material, and secondly, to enhance the natural appearance of the composite material.

Notwithstanding, the incorporation of HSF is an arduous process. The filler agglomeration results in a reduction of tensile strength, owing to the presence of stress concentration points within the epoxy matrix(Qi et al., 2014). To optimize the properties of the composites, thermal stability has to be stabilized alongside perfect dispersion of the filler (Kumar et al., 2019). Some work suggests that higher filler contents are usually correlated with lower mechanical properties of composites which indicates that a compromise must be made between the filler content and the required performance characteristics (Karagöz et al., 2024; Pradhan & Satapathy, 2022) .

The study is directed toward determining the effects of hazelnut shell flour on epoxy composites in terms of density, thermal behavior, and chemical interactions. Once this understanding is obtained, it will then be possible to engineer the composition of HSF-filled epoxy composites toward specific applications of focus that are lightweight structural materials.

EXPERIMENTAL DETAILS

Materials

The hazelnut shell were collected by the BTÜ - Central Research Laboratory in the region of Giresun-Turkey, respectively. Epoxy resin and its hardener were bought Admiral-Turkey.

Preparation of hazelnut shell flour filled epoxy composites

Hazelnut shells were milled by using Pulverisette 14 FritschTM Germany with 0.2 µm sieve and titanium knife at 5 min for obtaining hazelnut shell flour. Hazelnut shell flour were added in epoxy resin in different amounts and mixing using by hand using glass rod. After mixing, hardener was added in the mixture and again mixing by hand. These mixtures were poured in the silicone mould and waited for 24 hours in the room temperature. The hazelnut shell flour content in the resin and sample code were given in the Table 1. The production summary chart is given in Figure 1.

Characterizations of the samples

Particle size measurement

The particle size distribution of hazelnut shell flour dispersed in water was determined using a laser particle size analyzer (Mastersizer 3000E, Malvern).

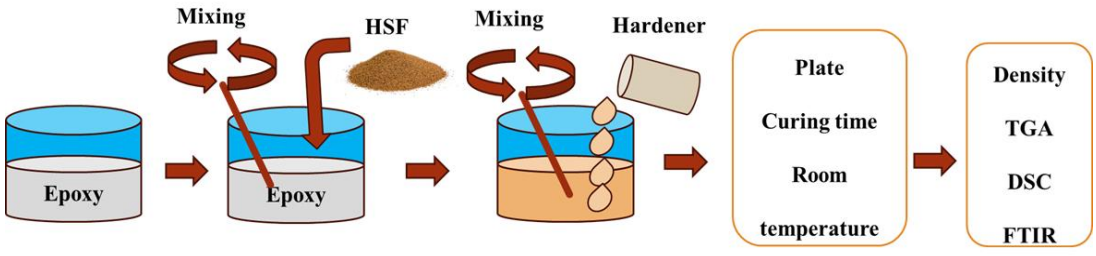

Figure 1. Production diagram of HSF filled epoxy plate

Table 1. Compositions and sample codes of hazelnut shell flour filled epoxy based composites.

Sample Content	Sample Code
Epoxy	E
Epoxy – 5% hazelnut shell flour	E – 5H
Epoxy – 10% hazelnut shell flour	E – 10H
Epoxy – 20% hazelnut shell flour	E – 20H
Epoxy – 30% hazelnut shell flour	E – 30H
Epoxy – 35% hazelnut shell flour	E – 35H

Fourier transform infrared (FTIR) spectroscopy analysis

FTIR analyses of the samples were carried out by Nicolet İ50 spectrophotometer with smart iTR ATR apparatus. The spectra of the samples were taken in between 600 and 4000 cm-1 with 16 scans.

Density measurement

The densities of samples were examined with a Shimadzu-Aux321 balance according to ISO 1183 by using Archimedes principle method.

Differential Scanning Calorimetry (DSC) analysis

DSC Discovery 250 instrument (TA instruments, USA) analysis was performed with hazelnut shell flour filled epoxy based composites. In order to remove the thermal history, heat from 20 ˚C to 200 ˚C for 1 minute, then cool to 20 ˚C and reheat to 200 ˚C at a consistent rate of 10 ◦C/min using a nitrogen atmosphere (50 mL min^{-1}).

Thermogravimetric analysis (TGA)

TA Instrument model Discovery SDT 650 was used for TGA analyses. Samples weight were about 5-10 mg. Heating range was 25-600 °C. The atmosphere was nitrogen and speed was 10 °C/min.

RESULTS AND DISCUSSION

Characterization of the hazelnut shell flours

TGA thermogram, particle size measurement and FTIR spectrums of hazelnut shell flours can be seen in Figure 2. The thermal analysis of hazelnut shell flour showed that the material had a moisture content (W1) of 9.46%, a volatile matter content (W2) of 64.05%, maximum decomposition temperature (Tmax) at 310.22°C, and an ash content of 26.45%. This indicates the relative high volatile matter content of hazelnut shell flour, since these values fall under those typical for organic materials, and significant ash content meaning inorganic residues will remain after combustion. From particle size distribution 10% of the particles (D10) are less than 5.65 µm, 50% of the particles (D50) are less than 36.5 µm while 90% of the particles (D90) are less than 161 µm. This feature delivers a relatively fine particle size, which might be beneficial for its adoption in applications requiring high surface areas. The hazelnut shell flour, on the contrary, had characteristic bands relative to its organic constituents e.g. C-O stretching vibration from cellulose and hemicellulose between 1000 and 1200 cm^{-1} these spectral peaks are observed at regions 1600-1700 cm^{-1} C=O stretch vibrations from carbonyl groups in lignin and other organic compounds and CH stretching of methylene and methyl groups at around 2900-3000 cm^{-1}.

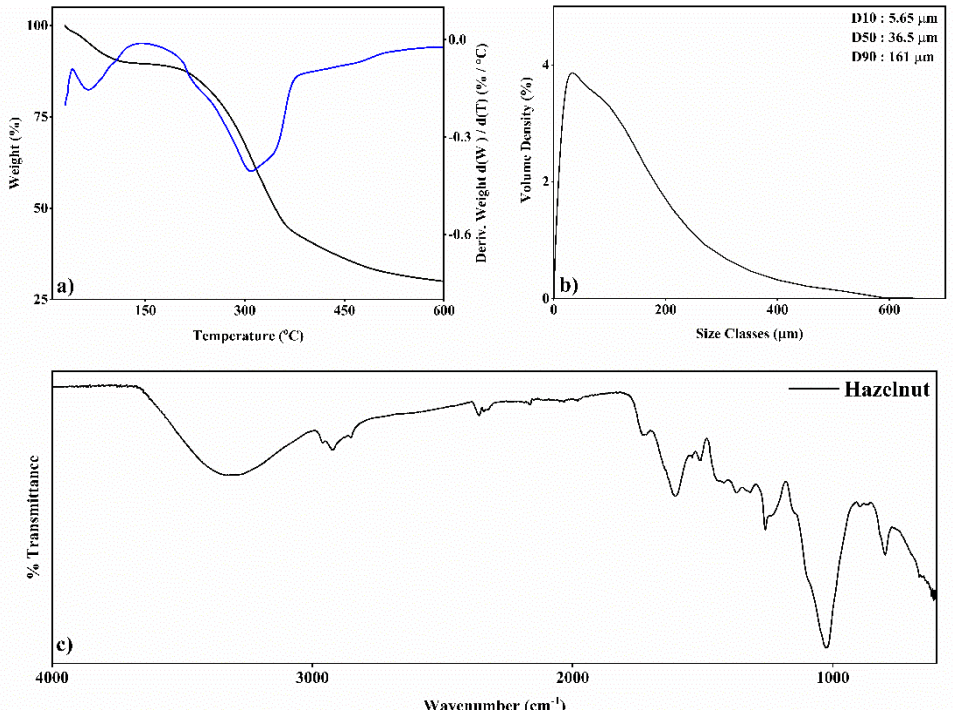

Figure 2. TGA thermogram, particle size measurement and FTIR spectrums of hazelnut shell flours.

Fourier transform infrared (FTIR) spectroscopy analysis

The FTIR spectra of the epoxy based composites can be seen in Figure 3. The analysis of the chemical structure and functional groups of epoxy resin samples filled with different proportions of hazelnut shell flour, using Fourier Transform Infrared Spectroscopy (FTIR), suggests a rather robust interaction of the organic filler with the epoxy matrix. The specific bands of the epoxy resins C-O-C stretch-type ether vibrations, ranging from 900 to 1100 cm^{-1}; C=C stretch-type vibrations of aromatic compounds in the range of 1500-1600 cm^{-1}; and OH stretching around 3300 to 3500 cm^{-1}. These bands are representative of chemical bonding during polymerization of epoxy and indicate the existence of hydroxyl groups probably coming from moisture or other sources (Sienkiewicz et al., 2022). The hazelnut shell flour, on the other hand, possessed characteristic bands pertaining to its organic content, for example: C-O stretching vibration from cellulose and hemicellulose between 1000 and 1200 cm-These spectral peaks are observed at regions 1600-1700 cm^{-1} C=O stretch vibrations from carbonyl groups in lignin and other organic compounds and CH stretching of methylene and methyl groups at around 2900-3000 cm^{-1}. Presenting these bands proved that the source of organic is hazelnut shell flour conformed with the epoxy matrix interactions (Sienkiewicz et al., 2022). For example, the cohabitation of hazelnut shell flour boosts the intensity of absorption bands in the areas 1000-1200 cm^{-1} and 1600-1700 cm^{-1}. Contributions of cellulose, hemicellulose, and lignin from hazelnut shell flour could be cited for boosting these marks. That means these components are interconnected into an epoxy framework. Changes in intensity of hydroxyl bands of the 3300-3500 cm^{-1} region may indicate hydrogen bond formation among the hydroxyl units present in both epoxy resin and hazelnut shell flour perhaps improving interfacial adhesion and compatibility of this composite (Piyanirund et al., 2021; Sienkiewicz et al., 2022). It may also indicate that new bands might occur as a result of shifting or formation, which further suggests chemical interactions between the epoxy and hazelnut shell flour. Modifications in the mechanical properties such as improvement of strength and flexibility could show that these interactions will happen in this composite. Such observation is consistent with other research works which have shown that mechanical performance improved when natural fibers/fillers were incorporated in epoxy matrices, attributed to better interfacial bonding and chemical compatibility. Therefore, FTIR result showed that the introduction of hazelnut shell flour

caused a huge swing in the chemical structure of epoxy resin. The successful incorporation of the filler into the epoxy matrix can be suggested based on the effect of increasing the intensity of the bands associated with cellulose, hemicellulose, and lignin. These chemical interactions are meant to be understood for optimizing the various mechanical and thermal properties of the composite materials, which could be further exploited in different engineering purposes (Sienkiewicz et al., 2022).

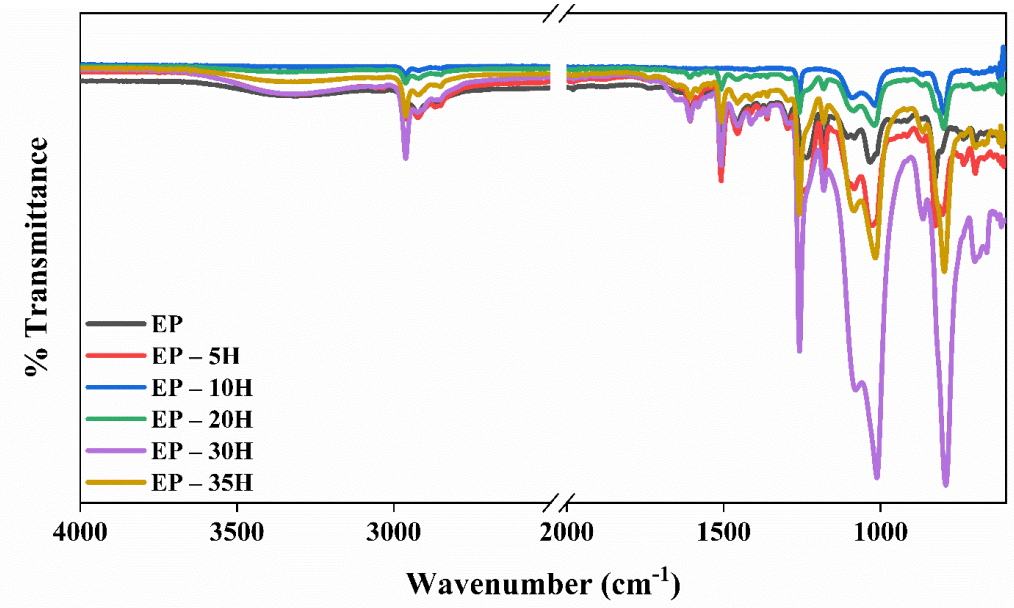

Figure 3. FTIR spectrums of the epoxy based composites.

Density measurement

Table 2show the density results of the epoxy based composites The measurements of density of epoxy-based composites with HSF show a definite trend depending on the filler content. Pure epoxy has a reference density of 1.167 ± 0.004 g/cm³. The addition of HSF to the composite increases its density initially and reaches a maximum at 20% HSF (E -20H) with a density value of 1.185 ± 0.007 g/cm³. This indicates the HSF densifies this composite up to this point because of its probably incorporation within the epoxy matrix; however, the density starts to decrease again after the 20% HSF content. The density of 30% HSF sample (E - 30H) is recorded as 1.170 ± 0.003 g/cm³, whereas the sample of 35% HSF (E-35H) has the lowest density of 1.162 ± 0.002 g/cm³. The decrease in density was attributed to lower density in HSF than that of epoxy matrix, which resulted in less dense composite at higher concentrations of filler. The data show that it is about 20% content of HSF in the composition, which serves the purpose of bringing the composite to higher density, past which the density would be less. This trend is consistent with much literature stating that excessive filling in the material reduces the properties because of poor resin wetting and agglomeration of fillers. These results are valuable for applications where density plays an important role, such as lightweight structural materials. Future research will focus on the mechanical and thermal properties of these composites for optimization of HSF incorporation, targeting specific applications (Barczewski et al., 2019; Raju & Kumarappa, 2012).

Table 2. Density measurement results of the epoxy based composites.

Sample Code	Density (g/cm^3)
EP	1.167 ± 0.004
E – 5H	1.171 ± 0.003
E – 10H	1.184 ± 0.012
E – 20H	1.185 ± 0.007
E – 30H	1.170 ± 0.003
E – 35H	1.162 ± 0.002

Thermal analysis

Table 3 and Figure 4-5 show the thermal results of the epoxy based composites. The Tg of pure epoxy was recorded at 48.81°C, while the inclusion of hazelnut shell flour kept Tg values within the 47-50°C range. Said stability means that the filler does not in any way significantly influence the glass transition temperature of the epoxy matrix, which has also been reported in other studies indicating that some fillers such as graphene oxide do not appreciably influence Tg upon incorporation into epoxy systems (Samsudin et al., 2022). Interestingly, E - 35H, that is, the composite with 35% hazelnut shell flour, showed a slight increase in Tg, reaching 49.98°C. This increase may be a result of the increased rigidity in the polymer matrix due to further loading with filler, which confirms the observations made in other composite materials, where higher content of fillers increased crosslinking density (Samsudin et al., 2022; Wang et al., 2020). Weight loss data by which thermal degradation behavior of the composites was assessed are specifically noted as W1 and W2. W1, which probably marks the moisture or volatile components loss, was recorded as increasing with filler loading from 9.46% for pure hazelnut shell flour to 23.39% for the 35% filled composite (E - 35H). Such observations imply, on the one hand, that adding hazelnut shell flour introduces relatively more thermally labile components into the epoxy system, which, on the other hand, was seen in the case of other composite study considerations where organic fillers contributed to weight loss through thermal instability (Chaudhary et al., 2024; Huang et al., 2020). In contrast, W2, which marks the main decomposition stage, went down from 74.48% for pure epoxy to 55.79% for the 35% filled composite. This means, at high temperatures, higher filler content is destabilizing for the epoxy matrix. This is a general observation in several other studies where increased filler loading disrupts the thermal integrity of the polymer matrix (Kavimani et al., 2021; Kumar et al., 2019). The maximum decomposition temperature (Tmax) was, however, quite preserved from sample to sample with a modest range of 364-368°C, implying thereby the addition of HSF does not interfere much with thermal degradation mechanisms of the epoxy. This observation finds further credence in studies of some fillers, which do not appreciably affect Tmax and keep the thermal degradation characteristics of the mother polymer intact (Gao et al., 2015; Rybak et al., 2018). A considerable increase in ash content, however, was noted, with an increase in the filler ratio, from 9.77% for pure epoxy to 20.34% for the 35% filled composite. An increase in this respect signifies higher inorganic content introduced by the hazelnut shell flour, in agreement with the findings of other studies, wherein the inclusion of inorganic fillers caused an increase in ash content due to their non-combustible nature (Rybak & Gaska, 2015; Vaisakh et al., 2014). To summarize, from all these results, hazelnut shell flour can be a good filler for epoxy composites, but its addition has an outstanding impact on thermal stability, especially at higher loading levels.

Table 3. Thermal test results of hazelnut shell flour filled epoxy composites.

Sample Code	Tg (°C)	W1(%)	W2(%)	Tmax(°C)	Ash(%)
EP	48.81	15.82	74.48	368.66	9.77
E – 5H	47.18	16.14	73.01	367.10	11.68
E – 10H	49.78	14.45	73.06	364.24	12.42
E – 20H	50.17	19.62	63.47	368.19	17.21
E – 30H	48.62	23.23	58.60	367.82	18.65
E – 35H	49.98	23.39	55.79	366.77	20.34

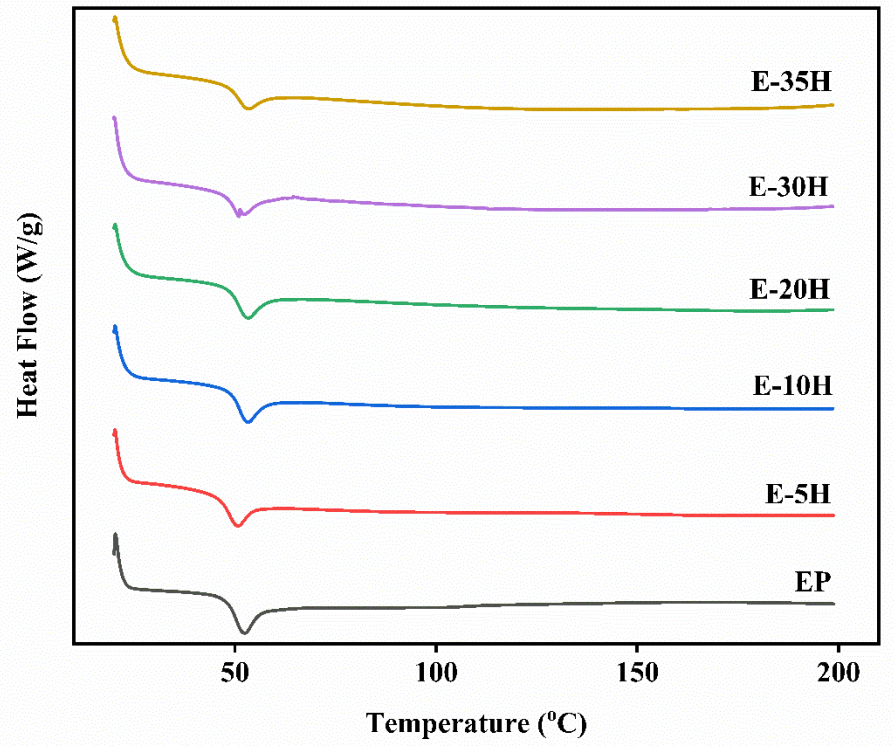

Figure 4. DSC thermograms of epoxy based composites.

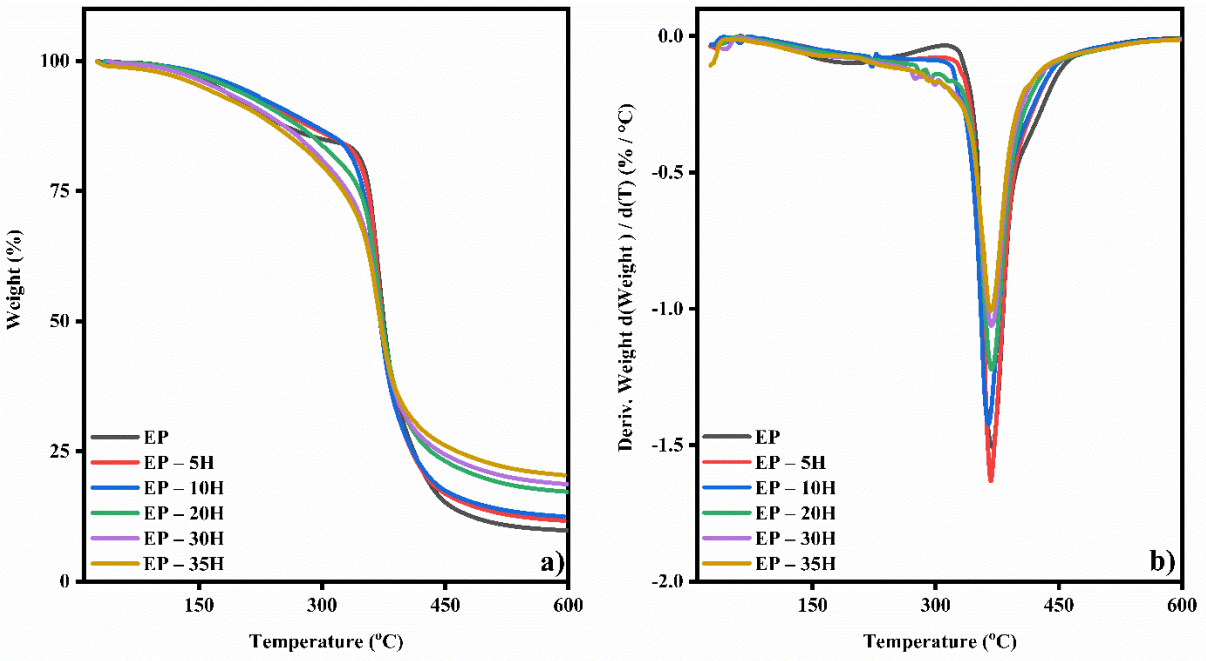

Figure 5. TGA thermograms of the epoxy based composites.

CONCLUSION

The present investigation presents hazelnut shell flour as a filler for epoxy composites to create sustainable alternatives for synthetic fillers. Moreover, it has been shown that the use of HSF has an effect on the density, thermal stability, and otherwise chemical interaction with the epoxy matrix. As for the optimal content, 20% of HSF gave the best density and thermal stability. FTIR analysis of HSF-epoxy composite confirmed its strong chemical bond between epoxy resin and HSF, which suggests that the interfacial adhesion has been improved. On the contrary, increased weight losses and ash content during thermal degradation were observed with higher HSF content (over 20%), showing a decrease in thermal stability.

The present findings present hazelnut shell flour as a possible alternative viable filler for epoxy composites with a specific attention to the lightweight and eco-friendly property required in applications. Future studies need to direct optimization of the mechanical properties and evaluation of real performance of these composites. Using agricultural by-products such as hazelnut shells, rather than synthetic and expensive raw material, opens a path toward developing lightweight and sustainable solutions to achieve increasing opportunities for the environment with ecoreMED materials in various industries.

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EXPLORING DYEING PROCESSES FOR ENHANCED RUBBING FASTNESS IN SHOE LINING LEATHERS

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ABSTRACT

Dye transfer from shoe lining leathers to socks or human skin is a prevalent issue in the footwear industry, often resulting in consumer dissatisfaction. One of the key factors in preventing this problem is the rubbing fastness of dyed leathers, which is significantly influenced by the dye type and dyeing process used. This study investigates the impact of various dye types and dyeing methods on the rub resistance properties of shoe lining leathers. Specifically, acid dyes, 1:2 metal complex dyes, and reactive dyes were applied to six chrome-tanned crust leathers under controlled laboratory conditions. After dyeing, the rub fastness properties of the leathers were assessed in dry, wet, and artificial sweat environments. The findings indicate that leathers dyed with 1:2 metal complex dyes exhibited superior rub fastness, significantly outperforming those dyed with reactive and acid dyes. The commercial shoe lining leather sample tested in the study showed lower rub fastness than the all dyed leathers. These results underscore the importance of selecting the right dye type and controlling dyeing parameters to enhance leather durability. The study offers valuable insights into the mechanisms of dye fastness and provides recommendations for improving footwear manufacturing processes, with the potential to reduce dye transfer and enhance consumer satisfaction.

Keywords: Leather, Lining Leather, Rub Fastness, Dye, Leather Processing.

INTRODUCTION

Leather has played a fundamental role in human civilization, prized for its exceptional combination of durability, flexibility, and aesthetic appeal. Archaeological evidence indicates that leather usage dates back to prehistoric times, where it served as an essential material for protection against harsh environmental conditions (Uysal, 2002). Over the centuries, leather processing techniques have advanced significantly, driven by technological progress and evolving societal needs. Today, leather remains a key material across multiple industries, including fashion, automotive, and particularly footwear manufacturing.

In footwear production, leather is crucial for ensuring comfort, durability, and functionality. Shoe lining leathers, which come into direct contact with the foot, must meet stringent performance standards, including moisture management, breathability, and resistance to wear and tear (Lkhagvajav, 2010). Among these critical attributes, rub fastness plays a pivotal role, as it determines the leather's ability to retain its dyed surface without transferring color to other materials, such as socks, under conditions of friction and moisture exposure.

Achieving high rub resistance is challenging due to the complex interactions between dyes, collagen fibers, and process parameters. Several factors, including dye type, pH levels, and fixation methods, significantly influence the final quality and fastness properties of dyed leather. Insufficient dye fixation can lead to color migration, uneven dyeing, and reduced durability, all of which compromise product marketability and customer satisfaction. Furthermore, human skin continuously releases perspiration, with a significant amount of sweat excreted from a single foot per day at rest. Fresh sweat exhibits a mildly acidic character, with a pH ranging from 5.2 to 7; however, due to the enzymatic breakdown of urea by urease, ammonia is released, shifting the sweat's pH to alkaline levels as high as 9.This shift in pH plays a crucial role in leather degradation, as alkaline conditions weaken the fiber structure and compromise the tanning process, particularly in vegetable-tanned leathers. The combination of perspiration, elevated pH, and the warm, humid environment inside footwear accelerates fiber deterioration, making the leather more brittle and further affecting its overall performance (Bitlisli et al., 2005).

Extensive research has been conducted to optimize dyeing processes and enhance leather quality (Haroun, 2005; Mutlu, 2009; Onem et al., 2012; Mutlu et al., 2024; Liang et al., 2024). Various dye classes used in the leather industry—such as acid dyes, 1:2 metal complex dyes, and reactive dyes—exhibit distinct chemical characteristics and bonding mechanisms with collagen fibers.

Acid dyes represent the largest dye class in the color index and are commonly used for dyeing nitrogen-containing materials such as wool, polyamide, silk, and leather. Most acid dyes belong to the azo, anthraquinone, or triarylmethane compound groups. The term "acid" refers to the presence of a higher proportion of acidic functional groups, such as sulfonate and carboxyl, in the molecular structure of the dye (Zee, 2002; Pazarbaşı, 2009). These dyes typically have low molecular weight and feature monoazo or simple anthraquinone systems. They produce exceptionally bright shades. Due to their rapid penetration into the inner layers of leather without binding to the surface, they are classified as penetration dyes (Sardroudi, 2021). Acid dyes, while producing vibrant colors, often demonstrate limited fastness under wet and sweat conditions.

Metal complex dyes are colorants composed of relatively large molecules that, in addition to the chromophore group, contain one or more atoms of metals such as chromium, nickel, or cobalt. When one metal ion forms a complex with one dye molecule, 1:1 metal complex dyes are produced, whereas when one metal ion complexes with two dye molecules, 1:2 metal complex dyes are formed. These dyes bind to fibers through electrostatic interactions, hydrogen bonding, Van der Waals forces, and coordinate bonds. Dyeing with metal complex dyes provides high levels of light, wet, and perspiration fastness. However, precise control of dyeing conditions is essential. While these dyes produce good color quality, achieving bright blue and green shades is challenging. Nonetheless, achieving the desired color shade is relatively easy (Freeman and Peters, 2000; Sardroudi, 2021).

Reactive dyes are primarily azo dyes containing one or more groups capable of forming covalent bonds between a carbon atom of the dye and an oxygen or amino group of the substrate. Although reactive dyes generally exhibit superior wash fastness on leather compared to their non-reactive anionic counterparts, their use in dyeing of chrome-tanned leather has remained relatively limited due to substrate-related constraints, particularly the restriction of

dyeing temperatures to a maximum of 60°C and a pH range of 7 to 8 (Burkinshaw and Jarvis, 1996). However, despite these limitations, the application of reactive dyes in leather dyeing has increased in recent years, driven by advancements in dyeing techniques and the growing demand for improved fastness properties.

Despite these advancements, achieving consistent rub resistance remains a significant challenge, particularly for shoe lining leathers subjected to varying environmental conditions. This study aims to systematically evaluate the rub fastness properties of leather dyed with acid, 1:2 metal complex, and reactive dyes under controlled experimental conditions. By assessing rub resistance in dry, wet, and artificial sweat environments, this research seeks to identify optimal dyeing strategies and process parameters that enhance the performance of shoe lining leathers.

Furthermore, this study contributes to a deeper understanding of the interplay between dye chemistry, process optimization, and leather performance. The findings are expected to provide valuable insights for leather manufacturers, assisting in the development of high-quality, dye-transfer-resistant products, minimizing customer complaints, and improving the overall sustainability of leather processing.

MATERIALS AND METHODS

Materials

To ensure consistency in material properties, this study utilized six chrome-tanned crust sheepskins of Metis origin leathers. These leathers were dyed using three different dye types, each selected for its distinct chemical bonding mechanism and fastness properties:

- Acid Dyes: These dyes are known for their bright coloration and form electrostatic bonds with leather fibers.
- 1:2 Metal Complex Dyes: Renowned for their robust fixation properties, these dyes create strong electrostatic, hydrogen, and coordination bonds, leading to superior fastness.
- Reactive Dyes: Characterized by their ability to establish covalent bonds with collagen fibers, reactive dyes offer improved wet fastness.

All dyes and auxiliary chemicals, including ammonia, formic acid, synthetic fatliquors, and fungicides, were supplied by Derma Leather Company, located in the Menemen Organized Leather Industry Zone.

A commercially produced shoe lining leather sample served as a control to benchmark the experimental results against standard industrial practices.

Dyeing Process

To prepare the leathers for dyeing, each hide was first cut along the backbone line into two symmetrical sides, resulting in a total of 12 leather sides. These sides were then grouped systematically to maintain consistency in material properties. Each group consisted of four sides derived from the same two hides, ensuring uniformity in fiber structure and processing history. As a result, three distinct groups were formed, each designated for dyeing with one of the three dye types: acid dyes, 1:2 metal complex dyes, and reactive dyes. The leathers were subjected to fatliquoring and dyeing processes, with acid dyes, 1:2 metal complex dyes, and reactive dyes used as the dyeing agents at each stage. The dyeing process was carried out using the specified dyeing recipes outlined below Table 1-3.

Table 1. Acid Dyeing Recipe

Process	%	Product	Temp. (°C)	Time (min)	pH
Cross-Section Dyeing	200	Water	40		
	1	Ammonia		60	
	Strain				
	100	Water	40		
	0.5	Ammonia		15	6
	2	Acid Dye		30	
	+100	Water	60		
	2	Synthetic Fatliquor			
	1	Combined Lecithin-Based Fatliquor			
	0.5	Emulsifier			
	0.5	Fungicide		60	
	1	Formic Acid		20	
	1	Formic Acid		20	
	0.5	Formic Acid		30	3.8
	Strain-Wash				
Surface Dyeing	200	Water	60		
	1	Acid Dye		30	
	1	Formic Acid		20	
	0.5	Formic Acid		30	3.6
	Strain-Wash				

Table 2. 1:2 Metal Complex Dyeing Recipe

Process	%	Product	Temp. (°C)	Time (min)	pH
Cross-Section Dyeing	200	Water	40		
	1	Ammonia		60	
	Strain				
	100	Water	40		
	0.5	Ammonia		15	6
	4	1:2 Metal Complex Dye		30	
	+100	Water	60		
	2	Synthetic Fatliquor			
	1	Combined Lecithin-Based Fatliquor			
	0.5	Emulsifier			
	0.5	Fungicide		60	
	1	Formic Acid		20	
	1	Formic Acid		20	
	0.5	Formic Acid		30	3.8
	Strain-Wash				
Surface Dyeing	200	Water	60		
	1	Metal Complex Dye		30	
	1	Formic Acid		20	
	0.5	Formic Acid		30	3.6
	Strain-Wash				

Table 3. Reactive Dyeing Recipe

Process	%	Product	Temp. (°C)	Time (min)	pH
Cross-Section Dyeing	200	Water	40		
	1	Ammonia		60	
	Strain				
	100	Water	40		
	0.5	Ammonia		15	7
	4	Reactive Dye		30	
	+100	Water	60		
	2	Synthetic Fatliquor			
	1	Combined Lecithin-Based Fatliquor			
	0.5	Emulsifier			
	0.5	Fungicide		60	
	1	Formic Acid		20	
	1	Formic Acid		20	4.2
	Strain-Wash				
Surface Dyeing	200	Water	60		
	1	Reactive Dye		30	
	1	Formic Acid		20	4
	Strain-Wash				

Determination of color fastness to cycles of to-and-fro rubbing

The leather specimens were first prepared in accordance with TS EN ISO 2418 (2017). Subsequently, to ensure standardized testing conditions, the samples were at 23 ± 2°C temperature and 50 ± 5% relative humidity for 48 hours, following TS EN ISO 2419 (2012).

The rubbing fastness test was performed by Bally Finish Tester 9029 (Germany), following the procedures outlined in TS EN ISO 11641 (2013). The specimens were stretched by 10% in the rubbing direction to ensure proper testing conditions. The test apparatus consisted of a felt-covered finger applying a 1000 g load to the leather surface.

Three different conditions were assessed using felts prepared according to the aforementioned standards:

Dry Rubbing Fastness (50 cycles): The felts designated for dry rubbing fastness were conditioned under the same environmental conditions as the leather specimens for 48 hours prior to testing.

Wet Rubbing Fastness (20 cycles): For wet rubbing fastness, the felts were placed in an appropriate beaker containing distilled water and heated on a magnetic stirrer until they became fully submerged. Once the complete immersion of the felts was observed, the heating was stopped, and the beaker was removed to cool to room temperature. The felts were then left at room temperature until they were ready for testing.

Perspiration Fastness (20 cycles): An artificial perspiration solution was prepared following TS EN ISO 11641 (2013). The felts were immersed in the artificial perspiration solution for 16 hours before testing. Immediately before use, the felts were removed from the solution and squeezed to reduce their artificial perspiration content to approximately 1 gram.

RESULTS AND DISCUSSION

The rub resistance performance of leathers dyed with acid, 1:2 metal complex, and reactive dyes, as well as a commercial shoe lining leather, is summarized in Table 4. The results indicate a clear distinction in performance across the different dye types and test conditions (dry, wet, and perspiration).

Table 4. Average Test Results of Color Fastness to Rubbing Cycles According to the Grey Scale

		Acid Dyes	1:2 Metal Complex Dyes	Reactive Dyes	Commercial Shoe Lining Leather
Rubbing Fastness (Leather)	Dry	5	5	5	4/5
	Wet	5	5	4/5	3
	Perspiration	4/5	5	4/5	1
Rubbing Fastness (Felt)	Dry	5	5	5	4/5
	Wet	4/5	5	5	4
	Perspiration	4/5	5	4/5	2

Leathers dyed with acid dyes exhibited excellent dry rub resistance, achieving a gray scale rating of 5. However, under wet and sweat conditions, their performance declined to 4/5. This aligns with the inherent chemical properties of acid dyes, which primarily form electrostatic bonds with leather fibers. Although acid dyes offer vibrant coloration and a strong affinity for nitrogen-containing materials such as collagen, their stability diminishes in the presence of moisture and perspiration. Despite their limitations under high-moisture conditions, acid dyes may still be a viable option for applications where aesthetic appeal is prioritized, and exposure to wet or sweat conditions is minimal. However, for shoe lining leathers that undergo prolonged exposure to friction and moisture, alternative dyeing solutions with higher fastness properties are preferable.

Reactive dyes displayed comparable dry rub resistance to acid and 1:2 metal complex dyes, achieving strong fixation to the leather matrix. However, under wet and sweat conditions, their performance slightly decreased (4/5). This can be attributed to their reliance on covalent bonding with leather fibers, which, while robust, may be partially compromised in high-moisture environments. Recent studies have highlighted the growing use of reactive dyes in leather dyeing due to their ability to produce bright, uniform colors with relatively good fastness properties. However, their performance under sweat conditions suggests that process optimization, including pH adjustments and fixation enhancers, may be necessary to improve their durability.

Among the three dye categories, 1:2 metal complex dyes consistently demonstrated the highest rubbing fastness, achieving a gray scale rating of 5 across all test conditions. This superior performance can be attributed to the strong interactions between these dyes and leather fibers, facilitated by electrostatic, hydrogen, and coordination bonds. Owing to their deep penetration ability and stable bonding with the leather matrix, metal complex dyes are particularly suitable for shoe lining leathers. Their exceptional resistance to moisture, sweat, and friction ensures minimal color transfer and high durability, making them the most reliable choice for demanding applications.

In contrast to the laboratory-dyed samples, the commercially sourced shoe lining leather exhibited significantly weaker rub fastness, particularly under sweat conditions, where it scored only 1 on the gray scale. This poor result underscores the challenges faced by manufacturers in ensuring adequate dye fixation and process control. The suboptimal fastness observed in the

commercial sample likely results from inadequate washing protocols and insufficient dye fixation, leading to color bleeding and diminished durability.

The findings highlight the critical role of dye selection and process optimization in achieving superior rubbing fastness properties. The superior performance of 1:2 metal complex dyes reinforces their suitability for applications requiring high durability, particularly in shoe linings exposed to prolonged moisture and friction. While reactive and acid dyes remain viable options under specific conditions, their performance can be significantly enhanced through meticulous control of pH, fixation agents, and washing protocols.

The substandard performance of the commercial sample indicates gaps in industrial dyeing practices, emphasizing the need for enhanced quality control measures. Poorly fixed dyes not only compromise product quality but also pose environmental risks due to dye leaching, necessitating stricter adherence to optimized dyeing methodologies.

Discussion on Process Optimization

- pH control: Maintaining precise pH levels during dyeing is crucial. Incremental acid addition in the 1:2 metal complex dyeing process prevents surface accumulation and ensures uniform penetration and fixation.
- Washing treatments: Effective washing is essential for removing unbound dyes and chemicals. The superior rub resistance of the laboratory-dyed samples compared to the commercial leather underscores the importance of rigorous post-dyeing treatments.
- Fixation enhancements: The incorporation of fixation enhancers or modifiers could improve the performance of reactive and acid dyes, particularly under wet and sweat conditions.

CONCLUSION

This study systematically examined the rub fastness properties of shoe lining leathers dyed with acid, 1:2 metal complex, and reactive dyes, focusing on optimizing dyeing parameters to achieve superior performance under dry, wet, and artificial perspiration conditions. The findings underscore the critical role of dye chemistry, process control, and post-dyeing treatments in determining leather quality.

The study demonstrates that the rub resistance of shoe lining leathers is highly dependent on the type of dye used and the dyeing process. Acid dyes, while exhibiting excellent performance in dry conditions, showed inferior resistance under wet and sweat exposure due to weaker bonding mechanisms. These dyes are best suited for applications where moisture contact is minimal. In contrast, leathers dyed with 1:2 metal complex dyes displayed superior rub resistance in all environments, particularly in wet and sweat conditions. This enhanced durability can be attributed to the strong electrostatic, hydrogen, and coordination bonds formed between the dye and leather fibers, making them the optimal choice for durable applications like shoe lining leathers. Reactive dyes, though showing good performance, experienced a slight reduction in fastness under moisture exposure, indicating the need for careful control of pH and fixation during dyeing to ensure optimal bonding with collagen fibers. Additionally, the commercial shoe lining leather sample tested in the study demonstrated significantly lower rub resistance, particularly in sweat conditions, revealing the need for improvements in industrial dyeing processes. Inadequate fixation and suboptimal washing protocols were identified as major contributors to poor fastness properties.

These findings emphasize the necessity of selecting appropriate dye types based on the intended application and exposure conditions of the final leather product. For shoe lining leathers, where prolonged contact with moisture and friction is inevitable, 1:2 metal complex dyes provide the most reliable solution. However, reactive and acid dyes can also be effective when dyeing parameters are carefully optimized.

Key recommendations for improving industrial leather dyeing include:

- Precise pH Control: Maintaining stable pH levels during dyeing and gradually adding acid during fixation prevents surface accumulation and enhances overall fastness properties.
- Effective Washing Protocols: Thorough washing at the end of the dyeing process is essential for removing unbound dyes and residual chemicals, thereby improving rub resistance and preventing color migration.
- Optimized Recipe Development: The selection of chemicals in pre-dyeing processes, including neutralization agents, retanning compounds, and fixation enhancers, should be carefully tailored to achieve optimal dye bonding and long-term durability.

This research contributes to the broader understanding of rub fastness in dyed leathers by providing valuable insights into the relationship between dye chemistry and leather performance. The study confirms the superiority of 1:2 metal complex dyes and provides a solid framework for improving leather dyeing processes by highlighting the challenges associated with reactive and acid dyes. Additionally, the findings underscore the need for enhanced quality control measures in industrial production. The poor performance of the commercial leather sample indicates gaps in dye fixation and process standardization, highlighting the importance of stricter process monitoring to ensure product consistency and customer satisfaction.

Based on these findings, future research should focus on advanced dye formulations by investigating new dye chemistries and eco-friendly alternatives that enhance rub resistance while minimizing environmental impact. Optimizing fixation techniques is crucial, particularly in developing innovative strategies to improve dye bonding for reactive and acid dyes, thereby enhancing fastness properties.

In conclusion, this study highlights the necessity of a systematic and tailored approach to leather dyeing. By aligning dye selection, formulation, and process optimization with product requirements, manufacturers can enhance the performance and durability of shoe lining leathers. Implementing these improvements will not only ensure long-term customer satisfaction but also strengthen market competitiveness by delivering high-quality, durable, and aesthetically appealing leather products.

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INVESTIGATION OF EPIDOT MINERALS WITH DIFFERENT FORMATIONS USING CONFOCAL RAMAN SPECTROMETRY

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ABSTRACT

Epidote is a sorosilicate with the formula $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$. Confocal Raman Spectrometry (CRS) studies concluded that Raman shifts of epidote minerals are generally seen in the low-frequency region (150-1200 cm^{-1}). It is characteristic in this region that while strong peaks are seen at values of 400 cm^{-1}-420 cm^{-1}, 550 cm^{-1}, 910 cm^{-1} and 1080 cm^{-1}; the pure epidote crystals have no peaks between 600 cm^{-1} and 820 cm^{-1}. The clinozoisite minerals have a strong peak at 980 cm^{-1} and 1090 cm^{-1} due to the Si-O bond; and at 570 cm^{-1} due to the Si–O–Si bond.

This study aims to describe the epidote mineral formation along the contact zone, shear zone and their formations within the alterations zones. Within the scope of the study, samples were taken from the Himalayan mountains and different provinces in the Anatolian region.

The epidote amphibole gneiss from the Himalayan Mountains belt has epidote, garnet, amphibole, plagioclase, quartz, K-feldspar, opaque mineral paragenesis. In Central Anatolia, amphibole, epidote, quartz, plagioclase, K-feldspar and opaque mineral paragenesis are observed in epidote-amphibole gneiss and epidote amphibolite samples from Yozgat. The sample from Niğde has large crystalline quartz and epidote crystals and a contact metasomatic formation. The metagranite sample from Rize has quartz, plagioclase, K-feldspar and epidote minerals. Epidotes were formed under high-pressure conditions in the shear zone. Mylonitic granite samples (Kırşehir City) have muscovite, quartz, plagioclase, chlorite and K-feldspar minerals.

The spectra of epidote minerals formed under the influence of dynamic metamorphism in the shear zone showed peaks between 600-800cm^{-1}. On the contrary, no peak was observed in this area for free-forming large epidote crystals in the contact zone. As a result, different spectra

were observed in CRS analyses of epidote minerals depending on the mineral's formation conditions.

Key Words: Epidote, Confocal Raman Spectroscopy, Contact zone, Shear zone, Metamorphism

INTRODUCTION

Epidote is a sorosilicate mineral and is formed as solid solution. Most epidote solid solutions in geological systems fall within the compositional range between $Ca_2Al_3Si_30_{12}(OH)$ (clinozoisite) and $Ca_2FeAI_2Si_30_{12}(OH)$ (epidote) (Deer et al., 1986; Kepeshinskas and Khlestov, 1971). The most abundant end-member is the Fe-rich Epidote mineral. Based on the charges of cations and anions dominating in the different sites of the crystal structure, this mineral group can be divided into four as epidote, allanite, dollaseite and askagenite group (Armbruster et. al., 2006; Mills et. al., 2009; Chukanov et. al., 2010; Varlamov et. al., 2019). Epidote minerals, except zoisite, crystallize in the monoclinic system. Zoisite crystallizes in the orthorhombic system. Epidote minerals are usually green, rarely yellow-black in colour and have vitreous luster. They have colourless to grayish streak colour. The hardness of the mineral is 6-7; and have 3,4 specific gravity.

The important factors controlling the composition of epidote can be summarized as temperature, pressure, oxygen fugacity, carbon dioxide fugacity, mineral assemblage, bulk rock composition and fluid chemistry.

Monoclinic epidote group minerals are typically associated with low-grade metamorphism and hydrothermal activity at 250-400°C and 1-2 kbars (Qin et al., 2016). In defined environmental conditions, rocks exhibit various Fe^{3+}-AI^{3+} substitutions and commonly form chemically zoned crystals. In prograde metamorphism, epidote minerals can be formed in prehnite-pumpellyite, greenschist, blueschist and epidote-amphibolite facies. Amphibolite, granulite, and eclogite facies rocks frequently contain epidote most likely as retrograde alteration. As the degree of metamorphism increases, Epidot minerals tend to become richer in iron (Arnason et. al., 1993).

This study aims to describe the epidote mineral formation along the contact zone, shear zone and their formations within the alterations zones. Within the scope of the study, samples were taken from the Himalayan mountains and different provinces in the Central and North-East Anatolian regions.

Confocal Raman Spectrometry (CRS) is a vibrational analysis method that allows the examination of atomic bonds of minerals at the molecular level. It is very useful in mineral determination as rapid measurement can be made without damaging the sample. (Akçe and Kadıoğlu, 2020). CRS studies concluded that Raman shifts of epidote minerals are generally seen in the low-frequency region (150-1200 cm^{-1}). It is characteristic in this region that while strong peaks are seen at values of 400 cm^{-1}-420 cm^{-1}, 550 cm^{-1}, 910 cm^{-1} and 1080 cm^{-1}; the pure epidote crystals have no peaks between 600 cm^{-1} and 820 cm^{-1} (Liebscher and Franz, 2004). The main peaks (near 570, 600, and 1090 cm^{-1}) arise from Si_2O_7 vibrational modes, and although their intensities also vary with the crystal orientation, among the three Si_2O_7-related signals, the 570 cm^{-1} peak is the sharpest (Nagashima and Mihailova, 2023). Nagashima et al., (2021) mention OH-stretching peaks in the high frequency region (3200–3600 cm^{-1}). According to this study, as the Fe content increases, stretching modes shift towards higher wavenumbers.

The clinozoisite minerals have a strong peak at 980 cm^{-1} and 1090 cm^{-1} due to the Si-O bond; and at 570 cm^{-1} due to the Si–O–Si bond. In the zoisite mineral spectrum, a strong peak is expected at 490 cm^{-1} due to Si-O. Apart from this, other peaks are also seen at values of 680 cm^{-1}, 870 cm^{-1}, 1070 cm^{-1} and 1091 cm^{-1}. While zoisite and allanite are easily identified by their

strong peaks at approximately 490 cm^{-1} and 689 cm^{-1}, respectively, their distinction within the epidote-clinozoisite series requires additional attention (Limonta et. al., 2022).

METHODOLOGY

Sampling

Samples were taken from epidote amphibole gneiss rocks that have undergone regional metamorphism and have been subjected to high pressure due to the impact of the collision regime in the Himalayas. In the Anatolian region, it was preferred to take samples from different cities to represent different temperature and pressure conditions. The regional metamorphic rock samples were obtained from Central Anatolia (Ankara and Yozgat Cities). Contact metamorphosed rock samples were taken from Niğde city. Samples that were affected by dynamic metamorphism collected from Central (Kırşehir City) and Northeastern Anatolia (Rize City).

Mineralogy-Petrography

In mineralogy and petrography studies, mineral composition, texture, mineral zone, metamorphism type and degree, facies, and source rock were determined by examining thin sections under a polarizing microscope.

Confocal Raman Spectrometry

CRS analysis was carried out at the Ankara University Earth Sciences Application and Research Center (YEBİM) Laboratory, using a high-resolution and analytical confocal microscope "Thermo DXR" model confocal Raman spectrometer, and Labspec 4.02 software.

CRS Analysis was carried out using a laser with a wavelength of 633 nm (laser power 7mW), 25 μm slit confocal hole, and spectra were obtained using a CCD detector, It includes an Olympus optical microscope with 10X, 20X, 50X and 100X magnification objectives. Wave numbers were recorded over the region from 100 to 1200 cm^{-1}.

CONCLUSION AND DISCUSSION

Epidote minerals can be found in low-grade, regionally metamorphosed rocks and hydrothermal veins, associated alteration. This study aims to describe the epidote mineral formation along the contact zone, shear zone and their formations within the alteration zones.

The epidote amphibole gneiss from the Himalayan Mountain belt has epidote, garnet, amphibole, plagioclase, quartz, K-feldspar, opaque mineral paragenesis. These rocks with granonematoblastic texture were formed in the garnet mineral zone of the amphibole facies. The source of these rocks, which was formed in an environment where high temperature and pressure conditions prevail, is metabasic.

In Central Anatolia, amphibole, epidote, quartz, plagioclase, K-feldspar and opaque mineral paragenesis are observed in epidote-amphibole gneiss from Yozgat City (Akdağmadeni). These samples formed under greenschist facies conditions, garnet mineral zone and from a metabasic source. Epidote amphibolite samples from Yozgat City (Akdağmadeni) have metabasic source and have amphibole, epidote, quartz, plagioclase, K-feldspar and opaque mineral assemblage. These rocks have nematogranoblastic texture and are formed under amphibolite facies, garnet zone. Epidote amphibolite samples from Ankara City (Kesikköprü) have epidote, quartz, opaque minerals, plagioclase, amphibole and chlorite minerals. Samples

formed under amphibolite facies conditions and have a metabasic source rock. The sample from Niğde City has very large quartz and epidote crystals and formed in contact metamorphic zone. This sample, which formed in the Zoisite (epidote) mineral zone of the hornfels facies, has a metapelitic origin. The metagranite sample from Rize City has quartz, plagioclase, K-feldspar and epidote minerals. Rock that has been affected by dynamic metamorphism and shows cataclastic texture. Epidotes were formed under high-pressure conditions in the shear zone. Mylonitic granite samples (Kırşehir City) have muscovite, quartz, plagioclase, chlorite and K-feldspar minerals. Rocks have been affected by advanced dynamic metamorphism and show mylonitic texture.

When the spectra obtained with Confocal Raman Spectrometry of epidote minerals are examined, some differences are observed according to the formation conditions. The spectra of epidote minerals formed under the influence of dynamic metamorphism in the shear zone showed peaks between 600-800 cm^{-1} which is not normally expected (Figure 1). On the contrary, no peak was observed in this area for free-forming large epidote crystals in the contact zone. Peaks originating from impurities in the mineral are also present, although small, in unexpected shifts.

The main peaks of epidote minerals in regional metamorphic rock samples obtained from the Himalayan Mountain belt are observed to differ from Anatolia. It is known that regional metamorphic rock samples from the Himalayan Mountain belt were formed under higher pressure compared to rock samples taken from Anatolia.

Temperature increases rapidly in contact metamorphism, while in dynamic metamorphism, pressure rises rapidly. However, in regional metamorphism, the same temperature and pressure conditions prevail for a long time. Therefore, the peaks seen in the regional metamorphic rocks must represent cleaner, more stable spectrum.

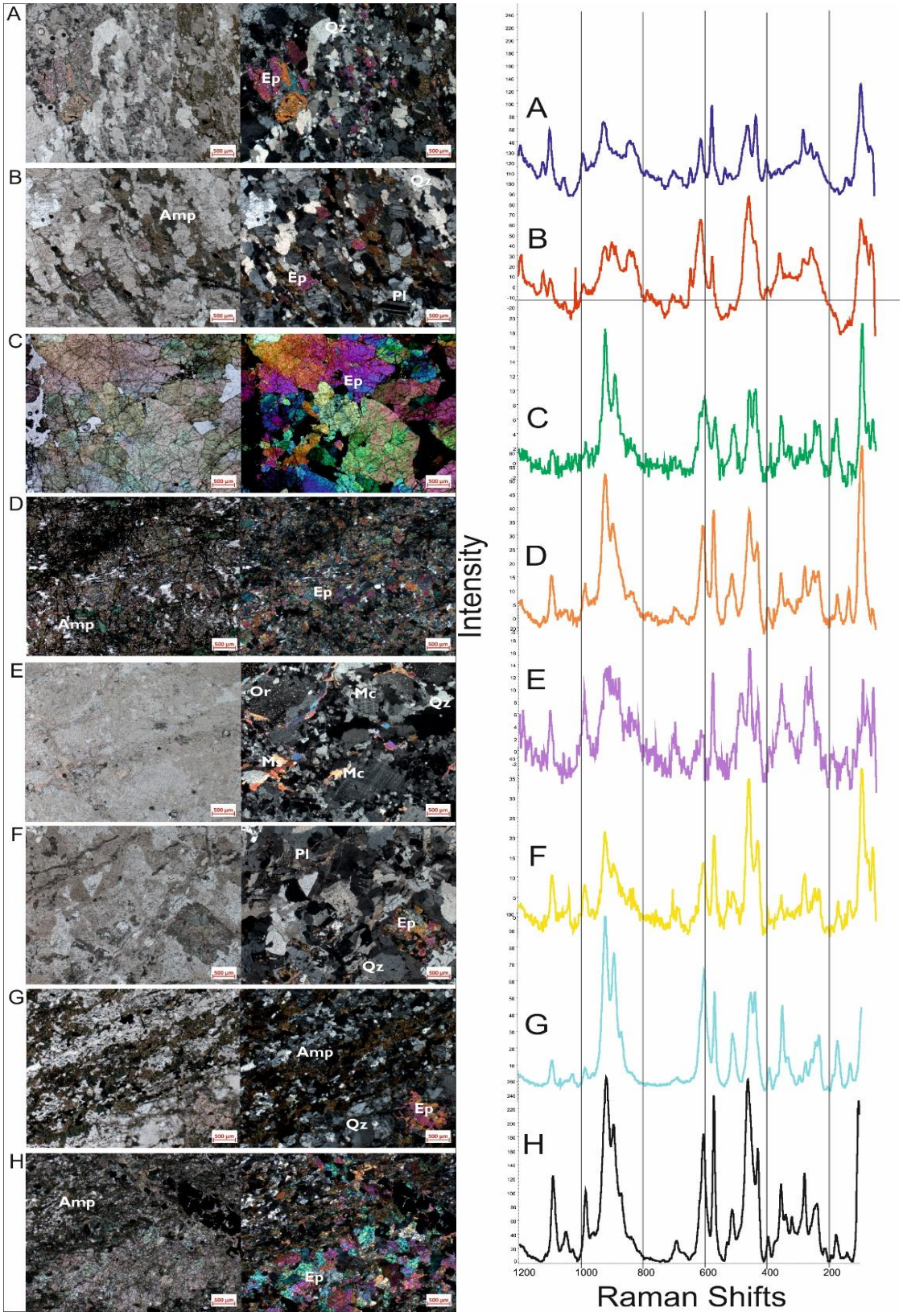

Figure 1. Microphotographs (Left side) and Raman Spectra (Right Side) of the A) Garnet epidote amphibole gneiss (Himalayan), B) Garnet epidote amphibole gneiss (Himalayan), C) Epidote + Quartz (Niğde), D) Epidote Amphibolite (Ankara), E) Mylonitic Granite (Kırşehir), F) Metagranite (Rize), G) Amphibole gneiss (Yozgat), H) Epidote Amphibolite (Yozgat).

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LUMINESCENCE SIGNAL PROPERTIES OF NATURAL CALCIUM SULPHATES UPON INCREASING ANNEALING TEMPERATURES:PRELIMINARY STUDY

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ABSTRACT

Naturally occurring calcium sulphates, such as gypsum and anhydrite, possess luminescence properties valuable for understanding their thermal history and geological context or radiation dosimetry research. This study examined the influence of progressively increasing annealing temperatures (room temperature to 850°C) on the luminescence characteristics of natural calcium sulphate samples sourced from Çankırı, Türkiye. Samples underwent controlled atmosphere annealing, followed by thermoluminescence (TL) and optically stimulated luminescence (OSL) measurements using a luminescence reader. Analysis focused on sensitivity changes on luminescence signals to evaluate annealing effects. Results revealed significant alterations in natural calcium sulphate's luminescence properties post-annealing. Annealing enhanced luminescence sensitivity, possibly due to the removal of pre-existing defects. Subsequent annealing steps induced varying degrees of intensity in the luminescence signals, thus suggesting complex interactions between defect removal, creation, and modification within the mineral lattice.

Keywords: Calcium sulphate, Gypsum, Luminescence, Thermoluminescence (TL), Optically Stimulated Luminescence (OSL), Annealing, Luminescence sensitivity

INTRODUCTION

Naturally occurring calcium sulphates ($CaSO_4$), most notably gypsum and anhydrite, function as repositories of geological information, their luminescence properties offering a unique perspective on past thermal events and radiation exposure. These minerals, which are prevalent in evaporite formations and diverse geological contexts, have emerged as sensitive dosimeters and chronometers, capable of recording intricate details of their formation and subsequent history. Thermoluminescence (TL) and optically stimulated luminescence (OSL) are well-established techniques in the fields of geochronology and sediment provenance studies. These techniques exploit the ability of certain minerals to store energy derived from ionizing radiation and subsequently release it as photons upon thermal or optical stimulation, respectively. However, the luminescence signals emitted by natural calcium sulphates are often complex, influenced by a confluence of factors including intrinsic defects, the presence and distribution of impurities, and the cumulative effects of prior thermal exposure. The accurate interpretation of luminescence data is significantly hindered by the complex interplay of these factors. Annealing, defined as a controlled thermal treatment, has been shown to play a crucial role in modifying the defect structure and luminescence behaviour of these minerals. A comprehensive understanding of how annealing, across a range of temperatures, alters the luminescence characteristics of calcium sulphates is paramount. This has importance for two reasons. Firstly, it is essential for accurate geochronological interpretations. Secondly, it is also vital for optimizing their utility in dosimetry and other applications.

Calcium sulfate materials both natural and dopped versions exhibit distinct temperature-dependent changes in their luminescence signals (Medlin, 1968). In $CaSO_4$:Dy phosphors that have been annealed between 650°C and 1000°C, thermoluminescence measurements demonstrate a decrease in a dosimetric glow peak at 240°C, accompanied by an increase in a lower-temperature satellite peak (Fiorella et al., 1978). In the case of $CaSO_4$:Dy and CaSO4:Tm phosphors heated to 800°C, a thermal stimulated luminescence peak at 230°C declines markedly while new peaks emerge at 60°C and 120°C (Lakshmanan et al., 2005). Mori et al. (2011) have done research on $CaSO_4$ doped with europium indicates that fluctuations in fluorescence are attributable to an irreversible conversion of Eu^{3+} to Eu^{2+} within the 600–900°C range, resulting in a modification of the Eu^{2+}/Eu^{3+} emission ratio. In samples of $CaSO_4$:Eu^{3+},Pr^{3+}, multiple thermoluminescence peaks are recorded at 130°C, 160°C, 240°C, 260°C, and 355°C, which become more intense with increased X-ray irradiation up to 400°C (Lapraz et al.,2000, Bakshi et al., 2007). In each instance, the studies establish a correlation between these thermal-induced changes and variations in defect centers and material structure, thereby emphasizing the important role of composition in affecting luminescence behaviour.

As for this study, it systematically investigates the effects of progressively increasing annealing temperatures on the TL and OSL properties of natural calcium sulphate samples originating from Çankırı, Türkiye. Through detailed analysis of sensitivity changes, the evolution of TL and OSL characteristics, the objective is to unravel the underlying mechanisms responsible for signal modification. Furthermore, the potential of these annealed materials for refined geological and geochronological applications is evaluated. The research contributes to a more detailed and comprehensive understanding of luminescence phenomena in naturally occurring calcium sulphates, paving the way for improved precision and accuracy in their application within Earth science and radiation dosimetry disciplines.

METHODOLOGY

Natural calcium sulphate samples were collected from Çankırı, Türkiye, and prepared for analysis by homogenization and sieving to isolate coarse grain sizes. All subsequent experimental procedures were conducted at the Earth Sciences Application and Research Center, Ankara Universtiy. Annealing treatments were performed using a furnace, capable of

reaching 1400°C. Samples were heated in a controlled atmosphere of air at progressively increasing temperatures ranging from room temperature to 850°C, with a heating rate of 5°C/s and a holding time of 30 mins at each temperature step. Following each annealing step, the samples were allowed to cool to room temperature within the furnace. Thermoluminescence (TL) and optically stimulated luminescence (OSL) measurements were carried out using a Risø TL/OSL reader. The TL measurements were performed by heating the samples from room temperature to at 500°C a heating rate of 5°C/s. OSL measurements were conducted using blue LEDs with a stimulation power of 80 mW/cm² for a duration of 100s. The luminescence signal was detected using a photomultiplier tube. Irradiations were constructed by irradiating aliquots of each sample with known doses of $^{90}Sr/^{90}Y$ beta source and subsequently measuring the TL/OSL signal. The resulting data were analysed to determine the sensitivity changes following each annealing step.

CONCLUSION AND DISCUSSION

Figure 1(a) illustrates the impact of progressively increasing annealing temperatures on the TL glow curves of natural calcium sulphate. The sample exhibits a dominant TL peak at approximately 80°C and 160°C. As the annealing temperature increases, a shift towards higher temperature peaks becomes evident, accompanied by changes in peak intensity. This shift indicates a modification of the trap distribution within the material, with higher-temperature traps becoming more prominent after annealing. Figure 1(b) displays the corresponding effect of annealing on the OSL decay curves. The initial OSL intensity decreases with increasing annealing temperature. However, annealing beyond 350°C results in a substantial increase in the OSL signal. This behaviour could indicate the removal of competing non-radiative recombination pathways or the creation of new luminescence centers at elevated temperatures. Further investigation is required to fully explain the underlying mechanisms responsible for these changes and to assess their implications for geochronological and geological applications.

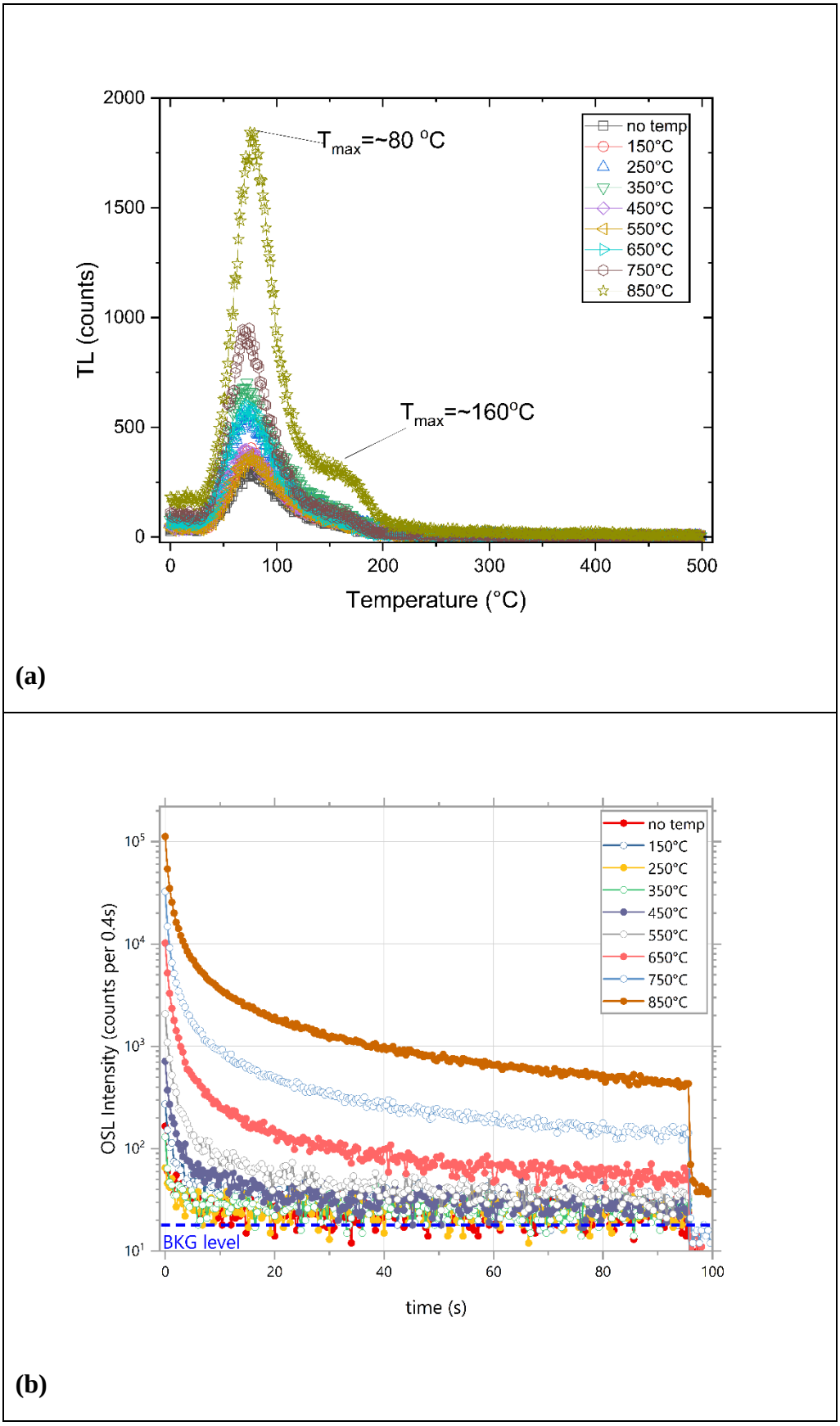
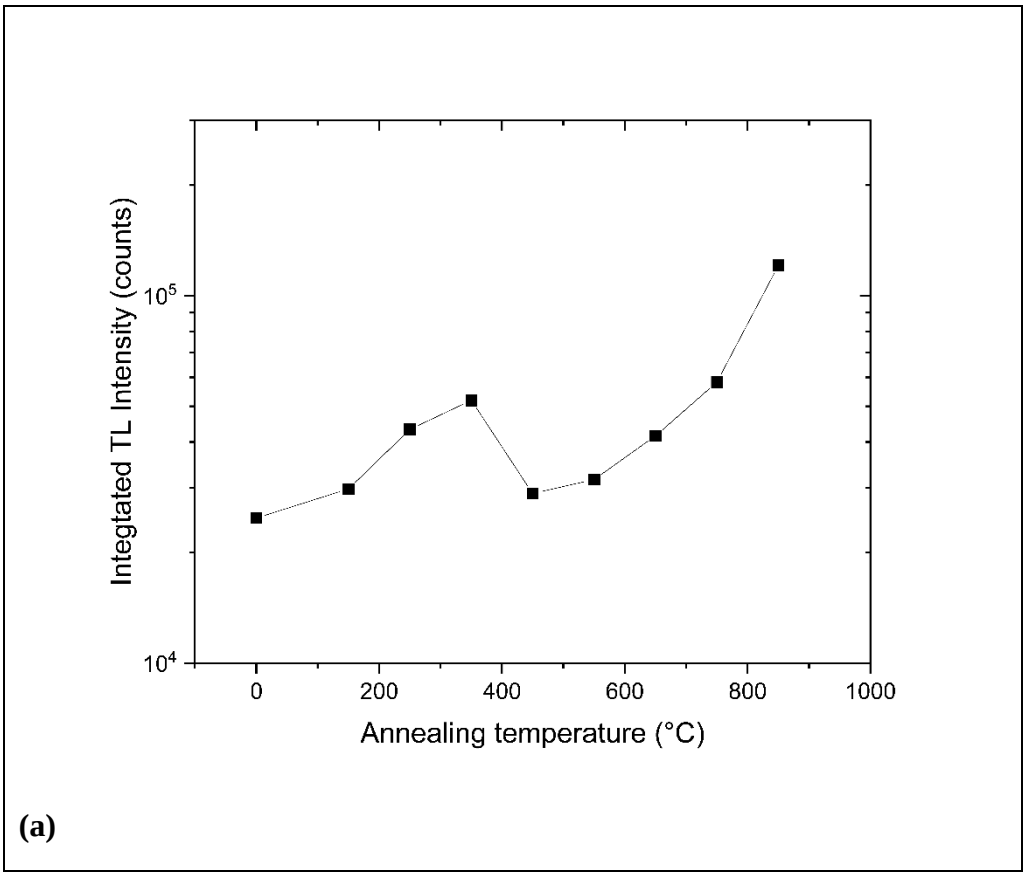


Figure 1. Influence of annealing temperature on the luminescence properties of natural gypsum. (a) TL glow curves and (b) OSL decay curves for samples annealed at various temperatures.

Figure 2 depicts the variation in integrated TL and OSL intensities as a function of annealing temperature for natural calcium sulphate. In Figure 2(a), the integrated TL intensity exhibits a complex trend. An initial increase is observed up to approximately 350°C, followed by a decrease until around 500°C. Beyond 500°C, the TL intensity rises sharply, reaching its maximum value at 850°C. This non-monotonic behaviour suggests the interplay of competing processes. The initial increase may be attributed to the removal of quenching defects or the activation of luminescence centres, while the subsequent decrease could indicate the thermal destruction of these centres. The final sharp increase in TL intensity above 500°C might be related to the formation of new trapping centers or structural changes within the mineral lattice. As demonstrated in Figure 2(b), the integrated OSL intensity manifests a more consistent trend. A gradual increase is observed up to approximately 350°C, after which the OSL intensity increases dramatically with annealing temperature, exceeding the TL intensity beyond 750°C.This suggests that annealing enhances the OSL sensitivity more significantly at higher temperatures, potentially due to an increase in the number of traps that can be stimulated optically or due to a reduction in non-radiative recombination pathways. The observed discrepancies in the TL and OSL responses to annealing underscore the discrete mechanisms that govern these two distinct luminescence processes. This finding signifies the prospect of manipulating luminescence properties through the implementation of meticulously controlled thermal treatments. These findings have important implications for optimizing luminescence dating and dosimetry protocols using natural calcium sulphates.



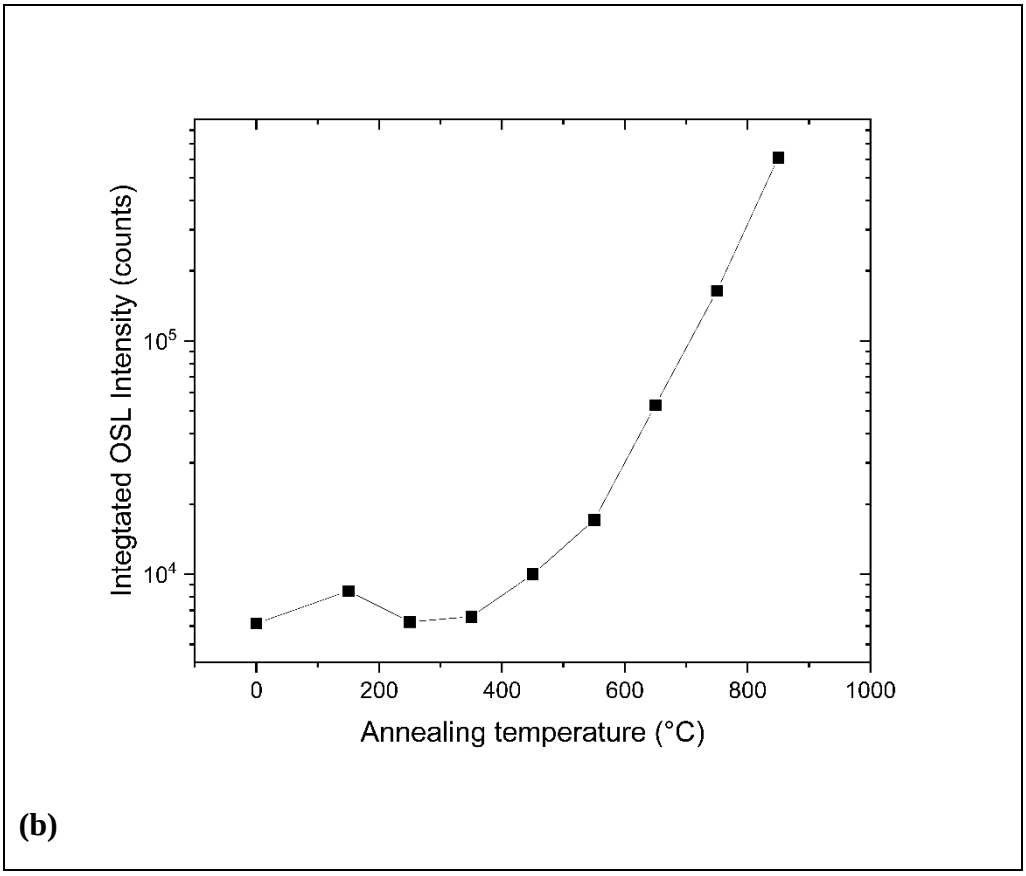


Figure 2. Dependence of integrated TL and OSL intensities on annealing temperature. (a) Integrated TL intensity as a function of annealing temperature. (b) Integrated OSL intensity as a function of annealing temperature

The results demonstrate that annealing significantly modifies the luminescence properties of this material, affecting both the signal intensity and the structure of the glow curves. Further research is required to fully elucidate the microscopic mechanisms responsible for the observed annealing effects. Such research should incorporate complementary techniques such as electron spin resonance (ESR), scanning electron microscopy, and further spectral measurements. Moreover, there appears to be considerable scope to exploit natural calcium sulfate in its capacity to function as a luminescence dosimeter and chronometer.

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PREPARATION AND CHARACTERIZATION OF PLASTICISED POLYLACTIC ACID BASED COMPOSITE FILMS WITH INCORPORATED LEONARDITE MINERAL

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ABSTRACT

In this study, the production and characterization of composite films containing polylactic acid (PLA) and Leonardite mineral, which attracts attention with its environmentally friendly and biodegradable properties, were investigated. Leonardite mineral was used as a potential natural filler for PLA matrix, which offers a lower environmental impact compared to petroleum-derived plastics with its rich humic acid content. Epoxidized soybean oil (ESBO), a natural plasticiser derived from vegetable oils, was used as a plasticiser to provide optimal conditions in the film production process by improving the processability of PLA. Within the scope of the study, Leonardite mineral was added to PLA at different ratios (1, 3, 5 and 10 wt%) and films were produced by solvent casting method. In these studies, the ESBO ratio was determined as 10%. The resulting composite films were characterised structurally by Fourier Transform Infrared Spectroscopy (FTIR), thermally by Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), thermomechanically by Dynamic Mechanical Analysis (DMA) and mechanically by tensile testing. As a result of the characterization, FTIR analysis showed that there was a chemical reaction between ESBO and PLA, but only intermolecular interactions were observed with the addition of leonardite. DSC and TGA analyses showed that the crystallinity ratios of the composite films increased while the maximum degradation temperatures decreased. DMA analysis results showed that the addition of Leonardite increased the storage modulus values, while mechanical analyses similarly showed an increase in elasticity modulus and tensile strength values. The results show that the Leonardite mineral can potentially contribute to the production of environmentally friendly, high-performance materials in PLA-based composites. This research shows that it is possible to use biodegradable plastics with natural minerals, taking into account the properties and sector needs.

Keywords: Polylactic acid films; Leonardite; Plasticised Polylactic acid; Material characterization.

INTRODUCTION

Polylactic Acid (PLA) is a type of plastic derived from biodegradable and renewable resources and is generally produced from plant materials such as sugar cane or corn starch has biodegradable, environmentally friendly properties. Due to its environmentally friendly properties, it is widely used in sectors such as packaging, automotive, medical, medical, textile (Khouri et al., 2024). The fact that PLA has biodegradable properties gives it an important advantage that distinguishes it from traditional plastics. Epoxidised oils are used as plasticisers to help improve the stiffness, flexibility and other mechanical properties of bioplastics (Burkov et al., 2021). Epoxidised soybean oil (ESBO) is a compound obtained by modifying vegetable oils with epoxy groups by chemical processes and is used in bioplastics such as PLA to provide better processability and durability. Using ESBO can strengthen the properties of PLA such as

flexibility, stiffness and thermal stability, thus producing more durable and long-lasting bioplastics. ESBO-plasticised PLA structures gain flexibility with an environmentally friendly plasticiser and have high heat resistance, low viscosity and stability properties (Ali et al., 2009; Ge & Dou, 2023).

Inorganic fillers are widely available in nature and are preferred due to their low price and easy availability while improving the physical, thermal and mechanical properties of composite structures. Talc, kaolin, wollastonite, zeolite are the most commonly used minerals in composite structures (Kotal & Bhowmick, 2015). Leonardite is a natural-based mineral rich in organic compounds with a high content of humic acid. Although it is generally used as a soil improver in agriculture, it also plays a key role in environmentally friendly production processes. Leonardite is known to improve the properties of bioplastics, increase their biodegradability and reduce environmental impact (Şen, 2024b; Şen et al., 2024).

The use of a natural-based inorganic additive such as Leonardite with PLA, a bio-based polymer, and ESBO, an epoxidised vegetable oil, can make an important contribution to the production of environmentally friendly, sustainable and biodegradable plastics. The use of these three materials together will improve the properties of bioplastics and provide more efficient, durable and environmentally friendly products and contribute to environmentally friendly production processes.

MATERIAL AND METHOD

Materials

The polylactic acid (PLA) used in the study with a density of 1.24 g/cm^3 was supplied by Total Corbion/China under the trade name Luminy L175. Epoxidised soybean oil (ESBO) used as plasticiser was supplied by Plastifay Kimya, Turkey. Leonardite used as a mineral additive was purchased from Kazdağı Organik, Turkey. The supplied leonardite mineral powders were passed through a 38 μm sieve and the remaining powders were used.

Methods

Preparation of the composite films

Composite films containing varying ratios of PLA, ESBO and leonardite mineral were produced by solvent casting method according to the ratios given in Table 1. In the productions carried out on a magnetic stirrer at 60 °C, leonardite mineral powders were added to the PLA and ESBO mixture dissolved in chloroform at the determined ratios, and mixing was carried out at 400 rpm until a homogeneous mixture was obtained. The solutions were poured into petri dishes and kept in an oven at 50 °C during 16 hours to remove the solvent and films were removed.

Table 1. The proportions of the components of the composite films.

Sample Code	PLA (wt. %)	ESBO (wt. %)	Leonardite (wt. %)
PLA	100	-	-
PES	90	10	-
PES1	89	10	1
PES3	87	10	3
PES5	85	10	5
PES10	80	10	10

Structural analysis

Fourier transform infrared spectroscopy (FTIR) analysis was performed to evaluate the functional groups in the structures of the composite structures and the changes in these groups. The FTIR spectra of the composite films were recorded using a Thermo Nicolet IS50 model spectroscopic instrument in the 4000-600 cm^{-1} wave number range.

Mechanical analysis

The mechanical properties of the composite films were characterised using a Testform/AS1 mechanical testing machine. Tests were carried out at room temperature, using a 1 kN load cell, with a tensile speed of 10 mm/min and modulus of elasticity (EM), tensile strength (TS) and elongation at break (EB) values were analysed.

Thermal analysis

Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA) and Dynamic Mechanical Analysis (DMA) were used for the thermal characterisation of the composite films. The DSC analysis characterised the glass transition temperature (Tg) crystallisation enthalpies and temperatures (ΔHcc and Tcc), melting enthalpies and temperatures (ΔHm and Tm) of the films and determined the crystallinity ratios (Xc). TGA analysis was used to determine the degradation rates (W), maximum degradation temperatures (Tmax) and the inorganic ash content of the films. The storage modulus and temperature at maximum Tan δ values (Tg) were characterised in DMA analyses where the viscoelastic properties of the films were determined.

RESULTS

FTIR analysis results

FTIR spectra of the composite films are given in Figure 1. When Figure 1 is examined, it can be stated that the films basically give peaks associated with the functional groups in the PLA structure. Among these peaks, 3000-2850 cm^{-1} peaks could be assigned to C-H stretching vibrations, indicating both CH_2 and CH_3 groups of PLA. In addition, the peak at 1749 cm^{-1} is associated with the C=O group in the PLA structure, the peaks at 1181 cm^{-1}, 1129 cm^{-1} and 1082 cm^{-1} with C-O stretching, the peak at 1043 cm-1 with OH bending and the peak at 867 cm^{-1} with C-C stretching (Lopresti et al., 2021; Tuna, 2025). The CH_2 asymmetric stretching peak observed in the 2920 cm^{-1} band, which is different in films containing ESBO, indicates that ESBO undergoes a ring-opening reaction with PLA and that there is a chemical interaction between PLA and ESBO (Ge & Dou, 2023). The addition of leonardite to the composite films did not cause any change in the functional groups.

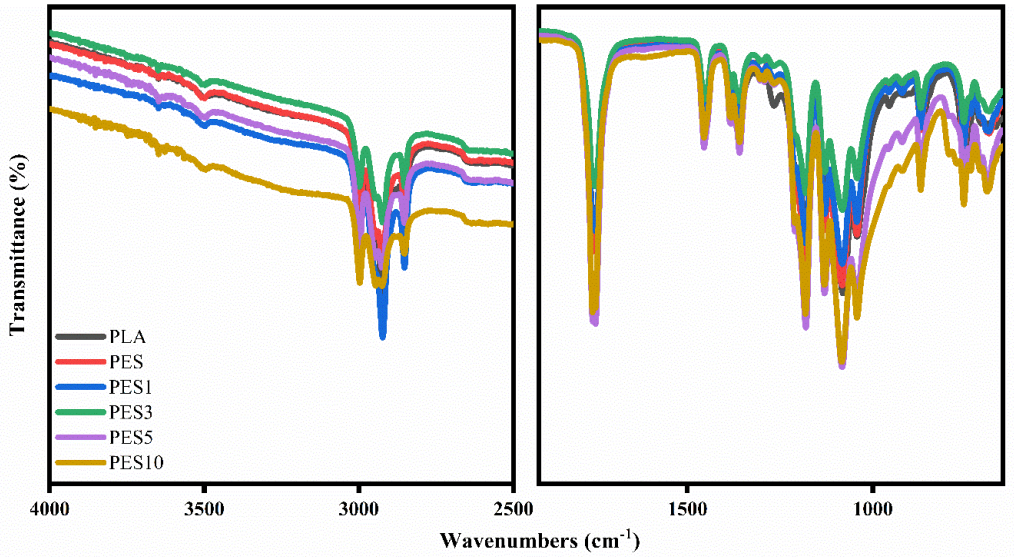

Figure 1. FTIR spectra of the composite films.

Tensile test results

The mechanical test results of the composite films are given in Table 2. When the tensile strength values are examined, it is seen that the tensile strength value decreased slightly due to the plasticising effect of ESBO addition, but the addition of leonardite mineral caused an increase (Ge & Dou, 2023). The highest tensile strength value was obtained at 5% leonardite addition and a decrease in tensile strength was observed at 10% leonardite addition. This can be attributed to the fact that high mineral addition causes agglomeration (Tuna, 2025). When the elongation at break values are examined, the plasticising effect of ESBO is clearly seen and it can be said that the addition of ESBO doubled the elongation at break value compared to pure PLA. However, the addition of leonardite settled between the polymer chains, restricted the chain mobility and decreased the elongation values (Haafiz et al., 2013). Elastic modulus values generally increased due to the addition of leonardite. This can be explained by the increase in the load carrying capacity as a result of the mechanical support of leonardite to the polymer structure due to the general intermolecular interaction (Sucinda et al., 2021).

Table 2. Mechanical test results of the composite films.

Sample Code	Tensile Strength, TS (MPa)	Elongation at Break, EB (%)	Elastic Modulus, EM (MPa)
PLA	43.21 ± 2.28	9.05 ± 0.79	1950.02 ± 276.31
PES	32.93 ± 3.71	19.5 ± 18.14	1274.96 ± 155.41
PES1	32.24 ± 0.95	13.2 ± 0.04	1626.25 ± 94.013
PES3	39.92 ± 1.78	11.1 ± 0.09	1732.22 ± 154.84
PES5	40.54 ± 0.48	11.7 ± 0.44	1928.21 ± 146.25
PES10	29.58 ± 1.60	6.62 ± 0.24	2069.67 ± 119.27

DSC test results

The thermograms obtained from DSC analyses of the composite films are given in Figure 2 and the data obtained from the thermograms are given in Table 3. When the glass transition temperatures were examined, a decrease in Tg value was first observed with the plasticising effect of ESBO addition, while Tg values close to each other were obtained with the addition of leonardite. The significant effect of leonardite addition was observed in crystallisation enthalpies and crystallisation rates. This can be explained by the fact that the filler added to the

composite structure can provide nucleation sites for the regular stacking of polymer chains (Berrabah et al., 2022).

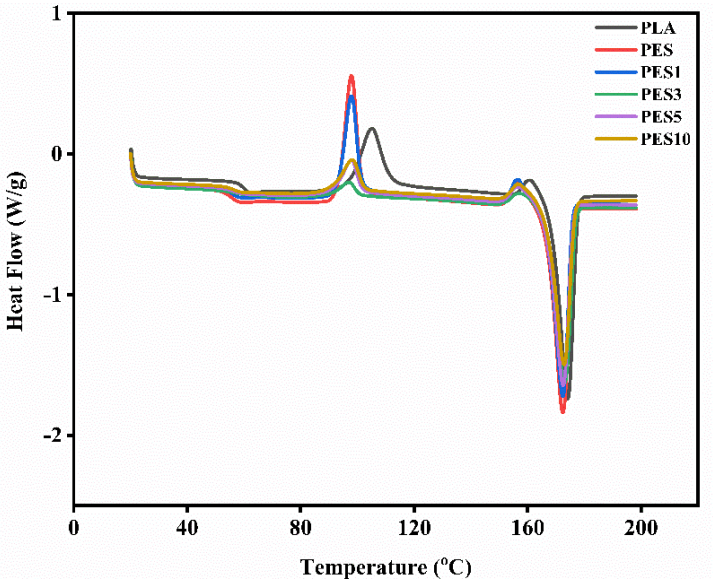

Figure 2. DSC thermograms of the composite films.

Table 3. DSC analysis results of the composite films.

Sample Code	Tg (°C)	ΔHcc (J/g)	Tcc (°C)	ΔHm (J/g)	Tm (°C)	Xc (%)
PLA	59.47	26.34	105.3	55.73	174.12	59.48
PES	55.23	26.87	97.88	61.03	172.41	72.37
PES1	55.43	22.46	93.36	56.36	172.35	67.58
PES3	57.19	7.102	97.25	51.89	173.07	63.65
PES5	56.38	10.69	97.83	52.22	172.52	65.57
PES10	56.28	11.05	98.14	49.39	172.79	65.89

TGA test results

TGA thermograms of the composite films are given in Figure 3 and the values obtained from the thermograms are given in Table 4. When the results are examined, it is seen that the composite films exhibit a two-stage degradation. In the first degradation (W1), volatile components such as moisture and solvent in the structure of the films were removed from the structure, and in the second degradation (W2), polymer degradation occurred. When the second degradation values are examined, it is seen that the addition of leonardite decreased the degradation temperature. This can be explained by the fact that leonardite accelerated the hydrolytic degradation of composite films due to its hygroscopic structure (Şen, 2024a). Residual ash ratios were found to be compatible with the added leonardite mineral ratios.

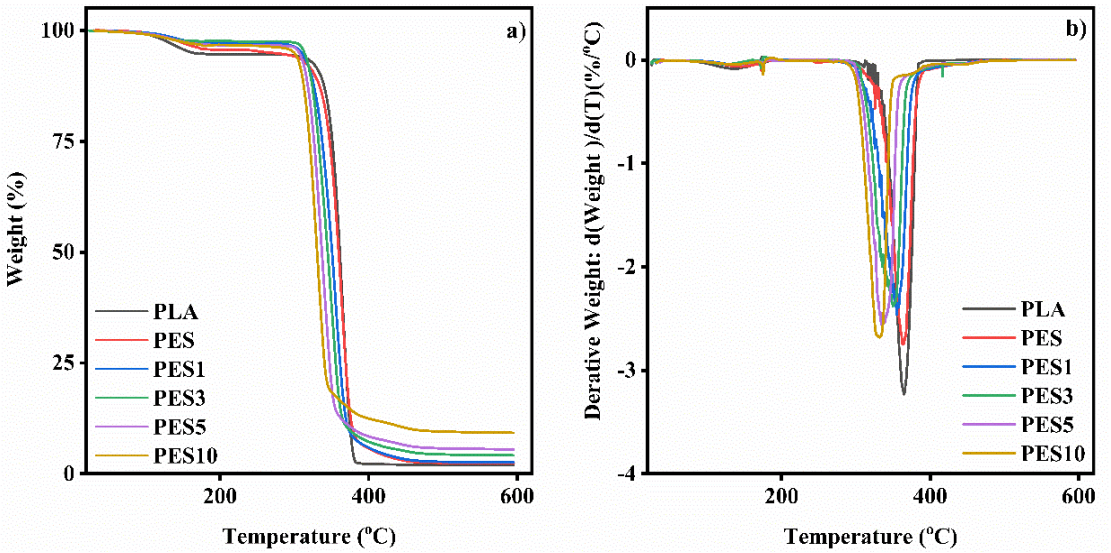

Figure 3. TGA thermograms of the composite films.

Table 4. TGA analysis results of the composite films.

Sample Code	W1 (%)	Tmax1 (°C)	W2 (%)	Tmax2 (°C)	Ash (%)
PLA	5.3	135.6	92.5	364.5	2.1
PES	4.4	145.7	93.2	363.4	2.4
PES1	2.7	139.7	94.5	355.1	2.7
PES3	2.5	125.8	93.3	350.1	4.3
PES5	3.3	135.7	91.0	335.5	5.7
PES10	3.3	134.3	87.3	332.1	9.5

DMA test results

DMA thermograms and analysis results of composite films are presented in Figure 4 and Table 5. When the results are examined, it is seen that the Storage Modulus and temperature at maximum Tan δ values decrease due to the plasticising effect of ESBO. This situation can be explained by the ease of chain movement with the addition of ESBO. As the amount of leonardite increased, SM and temperature at maximum Tan δ values increased due to the restriction of movement by increasing the distance between the chains (Ali et al., 2009; Burkov et al., 2021).

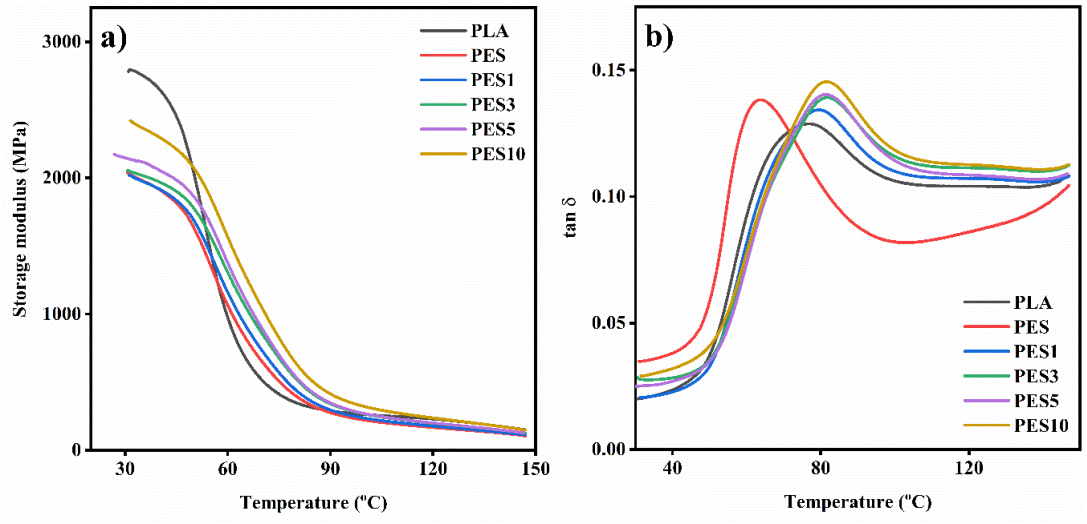

Figure 4. DMA thermograms of the composite films.

Table 5. DMA analysis results of the composite films.

Sample Code	Storage Modulus (MPa)	Temperature at maximum Tan δ (°C)
PLA	2651	76.64
PES	1914	63.62
PES1	1918	79.48
PES3	1971	81.76
PES5	2056	81.30
PES10	2299	81.61

CONCLUSION

In this study, a series of ESBO plasticised PLA films containing leonardite minerals in the concentration range of 0-10 wt% were prepared and characterised. FTIR study confirmed the successful incorporation of ESBO into PLA matrix through interaction of characteristic peak before and after composite formation. Mechanical tests showed that the addition of ESBO decreased the TS and elastic modulus values, while the addition of leonardite increased these values. DSC analysis indicated plasticising effects of ESBO as evidenced by the lower glass transition temperature (from 59 °C to 55 °C) and higher crystallinity level (from 59 to 72%), while the addition of leonardite also contributed to this effect as a result of the widening of the inter-chain distance. TGA data showed that the addition of ESBO and leonardite had an effect on the thermal stability of the PLA matrix, with degradation temperatures decreasing from 363 °C to 332 °C. SM and Tg values decreased at first as a result of the plasticising effect of ESBO facilitating chain mobility, and increased as the leonardite content increased due to the restriction of movement by increasing the distance between the chains. The study has shown that ESBO can be used as a natural plasticising additive in combination with PLA, a biodegradable polymer, and that it may be useful to modify the mineral ratios of ESBO and leonardite for this purpose by optimising the mechanical and thermal properties depending on the targeted application area.

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CHARACTERIZATION AND THERMAL ANALYSIS OF SCOTCH PINE FLOUR FILLED EPOXY-BASED COMPOSITES

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ABSTRACT

Epoxy resins have very good mechanical properties, chemical resistance, and even adhesion characteristics which, hence, assume importance in a variety of industries. Scotch pine flour could be a suitable filler owing to its availability, cheapness, and biodegradability. Thus, the present study analyzes the effect of Scotch pine flour on the physical and thermal properties of epoxy composites by focusing on density, glass transition temperature (Tg), and thermal degradation behavior. Scotch pine flour, work material was milled and introduced into epoxy resin with hardener in proportions of 5 percent 10 percent and 20 percent weight ratios. Room temperature curing was performed on composites followed by Fourier Transform Infrared Spectroscopy to investigate chemical interactions, particle size analysis for filler distribution assessment, as well as density measurements. Differential Scanning Calorimetry and Thermogravimetric Analysis were used in order to evaluate thermal properties with respect to Tg and thermal degradation, respectively. However, accompanied by the increase in percentage of Scotch pine flour in the composites, there was an appreciable decrease in density, the maximum reduction taking place at 20 weight per cent filler content. The DSC analysis showed a decrease in Tg with the addition of fillers, which was indicative of the plasticizing effect. On the other hand, TGA showed that thermal stability (Tmax) was unaffected by the filler content, while the degradation and ash residue increased with the filler content, which can be attributed to the inorganic components of pine flour. Scotch pine flour is an effective modifier for epoxy composites such that it reduces density and Tg while it provides thermal stability. The future study should optimize the amount of filler and study the mechanical properties of these green-cum-eco-friendly composites.

Key Words: Epoxy Composites, Scotch Pine Flour, FTIR Spectroscopy, Thermal analysis, Density.

INTRODUCTION

As far as industrial applications are concerned, epoxy resins are on the highest pedestal because of their superior mechanical properties, chemical resistance, and adhesive strength. But the increased emphasis on sustainability has forced researchers to study using natural fillers in epoxy matrices, par-ticularly the ligno-cellulosic fillers. Clean these natural fillers of renewable resources, improve the ecological profile of the composites, and alter their physical, thermal, and mechanical properties (Barkāne, Kampe, & Gaidukovs, 2023; Liu, Fei, Ban, Jia, & Qiu, 2017).

Of natural fillers, lignocellulosic materials, such as wood flour and cellulose fibers, have aroused notable interest. In particular, flour from Scotch pine (Pinus sylvestris) is a filler of potential interest due to its abundance, cheapness, and biodegradability. Pine wood flour, produced from the milling of pine wood, has a very high content of lignocellulosic components, namely cellulose, hemicellulose, and lignin, capable of interacting with the epoxy matrix and, in doing so, changing the composite properties (Barkāne et al., 2023; Cheng et al., 2018). The incorporation of such fillers can lead to an array of positive effects such as dec-reased density,

improved thermal stability, and enhanced mechanical properties (Barkāne et al., 2023; Margem, Monteiro, Neto, Rodríguez, & Soares, 2010).

The exploration process that the epoxy matrix constantly endures concerning the natural filler turns out to be complex and defines the final properties of the composite to quite a significant extent. Hydroxyl groups present in lignocellulosic materials undergo chemical interactions with the epoxy resin and are, therefore, expected to influence the curing process and overall performance of the composite (Barkāne et al., 2023; Margem et al., 2010). For example, the thermal characteristics like glass transition temperature (Tg) and thermal degradation behavior are some of the critical properties that help determine the feasibility of using epoxy-based composites in high-temperature applications. Adding natural fillers may change these properties and, in most cases, lead to a reduction in Tg due to the plasticizing action of the filler (Barkāne et al., 2023; Chu, Lin, & Kuo, 2016). In addition, the thermal degradation behavior of the composite can be influenced by the para-metric compounding of organic components present in the filler, which could decompose at lower temperatures than the epoxy resin (Abualroos, Idris, Ibrahim, Kamaruzaman, & Zainon, 2024; Barkāne et al., 2023).

This study intends the systematic investigation of an influence of Scotch pine flour on the physical and thermal properties of epoxy-based composites. The aim is to ascertain how the epoxy matrix interacts with the lignocellulosic filler by varying the filler content and the characterization techniques employed-Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and Thermogravimetric Analysis (TGA). The results obtained through this study will shed light on Scotch pine flour potential as a natural filler for epoxy composites, especially in situations that require lightweight and thermally stable materials.

EXPERIMENTAL DETAILS

Materials

The Central Research Laboratory (BTÜ) in the Artvin district of Turkey collected the scoth pines. We purchased epoxy resin and its hardener from Admiral-Turkey.

Preparation of scotch pine flour filled epoxy-based composites

Scoth pine flour was obtained by milling the scoth pines for five minutes using a titanium knife and a 0.2 μm screen in a Pulverisette 14 FritschTM Germany. Using a glass rod, scoth pine powder was manually mixed with varying volumes of epoxy resin. Hardener was added to the mixture after it had been mixed, and it was then mixed once more by hand. After pouring these concoctions into the silicone mold, they were allowed to sit at room temperature for a full day. Table 1 listed the amount of scoth pine flour in the resin and sample code.

Table 1. Compositions and sample codes of scoth pine flour filled epoxy based composites.

Sample Content	Sample Code
Epoxy	E
Epoxy – 5% scotch pine flour	E – 5S
Epoxy – 10% scotch pine flour	E – 10S
Epoxy – 20% scotch pine flour	E – 20S

Particle size measurement

A laser particle size analyzer (Mastersizer 3000E, Malvern) was used to measure the particle size distribution of scotch pine powders dissolved in water.

Fourier transform infrared (FTIR) spectroscopy analysis

The Nicolet İ50 spectrophotometer with smart iTR ATR equipment was used to perform FTIR studies on the samples. The samples' spectra were obtained using 16 scans between 600 and 4000 cm-1.

Density measurement

Using the Archimedes principle approach, the densities of the samples were measured using a Shimadzu-Aux321 balance in accordance with ISO 1183.

Differential Scanning Calorimetry (DSC) analysis

The DSC Discovery 250 instrument (TA instruments, USA) was used to analyze epoxy-based composites loaded with scoth pine. To eliminate the thermal history, use a nitrogen atmosphere (50 mL min-1) to heat from 20 ◦C to 200 ◦C for one minute, then cool to 20 ◦C and reheat to 200 ◦C at a constant rate of 10 ◦C/min.

Thermogravimetric (TGA) analysis

TGA studies were performed using the TA Instrument Discovery SDT 650 model. The samples weighed between 5 and 10 mg. °C ranged from 25 to 500. The speed was 10 °C/min and the environment was nitrogen.

RESULTS AND DISCUSSION

Characterization of scotch pine flours

FTIR spectrum, TGA thermogram and particle size measurement of the scoth pine flour can be seen in Figure 1. Heat analysis results of scotch pine flour have a bearing on the composition and properties of the flour. Moisture content (W1) reading 6.65 percent shows a fairly small amount of water just necessary for a special application in biomass utilization where moisture can affect combustion efficiency and activities of microorganisms(Makan, Assobhei, & Mountadar, 2013). The volatile matter content (W2) of 50.02 percent is quite typical of lignocellulosic materials, inferring that Scotch pine flour should release a good amount of gases which is characteristic of thermally softening organic materials rich in cellulose and hemicellulose when it is heated(Carrier et al., 2011). The highest decomposition temperature Tmax=365.81°C coincides with those from other studies and suggests that thermally stable lignocellulosic materials would tend to behave under temperatures close to this point before a significant degradation sets in because of the thermal stability property of lignocellulosic materials (Hasan et al., 2018). The average of the ash content 19.57 percent reflects inorganic residues of that biomass which could otherwise have different effects on the combustion properties and hence on the overall amount of energy yielded during combustion by the biomass (Olek, Perré, & Weres, 2011). Ash content is heavily linked to a two-associated combustion-related problem: slagging and fouling, resulting in a better understanding of the ash composition that is pertinent for optimization during biomass utilization (Rumbang, Karelius, Dirgantara, & Suastika, 2021). Particle size analysis enables a further description of the physical characteristics of Scotch pine flour. Distribution is where 10 percent of particles are 11.3 microns smaller, 50 percent are 58 microns smaller, and 90 percent are 207 microns smaller. This outline shows that there is a wide range of particle sizes, which is significant for applications that require high surface areas and reactivity such as bioenergy production and materials composites (Kuzmenko, Bratishko, Subota, & Kholodiuk, 2023). Smaller particles generally increase efficiency in biochemical processes, such as enzymatic hydrolysis, mainly because of the increased surface area available for reactions (Liu et al., 2017). The FTIR spectrum of Scotch pine flour is expected to have characteristic peaks confirming its lignocellulosic nature. This observation is corroborated by the broad peak corresponding to O-H stretching vibrations at 3300-3400 cm-1, marking the presence of cellulose and hemicellulose and, according to the peak at around 2900 cm-1, shows C-H stretching vibrations that are typical

of organic compounds (Sim, Mohamed, Nurul Aida Lu Mohd Irwan Lu, Sarman, & Samsudin, 2012). The sharp peak also at around 1730 cm-1 indicates the presence of carbonyl groups, presumably emanating from hemicellulose and lignin, further substantiating the identification of these components in biomass (Gogna & Goacher, 2017). Also, peaks positioned at near 1600 cm-1 and 1500 cm-1 refer to aromatic ring vibrations typical of lignin, while the strong peak at about 1030 cm-1 relates to C-O stretching vibrations found in cellulose and hemicellulose (Sim et al., 2012). Thus, the FTIR peaks are filling a clear chemical fingerprint of Scotch pine flour showing its organic and structural composition as a lignocellulosic biomass.

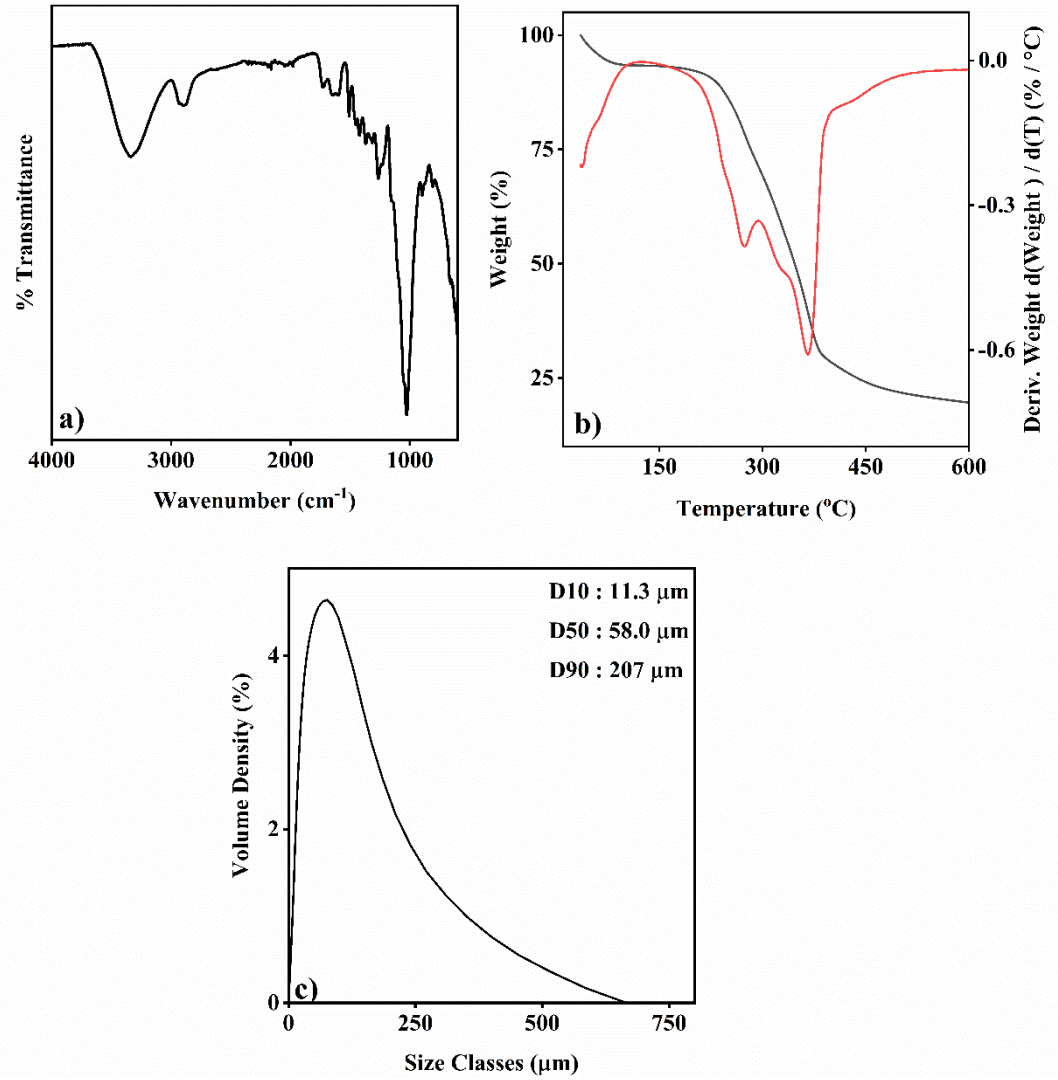

Fig.1. FTIR spectrum, TGA thermogram and particle size measurement of the scotch pine flour.

Fourier transform infrared (FTIR) spectroscopy analysis

The FTIR spectra of the epoxy based composites can be seen in Figure 2. FTIR is a significant technique to analyze the chemical structure of epoxy composite materials, especially those filled with natural materials like scotch pine flour. The pure epoxy FTIR spectrum usually shows the most intense absorption bands defining its chemical functionalities. There are characteristic peaks for epoxy functional groups between 910 and 830 cm^{-1}. The aromatic rings present in the epoxy structure give rise to peaks around 1500-1600 cm^{-1}. The region between 2800 and 3000 cm^{-1} accounts for the C-H stretching vibrations (Mendes et al., 2020). It is because scotch-pine flour content increases in the epoxy composites that one can expect to find new peaks and changes in intensity in FTIR in the lignocellulosic components contributed by the wood flour. Especially the O-H stretching vibration in the range of about 3200-3500 cm-1 as it concerns to hydroxyl groups resulting from lignin, cellulose, and hemicellulose. In

addition, peaks within the range of 1000-1200 cm^{-1} for C-O stretching are noteworthy since they mark the presence of wood-derived polysaccharides in the structure (Mendes et al., 2020). Any changes in peak intensity or shifts in the FTIR spectrum reflect the interaction of the epoxy matrix with scotch pine flour. One notable change is the peaks of the epoxy materials, which do not appear as intense as before, thus indicating that the epoxy groups might be partially consumed or perhaps chemically interact with the wood flour components. This phenomenon has been reported in the literature, where changes in the FTIR spectra were seen due to the introduction of natural fibers in epoxy matrices which implies possible chemical interaction or physicochemical interaction of their components. For instance, Mendes et al. observed characteristic bands associated with cellulose and lignin in epoxy/sawdust composites' FTIR spectra, thereby confirming the presence of these components in the composite matrix. The FTIR spectra analysis can afford an insightful approach into the extent of cure and efficiency of interaction between epoxy and wood flour. Enhanced presence of hydroxyl groups from natural fibers has been reported to strengthen the interfacial bonding in epoxy composites, which is pivotal for bettering mechanical properties (Kumar et al., 2022). Such interactions greatly influence the advancement of bio-based composites in that they are likely to impart enhanced performance characteristics while exploiting renewable resources. On the whole, FTIR analysis constitutes an extremely important method for elucidating the chemical structure of epoxy-based composites filled with scotch pine flour. The existence of characteristic peaks for both the epoxy resin and the wood flour components confirms the interaction in the composite matrix, thus providing necessary insight for further optimization of material properties.

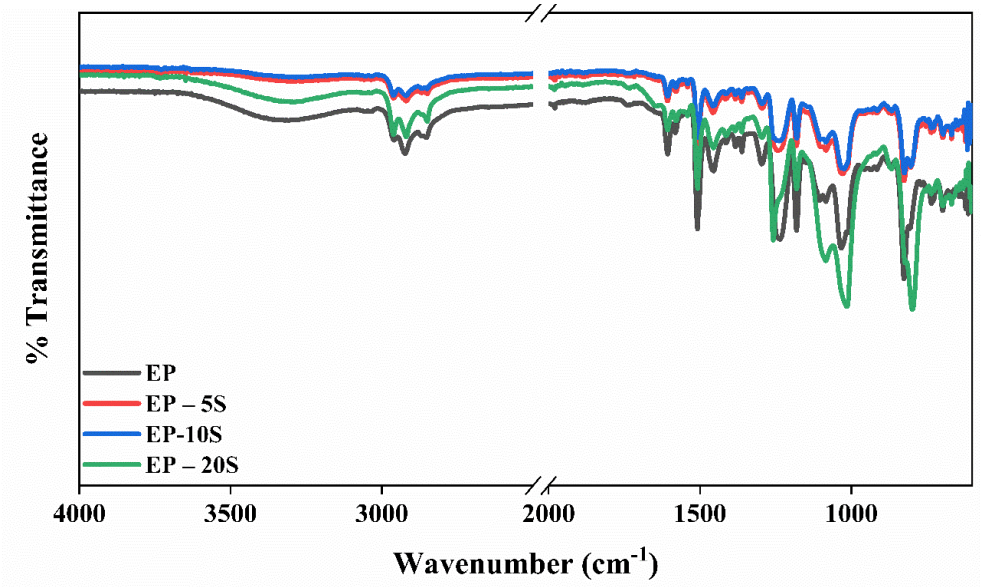

Fig.2. FTIR spectra of the epoxy-based composites.

Density measurement

Presented in Table 2 are the density measurement results for the epoxy based composites. The density measurements of epoxy-based composites filled with varying percentages of Scotch pine flour indicate a trend of decreasing density with increasing filler content. The pure epoxy sample (EP) has a density of 1.167 ± 0.004 g/cm^3. When 5% Scotch pine flour is added (E - 5S), the density remains nearly unchanged at 1.166 ± 0.004 g/cm^3. However, as the filler percentage increases to 10% (E -10S), the density decreases to 1.159 ± 0.005 g/cm^3, and the most significant reduction occurs at 20% Scotch pine flour (E - 20S), where the density drops to 1.118 ± 0.002 g/cm^3. This trend suggests that the incorporation of Scotch pine flour, which has a lower density than the epoxy resin, effectively reduces the overall density of the composite, indicating an inverse relationship between the amount of filler and the composite density. This phenomenon is consistent with findings in the literature regarding the effects of

natural fillers on composite materials. For instance, studies have shown that the addition of lightweight fillers, such as wood flour, tends to decrease the density of the resulting composites. He et al. discuss the properties of wood flour reinforced lignin-epoxy composites, highlighting that the addition of wood flour can influence the mechanical and thermal properties of the composite, reinforcing the idea that filler characteristics significantly affect composite behavior (He, Liu, & Di, 2016). Moreover, the findings align with the research conducted by Biswas et al., which indicates that the incorporation of solid filler phases into epoxy matrices can modify physical properties, including density. Their study on bamboo-fiber-reinforced epoxy composites suggests that the addition of fillers can lead to a decrease in tensile strength, which may correlate with the observed density changes in the current study (Biswas, Patnaik, & Kaundal, 2012). Additionally, the work of Ogah et al. emphasizes the role of natural fibers in modifying the properties of epoxy composites, indicating that the type and amount of filler can significantly impact the physical characteristics of the material (Ogah, Madu, Timothy, Olivia, & Ikelle, 2024). In summary, the observed trend of decreasing density with increasing Scotch pine flour content in epoxy composites is well-supported by existing literature. The findings underscore the importance of filler properties in determining the overall characteristics of composite materials, particularly in applications where weight reduction is critical. The incorporation of natural fillers like Scotch pine flour not only affects density but may also influence other mechanical properties, making it a valuable consideration in composite material design.

Table 2. Density measurement results of the epoxy based composites.

Sample Code	Density (g/cm^3)
EP	1.167 ± 0.004
E – 5S	1.166 ± 0.004
E – 10S	1.159 ± 0.005
E – 20S	1.118 ± 0.002

Thermal analysis

Table 3 and Figure 3-4 show the thermal results of the epoxy based composites. The thermal properties of epoxy-based composites filled with different percentages of Scotch pine flour speak volumes about the behavior of the material under thermal stress. The glass transition temperature (Tg) for pure epoxy (EP) was measured at 48.81°C, whereas for E-20S containing 20% Scotch pine flour, Tg dropped significantly to 44.83°C. This reduction in Tg indicates a plasticizing action of Scotch pine flour on the epoxy matrix findings in studies where incorporation of fillers leads to reduced Tg effect due to the enhanced mobility of polymer chains in the matrix (Asim, Jawaid, Tahir, & Nasir, 2019; Jiang et al., 2017). The pure epoxy sample recorded weight loss of 15.82% at the first degradation stage and 74.49% at the second stage. The E-20S sample displayed an initial higher weight loss of 18.48% and lower second stage weight loss of 68.24%. This shows that addition of the Scotch pine flour might have modified the composites' thermal degradation behavior, which might have been earlier at a higher proportion of fillers. This behavior is in agreement with what have been revealed in other materials comprised of composites where the inclusion of natural fibers has been associated with alteration in thermal degradation patterns thus bringing it sooner than later as a result of lower thermal stability of organic fillers as compared with epoxy matrix (Asim et al., 2019; Huang et al., 2020). The Tmax across the samples stayed pretty much constant at roughly between 362.95°C for the E-20S sample and 368.66°C for the pure epoxy. This Tmax stability indicates that the overall thermal stability of the composites is not greatly compromised with the addition of Scotch pine flour. Other studies showed nearly the same things with other fillers. The Tmax, therefore, remained unchanged across the range of filler contents, a clear indication that even introduction of organic materials could still ensure the maintenance of thermal stability of the epoxy matrix (S. Wang, Cao, Wang, Chen, & Wang, 2022; Z. Wang, Wang, Ye,

Huang, & Liu, 2020). In addition, the percentage of ash residue increased with an increase in Scotch pine flour content, starting from 9.77% for the pure epoxy and reaching as high as 13.58% in the E-20S sample. This was inevitable since as Scotch pine flour comprises inorganic components, it would in turn have to leave some degree of ash after thermodecomposition. The correlation between filler loading and ash residue is well-known in the literature in that presence of inorganic materials in composites usually led to higher ash content upon thermal degradation.This means that minor incorporation of scotch pine flour into epoxy-based composites positively shifts the glass transition temperature downwards and probably has some influence on the weight loss mechanism under thermal degradation. However, the overall thermal stability, measured using maximum degradation temperature, is still fairly unaffected. Reasonably high levels of ash content increased with an increase in filler content, consistent with the findings derived from the presence of inorganic portions in the scotch pine flour and thus further backing previous results from studies on materials composed of composites.

Table 3. Thermal test results of epoxy based composites.

Sample Code	Tg (°C)	W1(%)	W2(%)	Tmax(°C)	Ash(%)
EP	48.81	15.82	74.49	368.66	9.77
E – 5S	46.38	14.93	74.99	366.04	10.17
E – 10S	46.32	14.94	73.23	367.38	11.82
E – 20S	44.83	18.48	68.24	362.95	13.58

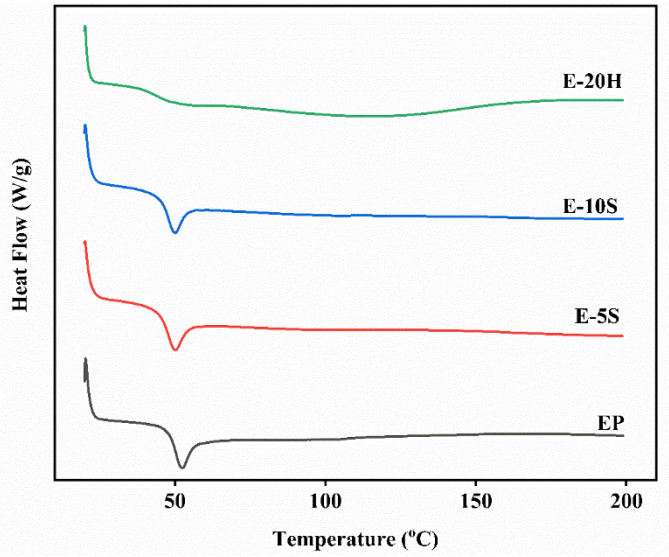

Fig.3. DSC thermograms of epoxy based composites.

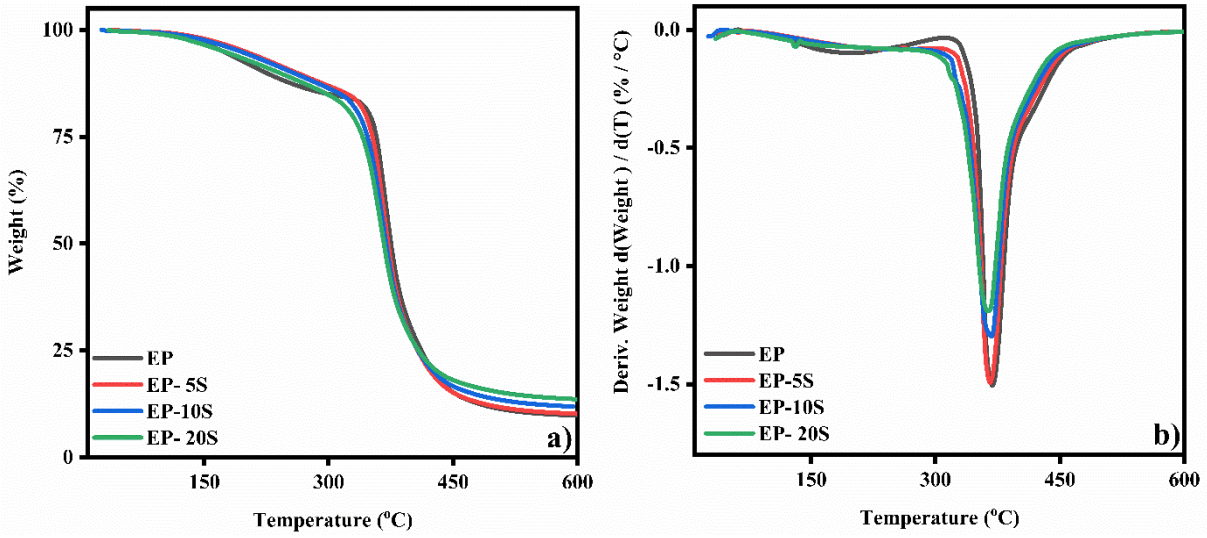

Fig 4. TGA thermograms of the epoxy based composites.

CONCLUSION

This work systematically studies the effects of Scotch pine flour on epoxy-based composites. The findings showed that incorporating Scotch pine flour reduced the density of the composites, thus making them lighter. With the increase of filler, thermal analysis indicated a decrease in the Tg, suggesting some plasticizing action by Scotch pine flour in the epoxy matrix. The FTIR spectra confirmed the presence of lignocellulosic constituents in the composites, which demonstrates some interaction between epoxy resin and Scotch pine flour. The overall thermal stability, evaluated as a maximum degradation temperature (Tmax), remained fairly unaffected, which suggests that the addition of Scotch pine flour did not severely compromise the overall thermal stability. Nevertheless, alterations were observed in terms of weight loss during thermal degradation, as the residue increased with higher filler content. The obtained results confirm that Scotch pine flour is suitable as a natural filler to modify the physical and thermal properties of epoxy-based composites. These materials present applications in industries wherein lightweight and thermally stable materials are required. Future works could consider optimizing the filler content and evaluating the mechanical properties of these composites for further improvement in their respective applications.

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SEASONAL INVESTIGATION OF METHANE AND NDVI RELATIONSHIP IN IĞDIR WITH SENTINEL-5P AND MODIS DATA

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ABSTRACT

Methane (CH_4) emissions are a significant contributor to climate change, while vegetation health and density are important indicators of environmental changes. This study aims to compare Sentinel-5P-based methane data with MODIS-based Normalized Difference Vegetation Index (NDVI) data seasonally throughout 2024 to examine the relationship between methane emissions and vegetation. The province of Iğdır, located in eastern Türkiye, was selected as the study area. The Iğdır Plain, the Aras River, and surrounding wetlands contribute significantly to the region's biodiversity. Its flat and expansive topography, along with intensive agricultural practices and various land use types, makes Iğdır an ideal environment for remote sensing studies. In this study, to focus the analysis on agricultural areas, only regions with dense agricultural lands were selected, excluding the provincial and district centers of Iğdır. Methane data obtained from the Sentinel-5P satellite using the TROPOMI sensor were collected at high resolution. MODIS data were analyzed using 16-day composite NDVI products from the Terra and Aqua satellites. The data were evaluated separately for each of the four seasons in 2024 on the Google Earth Engine (GEE) platform. Statistical analyses were conducted to determine the relationship between methane concentrations and NDVI values. When examining the seasonal images, the differences between the two variables were not visually distinguishable. The correlation values for the December–February, March–May, June–August, and September–November periods were found to be -0.049, -0.09, 0.09, and -0.018, respectively. When considering all data over the one-year period, the overall correlation coefficient was calculated as -0.22. These results indicate that there was no significant relationship between methane concentrations and NDVI values. The results provide important insights into the relationship between methane emissions and vegetation density. The effects of methane emissions on vegetation health and the evaluation of this relationship in the context of climate change are

necessary. This study demonstrates that Sentinel-5P and MODIS data can be used together to seasonally examine the relationship between methane emissions and vegetation. Future research should focus on integrating higher-resolution data and long-term monitoring studies.

Keywords: Remote Sensing; Air Quality; Air Pollution; Agriculture; Google Earth Engine

INTRODUCTION

Methane (CH_4) is a potent greenhouse gas, contributing significantly to global climate change due to its high radiative forcing and atmospheric lifetime. Over the past century, atmospheric methane concentrations have increased dramatically, driven by anthropogenic activities such as agriculture, fossil fuel extraction, and waste management, as well as natural sources like wetlands and wildfires (IPCC, 2021; Saunois et al., 2020). Methane is estimated to be responsible for approximately 20% of global warming since the pre-industrial era, with recent studies indicating a sharp rise in emissions from tropical and temperate regions (Jackson et al., 2020; Nisbet et al., 2019). Understanding the spatial and temporal dynamics of methane emissions is critical for developing effective mitigation strategies and addressing the challenges of climate change (Turner et al., 2016; Zhang et al., 2015). Remote sensing technologies have emerged as powerful tools for monitoring methane concentrations at regional and global scales, with satellites such as Sentinel-5P providing high-resolution data on atmospheric methane distributions (Hu et al., 2018; Jacob et al., 2016).

Vegetation health and density, often assessed using the Normalized Difference Vegetation Index (NDVI), are key indicators of ecosystem dynamics and play a vital role in carbon cycling and climate regulation (Myneni, Keeling, Tucker, Asrar, & Nemani, 1997; Pettorelli et al., 2005). NDVI, derived from satellite sensors like MODIS, measures photosynthetic activity and vegetation cover, making it a valuable parameter for studying land use changes, agricultural productivity, and ecosystem responses to environmental stressors (Gitelson, Kaufman, & Merzlyak, 1996; Tucker, 1979). While the relationship between methane emissions and vegetation has been explored in various contexts, such as wetlands (Bloom, Palmer, Fraser, Reay, & Frankenberg, 2010; Zhang et al., 2015) and rice paddies (Wang et al., 2018; Yan, Akiyama, Yagi, & Akimoto, 2009), the interactions between atmospheric methane concentrations and vegetation dynamics in diverse agricultural landscapes remain poorly understood (Bousquet et al., 2006; Kirschke et al., 2013).

The province of Iğdır, located in eastern Türkiye, presents a unique case study for investigating these interactions. Characterized by a microclimate that supports intensive agricultural activities, Iğdır is home to the Iğdır Plain, the Aras River, and surrounding wetlands, which contribute to its rich biodiversity and complex land use patterns. Vegetation is one of the key factors influencing methane dynamics in wetland environments (Kao-Kniffin, Freyre, & Balser, 2010). The amount of methane flow from sediments to the atmosphere is significantly influenced by the presence or lack of vegetation as a gas-channel (Bellisario, Bubier, Moore, & Chanton, 1999; King, Reeburgh, & Regli, 1998). This study aims to address this research gap by investigating the seasonal relationship between atmospheric methane concentrations and NDVI values in Iğdır using data from the Sentinel-5P and MODIS sensors. Specifically, the study seeks to: (1) analyze spatial and temporal variations in methane and NDVI across different seasons and (2) evaluate the correlation between methane concentrations and vegetation density.

MATERIALS AND METHODOLOGY

Study Area

In this study, the province of Iğdır, located in eastern Türkiye, has been selected as the study area (Figure 1). Bordering Armenia, Azerbaijan (Nakhchivan), and Iran, Iğdır hosts diverse ecosystems due to its unique geographical location and climatic conditions. Although situated within the Eastern Anatolia Region, the province benefits from a microclimate that supports extensive agricultural activities. The Iğdır Plain, the Aras River, and surrounding wetlands contribute significantly to the region's biodiversity. Its flat and expansive topography, along with intensive agricultural practices and various land use types, makes Iğdır an ideal environment for remote sensing studies. In this study, to focus the analysis on agricultural areas, only regions with dense agricultural lands were selected, excluding the provincial and district centers of Iğdır.

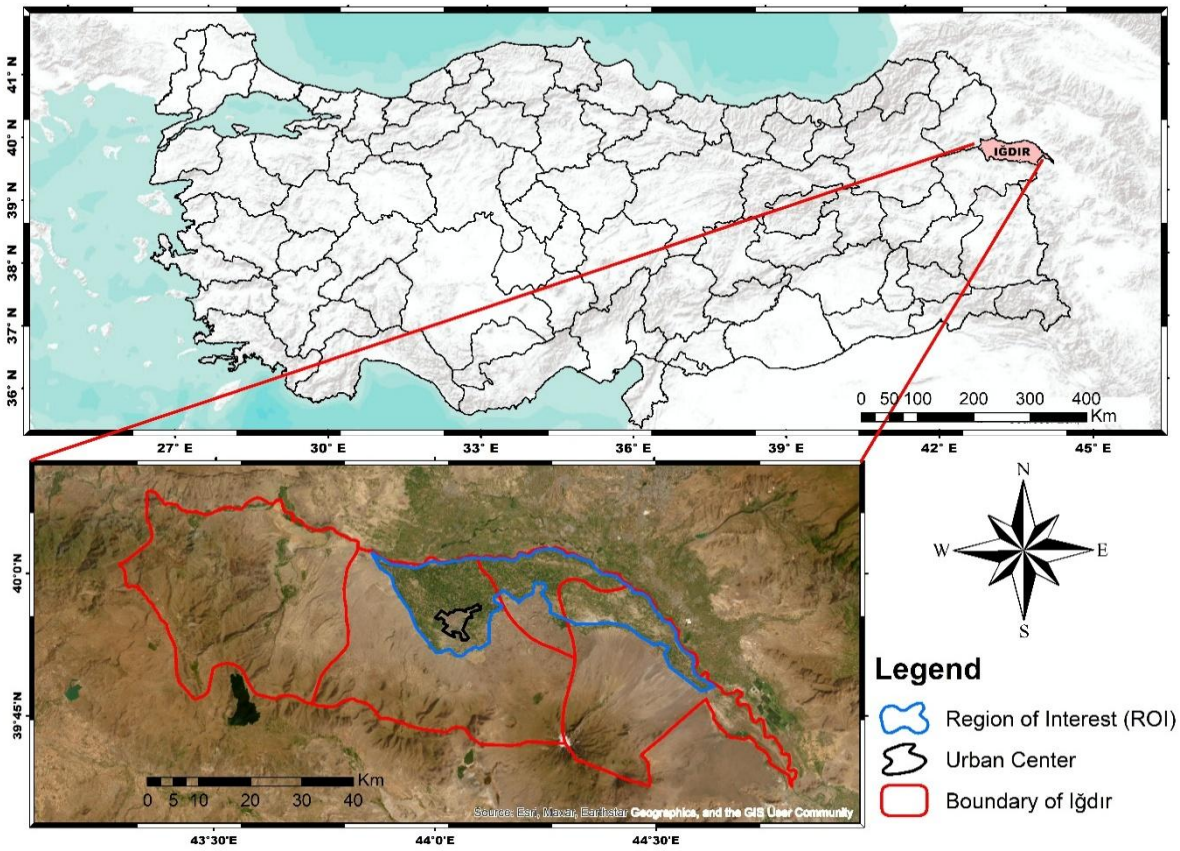

Figure 1. Location map of the study area; provincial and district boundaries

The variable landscape and agricultural patterns in Iğdır provide a valuable framework for assessing the spatial and temporal changes in agricultural development using NDVI time series. Additionally, the extensive agricultural lands and diverse crop patterns in the region enhance the study's specificity to Iğdır while also ensuring its broader methodological applicability.

Materials

Sentinel-5P operates with the highly spectrally resolved Tropospheric Monitoring Instrument (TROPOMI) sensor, which performs measurements in the ultraviolet, visible, near-infrared, and short-wave infrared spectral bands. In this study, methane (CH_4) concentrations in the atmosphere are determined using the "L3 (COPERNICUS/S5P/OFFL/L3_CH4)" level methane products obtained from the Copernicus Sentinel-5 Precursor (Sentinel-5P) satellite, launched by the European Space Agency (ESA). These products are capable of detecting the distribution and concentration of important greenhouse gases, such as methane, in the atmosphere with high precision.

To further evaluate the atmospheric methane distribution with vegetation condition, Normalized Difference Vegetation Index (NDVI) values have been used, which are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor. NDVI is a widely used remote sensing parameter for determining vegetation density and photosynthetic activity, calculated using the reflectance values in the red (Red) and near-infrared (NIR) spectral bands to assess the health and density of vegetation. MODIS is a satellite sensor located within NASA's Earth Observation System, designed to monitor the Earth's surface across various spectral bands. The MODIS sensor regularly collects NDVI data from various regions of the Earth's surface, providing crucial information for agriculture, forest ecosystems, climate change research, and environmental management.

Methodology

This study aims to compare the spatial and temporal variations between methane (CH_4) levels obtained from the Sentinel-5P satellite and the NDVI data derived from the MODIS sensor. In order to provide a more comprehensive evaluation of atmospheric methane distribution, Sentinel-5P data has been compared with NDVI data derived from NASA's MODIS sensor. NDVI values range from -1 to +1; negative values indicate water, ice, or cloudy regions, values near zero represent bare soil areas, and positive values correspond to healthy vegetation.

In the first phase, the boundaries of the designated study area, were defined on the Google Earth Engine (GEE) platform. Subsequently, methane products (CH_4) from the Sentinel-5P satellite were analyzed in three-month periods (December-February, March-May, June-August, September-November), and the average methane values in each period were calculated. The same procedure was also performed for the NDVI values derived from the MODIS data. These steps allowed for the extraction of comparable data sets with respect to their spatial resolution while maintaining the periodicity of the data.

During the data analysis process, various filtering methods, including spatial, temporal, spectral, and statistical filtering, were applied to calculate the periodical average methane concentrations. Spatial filtering ensured that only data within the Iğdır province boundaries were considered, while temporal filtering selected methane observations from December 2023 to November 2024. Spectral filtering was used to extract only the methane concentration band from the Sentinel-5P dataset. Additionally, statistical filtering helped determine the minimum and maximum methane values within the study area, enabling the identification of potential anomalies. This process resulted in the creation of raster format maps representing methane and NDVI distributions. These maps enabled a deeper investigation of the methane and NDVI data for each pixel, maintaining a similar spatial resolution within the Iğdır province boundaries.

Through this comparison, potential relationships between methane emissions and vegetation were assessed in areas with different land use types and varying vegetation densities. Specifically, the changes in methane concentrations in agricultural areas were examined, and an attempt was made to elucidate the dynamic relationship between atmospheric methane levels and vegetation.

RESULTS

In this study, the relationship between methane concentrations and vegetation dynamics in the Iğdır province has been examined in detail. In Figure 2 and Figure 3, the temporal and spatial distribution of methane levels and normalized NDVI values within the study area boundaries is visualized, respectively, over the designated periods.

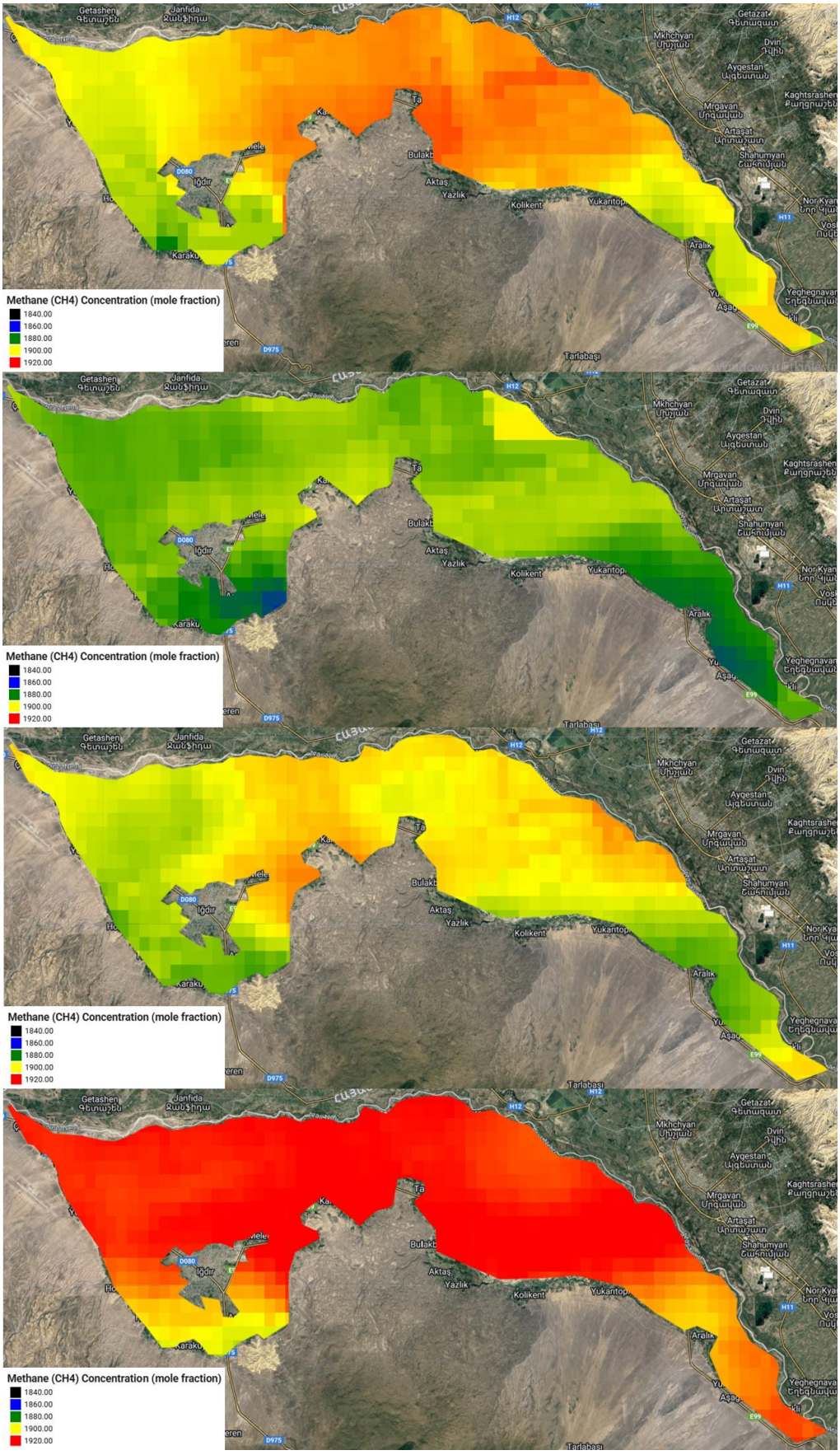

Figure 2. Seasonal methane maps for 2024.

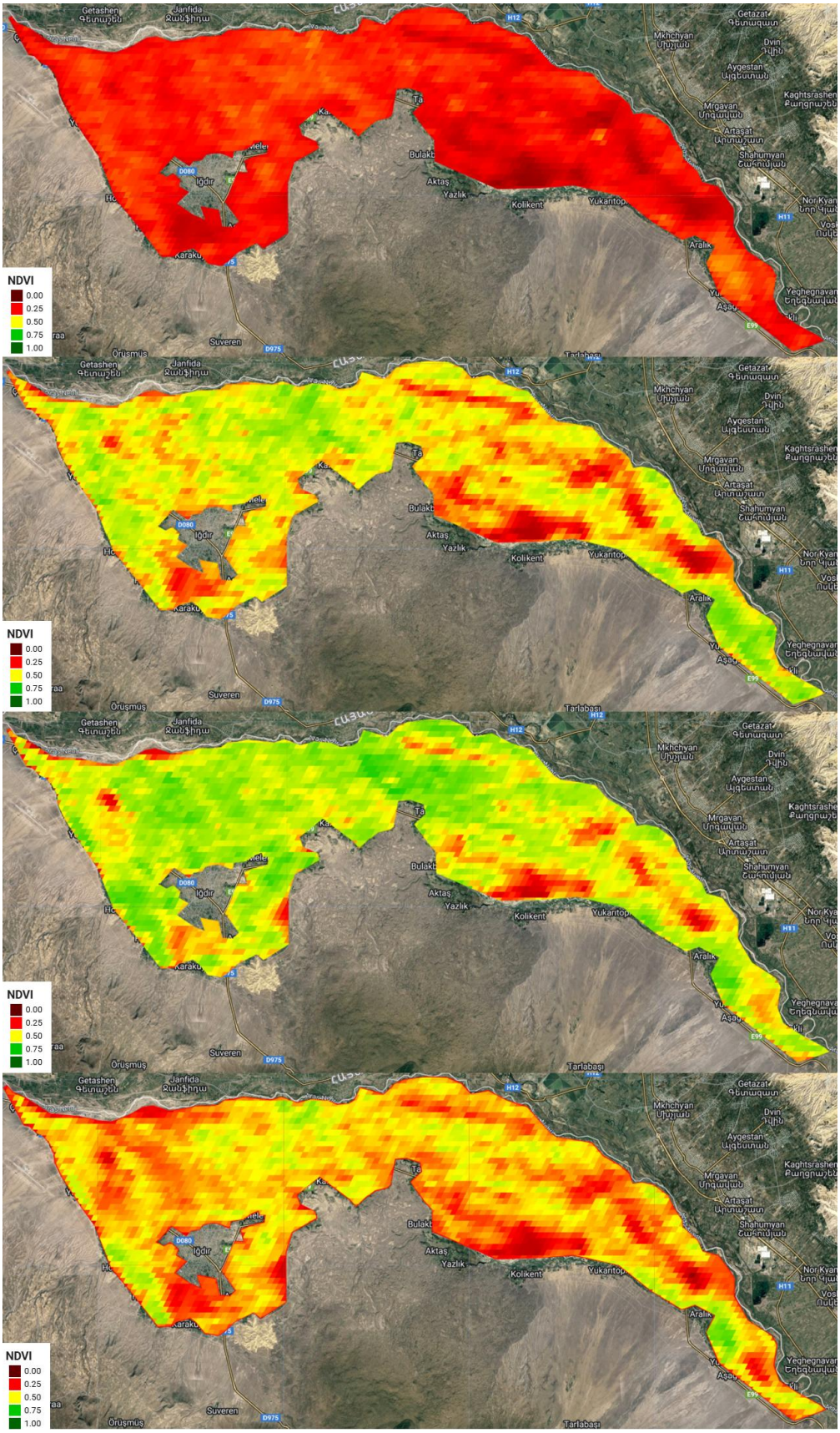

Figure 3. Seasonal NDVI maps for 2024.

Figure 2 illustrates the variations in atmospheric methane (CH_4) concentrations for the periods of December–February, March–May, June–August, and September–November, respectively. Similarly, Figure 3 presents the NDVI variations for the same time intervals. When examining

the images corresponding to these periods, the differences between the two variables are not visually distinguishable. Therefore, to gain deeper insight into the relationship between methane concentrations and NDVI values, scatter plots have been generated for the same time periods (Figure 4).

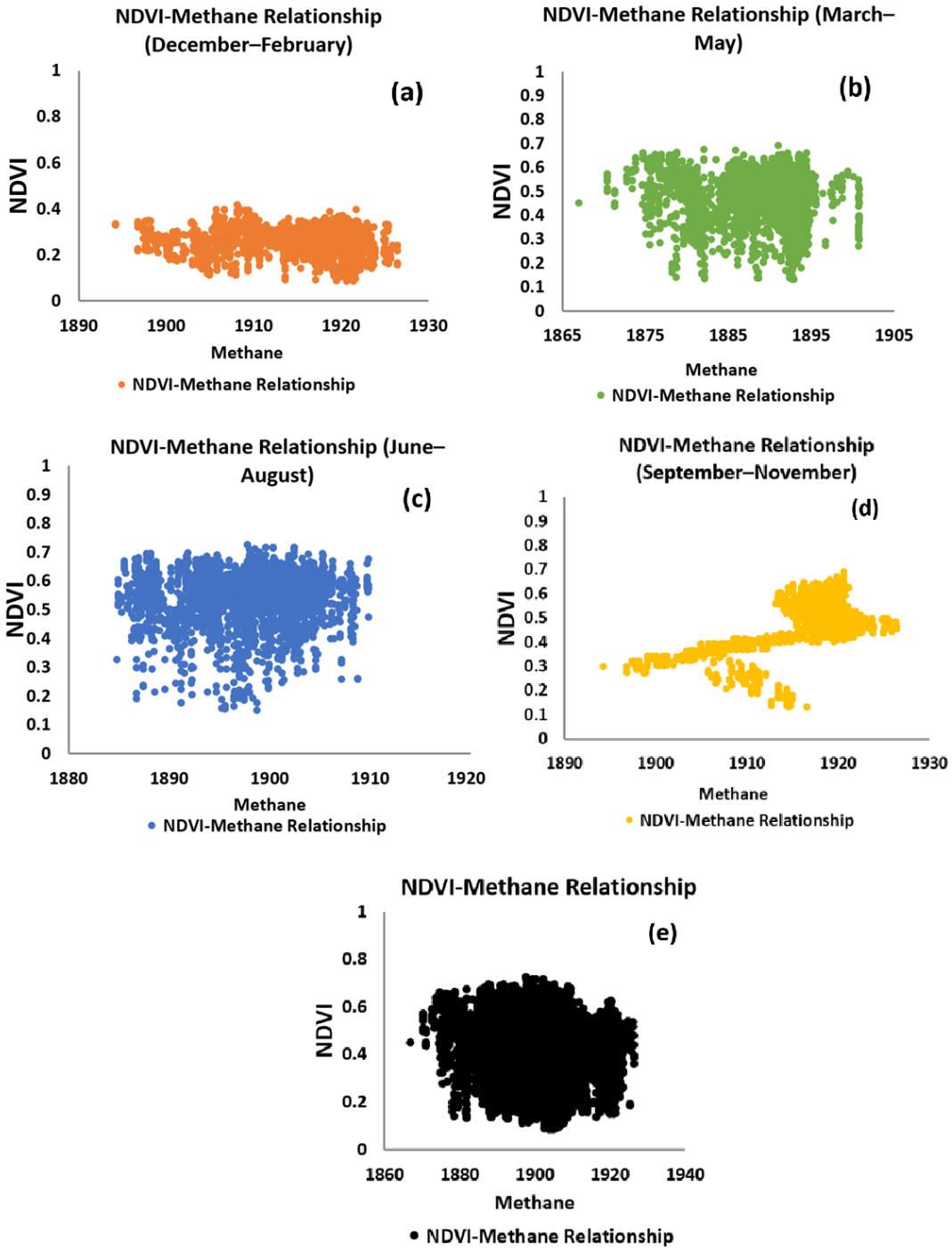

Figure 4. Scatter plots of seasonal Methane and NDVI values; a) December–February, b) March–May, c) June–August, d) September–November and e) Full year.

An analysis of the scatter plots for each season reveals no clear correlation between atmospheric methane (CH_4) concentrations and NDVI values. To further investigate this relationship, correlation coefficients were calculated for the corresponding periods. The correlation values for the December–February, March–May, June–August, and September–November periods were found to be -0.049, -0.09, 0.09, and -0.018, respectively. When considering all data over the one-year period, the overall correlation coefficient was calculated as -0.22. These results

indicate that there is no significant relationship between methane concentrations and NDVI values.

CONCLUSION

This study aimed to compare the spatial and temporal variations between atmospheric methane (CH_4) data obtained from the Sentinel-5P satellite and the NDVI derived from the MODIS sensor. The selected study area, Iğdır province, is characterized by intensive agricultural activities and diverse land use types, making it a suitable region for investigating potential relationships between methane emissions and vegetation.

The analyses conducted in this study revealed no significant visual correlation between atmospheric methane concentrations and NDVI values over the designated periods. Scatter plots and correlation analyses further confirmed the absence of a meaningful relationship between the two variables. The calculated correlation coefficients for the seasonal periods were -0.049, -0.09, 0.09, and -0.018, with an overall annual correlation of -0.22. These findings indicate that methane concentrations are not directly influenced by vegetation cover.

In conclusion, this study demonstrates the limited relationship between Sentinel-5P methane data and NDVI. Future research could further explore potential interactions between methane emissions and vegetation by incorporating additional environmental variables and conducting analyses at different spatial and temporal scales.

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THE IMPACT OF LOS ANGELES WILDFIRES ON NO_2 CONCENTRATIONS: TEMPORAL AND SPATIAL ANALYSIS USING SENTINEL-5P DATA

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ABSTRACT

Fires can have significant environmental impacts by releasing pollutants into the atmosphere. One such pollutant, nitrogen dioxide (NO_2), is emitted in large quantities during fires, altering air quality and environmental conditions. This study examines the temporal and spatial changes in NO_2 levels during a fire event that occurred in the Los Angeles area from January 5-16, 2025. Using NO_2 column density data obtained from the Sentinel-5P satellite, changes in NO_2 levels were analyzed for three periods: before the fire (January 5-6), during the fire (January 7-12), and after the fire (January 13-16). The data were processed using the Google Earth Engine platform with regional filters applied. The results show a significant increase in NO_2 levels during the fire event. NO_2 levels were normal before the fire, but from January 7, when the fire started, there was a sharp rise, reaching a peak between January 8-12, and spreading across the region. As the fire's effects diminished, NO_2 levels returned to normal after January 13. These changes clearly demonstrate the temporal variations and spatial distribution of NO_2 levels. Fires cause a rapid increase in NO_2 levels in the atmosphere, and this increase's spatial distribution can vary depending on the intensity of the fire. This study shows that remote sensing methods are an effective tool for studying the pollutants emitted by fires, and they can be used to assess the impact of future fires on air quality.

Keywords: Remote Sensing, Air Pollution, Sentinel-5P, NO_2, Google Earth Engine.

INTRODUCTION

Fires are significant events that disrupt the balance of natural ecosystems and have global-scale environmental impacts (Farid et al., 2024). As a result of these fires, large amounts of greenhouse gases and pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), and nitrogen dioxide (NO_2) are released into the atmosphere (Murmu et al., 2022). These gases not only negatively affect air quality but also contribute to climate change, leading to long-term environmental issues (Geraskina et al., 2022; Mastachi-Loza et al., 2024). In particular, gases like NO_2 and CO have direct harmful effects on human health and can trigger respiratory diseases (Atalay et al., 2025; Izuta, 2017).

Tracking fire-related gas emissions is crucial for understanding the scale of the event and evaluating environmental impacts. These monitoring efforts are typically carried out using traditional methods such as ground-based measurements and air quality stations (Partigöç & Çubukçu, 2017; Makineci, 2022). However, the installation and maintenance of these stations are costly, and they are often limited in number and located in specific regions, making them insufficient for covering large areas. This limitation restricts the spatial resolution of measurements and can lead to gaps in air quality assessments (Concas et al., 2021). To overcome these limitations, low-cost air quality sensors have emerged as an alternative solution. However, these sensors also face challenges such as cross-sensitivity, vulnerability to environmental factors, and loss of accuracy over time (Cassard et al., 2020).

At this point, remote sensing technologies offer a strong alternative for monitoring fire-related gases on a large scale. Satellite-based sensors allow for the monitoring of vast areas at low cost and continuously, while detecting the spatial and temporal changes of gas components in the atmosphere with high accuracy (Alvarado, 2020; Xulu, 2021). The Sentinel-5P satellite developed by the European Space Agency (ESA), with its Tropospheric Monitoring Instrument (TROPOMI) sensor, makes significant contributions to global air quality assessments by measuring NO_2, CO, CH_4, and other pollutants (Schneising, 2019; Magro et al., 2021; Van Der Velde et al., 2020). Monitoring and analyzing the spatial patterns of these emissions during fire events is crucial for understanding their dynamics (Neyrizi et al., 2024).

This study aims to highlight the advantages of remote sensing by evaluating how NO_2 emissions from fires can be temporally and spatially tracked using Sentinel-5P data. The study aims to extract NO_2 values from the atmosphere in mol/m² using Google Earth Engine (GEE) and assess the spatial-temporal distribution of NO_2 during the pre-fire, during-fire, and post-fire periods, alongside environmental parameters.

MATERIALS AND METHODOLOGY

Study area

The selected study area, Los Angeles, is a region that frequently faces wildfires, resulting in significant impacts on air quality (Figure 1). Located between latitudes 33.7° - 34.5° N and longitudes 117° - 119° W, this city has a Mediterranean climate, characterized by hot and dry summers and mild and humid winters. Particularly, the Santa Ana winds, which are active between September and November, contribute to the rapid spread of fires in the region. Historically, major fires such as the Woolsey Fire (2018), Bobcat Fire (2020), and Thomas Fire (2017) have occurred in and around Los Angeles, causing extensive ecological damage.

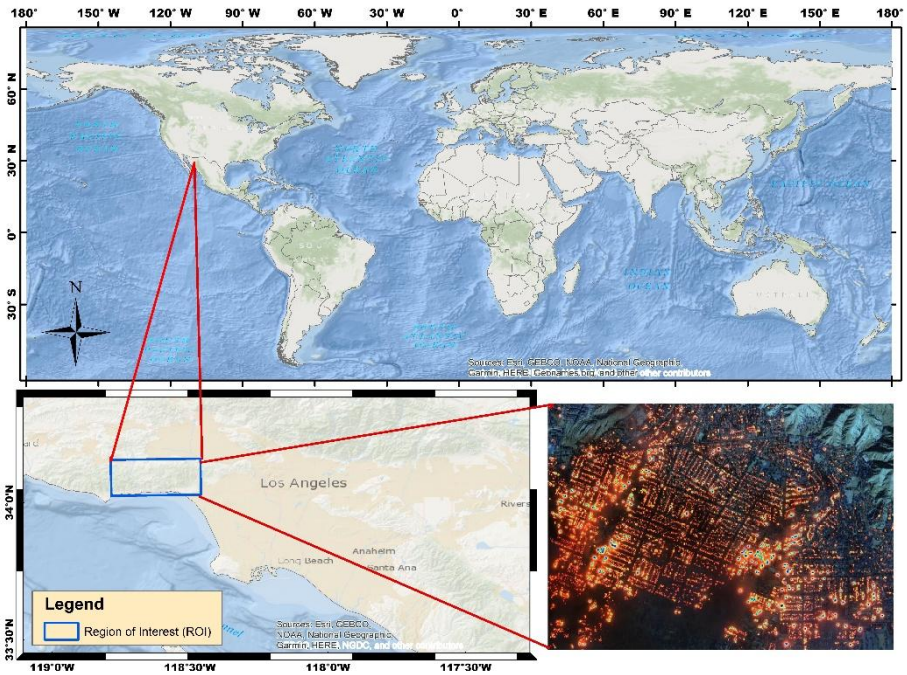

Figure 1. Location map of the study area

Fires in the region pose serious threats to air quality, ecosystem balance, and human health. During and after the fire, large amounts of carbon monoxide (CO), nitrogen dioxide (NO_2), and fine particulate matter (PM2.5, PM10) are released into the atmosphere, triggering respiratory diseases and negatively affecting public health. Additionally, post-fire soil erosion increases, and the risk of heavy metals contaminating water sources rises.

Materials

This study analyzes the spatial and temporal changes in NO_2 concentration before and after a large-scale fire that occurred in the Los Angeles area, using Sentinel-5P TROPOMI data. Sentinel-5P is an advanced satellite system capable of monitoring the global distribution of gases such as NO_2, O_3 (ozone), SO_2 (sulfur dioxide), CO (carbon monoxide), and CH_4 (methane) with high spectral and spatial resolution (Gharibvand et al., 2023). The satellite utilizes spectral bands from the short-wave ultraviolet (UV), visible (VIS), near-infrared (NIR), and short-wave infrared (SWIR) regions to determine the distribution of NO_2 in the troposphere. The TROPOMI sensor can detect NO_2 concentration globally with a spatial resolution of approximately 7×3.5 km² and provides daily global-scale data. This allows for a detailed analysis of the spatial and temporal changes in air pollution.

The NO_2 data produced by Sentinel-5P is categorized according to processing levels (Sharifi & Felegari, 2022). Near Real-Time (NRT) data is used for rapid analysis and short-term forecasts, while Offline (OFFL) data undergoes more detailed calibration and quality control processes, making it a more reliable option for scientific studies.

In this study, Sentinel-5P NO_2 offline data were processed using the Google Earth Engine (GEE) platform. The analysis of large-scale remote sensing data requires systems with high computational capacity. GEE, as a cloud-based geospatial data analysis platform, enables the processing of such large datasets (Zhao et al., 2021). By providing access to the extensive satellite data archive from NASA, ESA, and other space agencies, it facilitates the rapid and efficient study of global environmental changes. Its cloud computing infrastructure allows GEE to analyze large datasets directly without local hardware limitations. The platform supports JavaScript and Python APIs, assisting researchers with spatial modeling, time series analysis, and data visualization (Montero, 2021). Thanks to Google's high-capacity servers and parallel processing capabilities, large datasets can be analyzed quickly.

In addition to containing satellite datasets commonly used in remote sensing, such as Sentinel-1, Sentinel-2, Sentinel-5P, MODIS, and Landsat, GEE also provides access to climate models, DEM (Digital Elevation Model), and other geographic data sources. Sentinel-5P data can be easily processed on this platform through preprocessing, spatial and temporal filtering, statistical analysis, and visualization steps. Moreover, the time series analysis and spatial statistics offered by GEE provide a significant advantage in assessing air pollution changes.

Methodology

In this study, the spatial and temporal changes in nitrogen dioxide (NO_2) concentrations in the atmosphere before and after the fire in the Los Angeles area were analyzed. The analysis is based on data obtained from the TROPOMI (Tropospheric Monitoring Instrument) sensor on the Sentinel-5P satellite and aims to examine daily NO_2 values between January 5, 2025, and January 16, 2025. The study thoroughly examines the NO_2 concentrations in the atmosphere during this period to highlight the effects of the fire on air quality.

The data processing and analysis process began with the retrieval of data via the GEE platform. The Los Angeles study area was defined, and data covering only this region were filtered. To minimize errors caused by cloud cover, reliable pixels were selected using a quality criterion (qa_value). After these preprocessing steps, the daily NO_2 values between January 5, 2025, and January 16, 2025, were examined, and NO_2 density was mapped for each day. The spatial distribution was visualized day by day, and the temporal trends of NO_2 were evaluated by comparing the period before and after the fire. During the visualization phase of the study, thematic maps showing the spatial distribution of NO_2 levels were created, and the changes in NO_2 concentrations were supported by graphs. This allowed for a detailed interpretation of the fire's impact on air pollution.

RESULTS

The findings of this study reveal that the large-scale fire in the Los Angeles area had a significant impact on nitrogen dioxide (NO_2) concentrations in the atmosphere. Using TROPOMI data from the Sentinel-5P satellite, daily NO_2 values between January 5, 2025, and January 16, 2025, were examined, and the spatial and temporal changes during this period were analyzed in detail (Figure 2). This analysis clearly demonstrates the fire's effects on air quality, while also revealing how the changes in NO_2 levels responded to the fire's start and end dates.

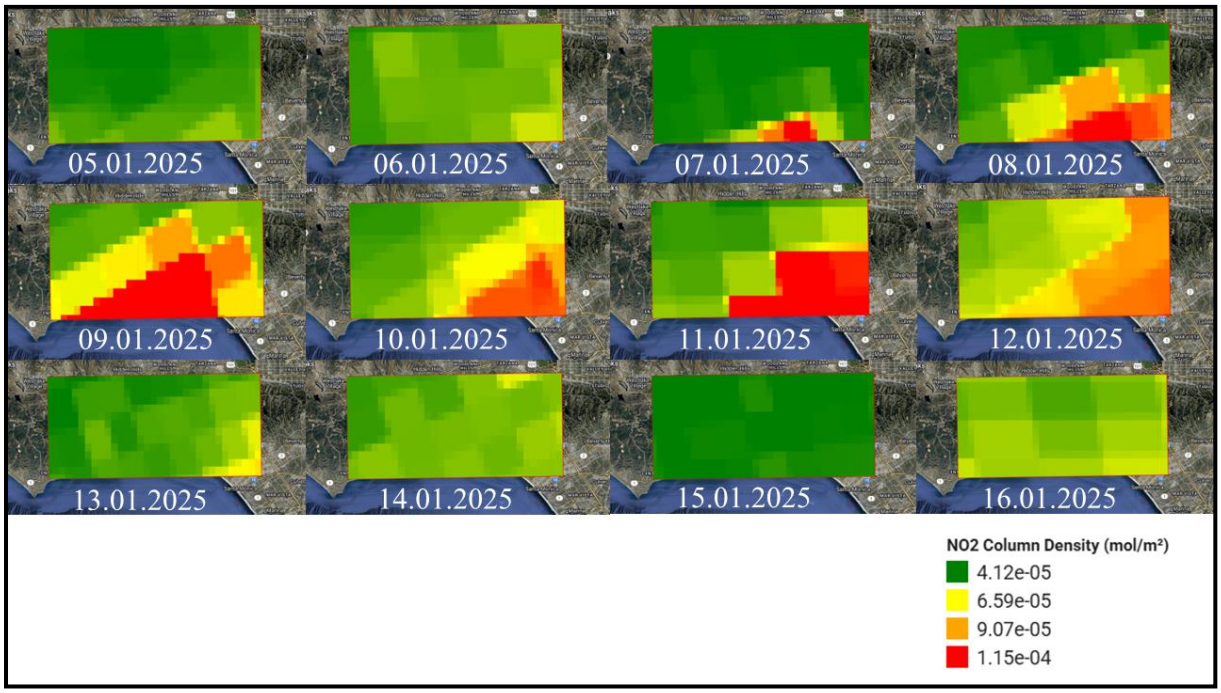

Figure 2. Daily trend of atmospheric NO_2 concentration (January 2025, LA Wildfire)

Before the start of the fire, on January 5, 2025, and January 6, 2025, the NO_2 concentration in the atmosphere continued to follow its normal pattern, and no unusual increase was observed. However, on January 7, 2025, it was determined that the fire had started, and from this date onward, a significant increase in NO_2 values was observed. This increase was directly related to the start of the fire, indicating a rapid acceleration in the release of atmospheric pollutants. During the fire, especially the spread of dense smoke into the atmosphere, imposed a significant burden on environmental conditions and air quality. This caused NO_2 concentrations to rise far above normal levels. Although this increase began to decrease after the fire ended on January 12, 2025, it was noted that the effects continued for a couple of more days.

Spatial analyses revealed that the increase in NO_2 concentrations changed regionally in parallel with the movement of the fire. From the moment the fire started, it was observed that NO_2 levels significantly increased, especially in areas close to the fire's center, and this increase gradually spread to a wider area over time. During the fire, the NO_2 density spread across various points of the Los Angeles area, with NO_2 levels peaking in areas where the smoke caused by the fire was particularly concentrated. As the fire's affected area expanded, NO_2 concentration increased over a wide area, and the spatial distribution of these changes followed the fire's path. It was clearly identified that the spread rate of the fire and the spatial changes in NO_2 levels were parallel.

In the period after the fire, although the decrease in NO_2 levels occurred rapidly near the fire's center, this reduction did not create a long-term effect. The complete dispersion of atmospheric pollutants and the clearing of the environment took a few more days. During this period, the effects of the fire were still felt, and NO_2 levels remained elevated for a few more days before returning to normal.

In conclusion, this study proves that the impact of the fire on NO_2 emissions can be analyzed in detail both spatially and temporally using Sentinel-5P data. The findings provide a better understanding of the effects of fires on air pollution and allow for more accurate predictions of the impacts of similar events in the future. Such analyses are critically important for monitoring air quality after large environmental disasters and assessing the effects on public health.

CONCLUSION

This study examined the spatial and temporal effects of a large fire in the Los Angeles area on atmospheric NO_2 concentrations. On January 7, 2025, the day the fire started, a sudden increase in NO_2 levels was observed, and this increase expanded in parallel with the areas affected by the fire. After the fire ended on January 12, NO_2 levels began to decrease, but the effects continued for some time. These findings clearly highlight the impact of fires on air quality and the changes in NO_2 concentration.

Future studies suggest that air quality models should be developed using larger datasets to monitor the long-term effects of fires. Additionally, early warning systems should be implemented, and measures should be taken to protect public health in response to changes in air quality following fires. The integration of remote sensing data and the use of different satellite observations can help model the impacts of such disasters more accurately.

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ORIGIN AND RAMAN SPECTROSCOPIC CHARACTERISTICS OF XENOLITHS IN THE KEBAN INTRUSIVE ROCKS

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ABSTRACT

The study area is located in the Keban district of Elazığ province, within the Anatolide-Tauride block in eastern Türkiye. The Late Cretaceous Keban magmatic units are composed of monzonite, quartz monzonite, syenite, foid syenite, and foid diorite, intruding into the Permo-Triassic Keban metamorphic rocks. The calc-slicate metamorphic rocks are products of the contact relations between Keban intrusives and metasedimentary rocks in the region. In the study area, xenoliths ranging from a few millimeters to several centimeters in size are observed within foid syenite and foid diorite. This study aims to determine the mineralogical, petrographic, and geochemical characteristics of these xenoliths and to elucidate their origin.

In line with the study objectives, xenolith and bedrock samples were collected from the study area. The xenolithic enclaves characterized by the presence of the metamorphic textures under the polizing microscope. these enclaves are mainly composed of quartz, albite, pyroxene with rare amounts of titanite, epidote and calcite. Confocal Raman Spectroscopy (CRS) was employed to identify the types of garnet and plagioclase minerals.

The host rock is foid syenite in composition and exhibit a holocrystalline granular texture and are composed of plagioclase, nepheline, garnet, fluorite, barite, and calcite. Foid diorite samples display a holocrystalline porphyritic texture, with quartz, nepheline, garnet, fluorite, barite, calcite, and plagioclase as their primary mineralogical components. Silicification, carbonatization, argillization, perthitization, and propylitization alterations were observed in the samples.

According to the CRS measurements, the garnet minerals were identified as andradite (873.63–369.04–351.71 cm^{-1} Raman shift) and demantoid (876.20–515.24–371.61–351.80 cm^{-1} Raman shift), while the plagioclase was classified as labradorite (1115.09–507.73–484.20–187.02 cm^{-1} Raman shift).

Key Words: Keban magmatics, xenolith, raman spectrometry, foid syenite, foid diorite

INTRODUCTION

Türkiye is located within the Alpine-Himalayan Mountain belt and comprises continental fragments that amalgamated during the Late Tertiary. In the north, the Strandja, Istanbul, and Sakarya terranes collectively constitute the Pontides.The classification of the Central Anatolian Crystalline Complex as a distinct terrane within the Anatolide-Tauride block remains a subject of debate. Southeastern Anatolia constitutes the northern margin of the Arabian Platform (Okay, 2008). Keban, the location of the study area, lies within the Anatolide-Tauride block and underwent metamorphism during the Alpine orogeny.

Allochthonous and autochthonous units are present in the study area and its surroundings. The allochthonous units include the Keban Marbles, Delimehmet Formation, Süleymanlı Formation, Bahçeli Metadiabase, Arapgir Limestones, and Nimri Formation. The Keban Marbles are of Middle to Late Devonian age. The Delimehmet Formation, aged to the Late Devonian, consists of clastic and carbonate rocks. Tectonically overlying this unit is the Süleymanlı Formation, which is of Early Carboniferous age and comprises phyllites, schists, calcareous schists, and recrystallized limestones. The Arapgir recrystallized limestones and the Nimri Formation, composed of schists, dolomitic limestones, and calcareous schists, overlie these units (Kaya, 2016). The autochthonous units include the Keban Magmatics, Kuşcular Formation, Kırkgeçit Formation, Alibonca Formation, Karabakır Formation, and Hamurlu Formation (Kaya, 2016). The Keban Magmatics intrude the metamorphic units and are subsequently overlain by Tertiary-aged sedimentary units.

Raman spectroscopy is a type of vibrational spectroscopy based on the principle of Raman scattering (Akçe and Kadıoğlu, 2020). It operates on the principle of measuring light scattered at a specific angle from a high-intensity laser source (Skoog, 1998). In Raman scattering, interactions between the incident light and molecules result in specific energy gains or losses. The differences in wavelength between the incident and scattered light are referred to as Raman shifts (Akçe and Kadıoğlu, 2020). A Raman spectrometer consists of three main components: a spectrometer, a light source, and a sample lighting system (Ferraro et al., 2003).

The Raman spectrometer has a wide range of applications in fields such as archaeology, medicine, biology, pharmaceuticals, and the paper industry. In recent years, it has been applied in geological sciences, yielding successful results, particularly in mineral identification studies (McMillan et al., 2003; Nasdala et al., 2004). The Raman spectrometer supports polarizing

microscopy and geochemical analyses and enables the precise identification of minerals that cannot be determined by X-ray diffraction (XRD). It offers advantages such as ease of sample preparation and the ability to conduct measurements in a short time. Consequently, its applications in geology have been increasingly expanding (Akçe and Kadıoğlu, 2020).

Raman spectroscopy has increasingly been used for the identification of minerals in igneous, sedimentary, and metamorphic rocks. In recent years, specific studies have focused on the identification of minerals, particularly in granitoids (Zoroğlu and Kadıoğlu, 2007; Kadıoğlu et al., 2011; Deniz et al., 2013; Güllü et al., 2019), while detailed investigations have also been conducted on the mineral composition of metamorphic rocks (Koralay and Ören, 2020).

In this study, calc-silicate metamorphic rocks were examined as products of the contact relationships between the Keban intrusions and the surrounding metasedimentary rocks. The mineral types of garnet and plagioclase within the xenoliths were identified using Raman spectroscopy.

METHODOLOGY

In this study, initial field observations were conducted. Representative samples were collected from the study area. Petrographic thin sections were prepared at the Thin Section Laboratory of the Department of Geological Engineering at Ankara University. These thin sections were examined using a Leica polarizing microscope, of the minerals, alterations, and textures were identified. Geochemical samples were analysed at the Earth Sciences Application and Research Centre (YEBIM) of Ankara University. Major, trace and rare earth element compositions were determined using ICP-OES and ICP-MS instruments (Figure 1).

Figure 1. Preparation of petrographic a) thin sections, b) grinding machine

Raman spectroscopy was performed on the minerals marked for identification in the thin sections (Figure 1a). These analyses were conducted using a HORIBA Jobin Yvon LabRAM HR Raman spectrometer at the Earth Sciences Application and Research Centre of Ankara University. A laser beam with a wavelength of 780 nm and a beam diameter of 25 μm was directed onto the samples (Figure 2), and the scattered light was collected by the detector to generate spectra. The obtained spectra were compared with reference peaks in the LabSpec software to determine the characteristics of the analysed minerals.

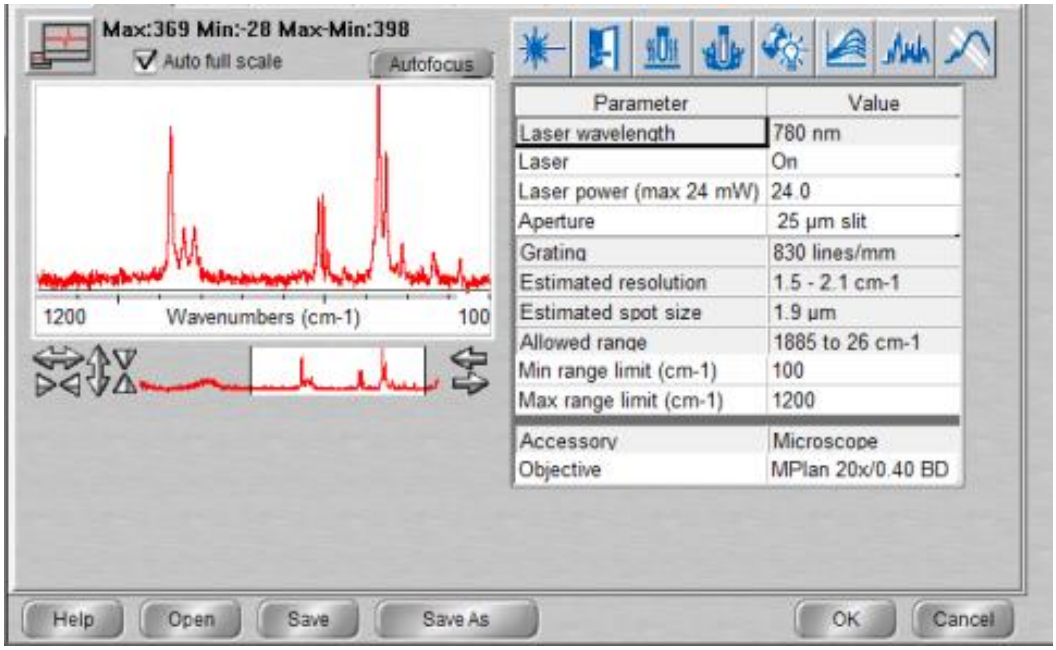


Figure 2. Raman spectrometer settings during the measurement.

CONCLUSION AND DISCUSSION

Petrographic descriptions were made in the thin section samples prepared from the specimens collected from the study area. Taken samples are composed of foid diorite, foid syenite, syenite, monzonite, and nepheline syenite. Alterations such as argillization, sericitization, iron oxidation, opacification, perthitisation, silicification, carbonation, sosurization, epidotization, and chloritization have been observed in the samples and the representative of petrography result is given in (Table 1).

Table 1. Representative petrography results of the collected samples.

Sample No	Location	Coordinates		Petrography	Texture	Mineral composition	Alteration
21M-DU-38	Elazığ/Keban/Yahyali	476712	4298250	Foid syenite	Holocrystalline porphyritic texture	Plagioclase, sanidine, apatite	Argillization, sericitization, iron oxidation, opacification
21M-DU-39A	Elazığ/Keban/Yahyali	477492	4298414	Syenite porphyry	Holocrystalline porphyritic texture	Plagioclase, sanidine, apatite	Argilization, sericitization, carbonation, silicification
21M-DU-51B	Elazığ/Keban/Kurubekir	474872	4290558	Syenite	Porphyritic texture	Plagioclase, alkali feldspar, quartz, titanite	Sericitization
21M-DU-52B	Elazığ/Keban/Kurubekir	474868	4290550	Monzonit Porphry	Porphyritic texture	Plagioclase, alkali feldspar, quartz, carbonate minerals, titanite	Sericitization
21M-DU-53B	Elazığ/Keban/Kurubekir	474880	4290495	Monzonite	Porphyritic texture	Plagioclase, alkali feldspar, quartz, carbonate minerals, titanite	Sericitization
21M-DU-54B	Elazığ/Keban/Kurubekir	473025	4289286	Monzonite Porphry	Porphyritic texture	Plagioclase, alkali feldspar, quartz, carbonate minerals, titanite	Sericitization

The geochemical samples taken plot on the foid syenite, foid diorite, syenite, monzonite and quartz monzonite area on the total alkali silica diagram (Middlemost, 1994) (Figure 3).

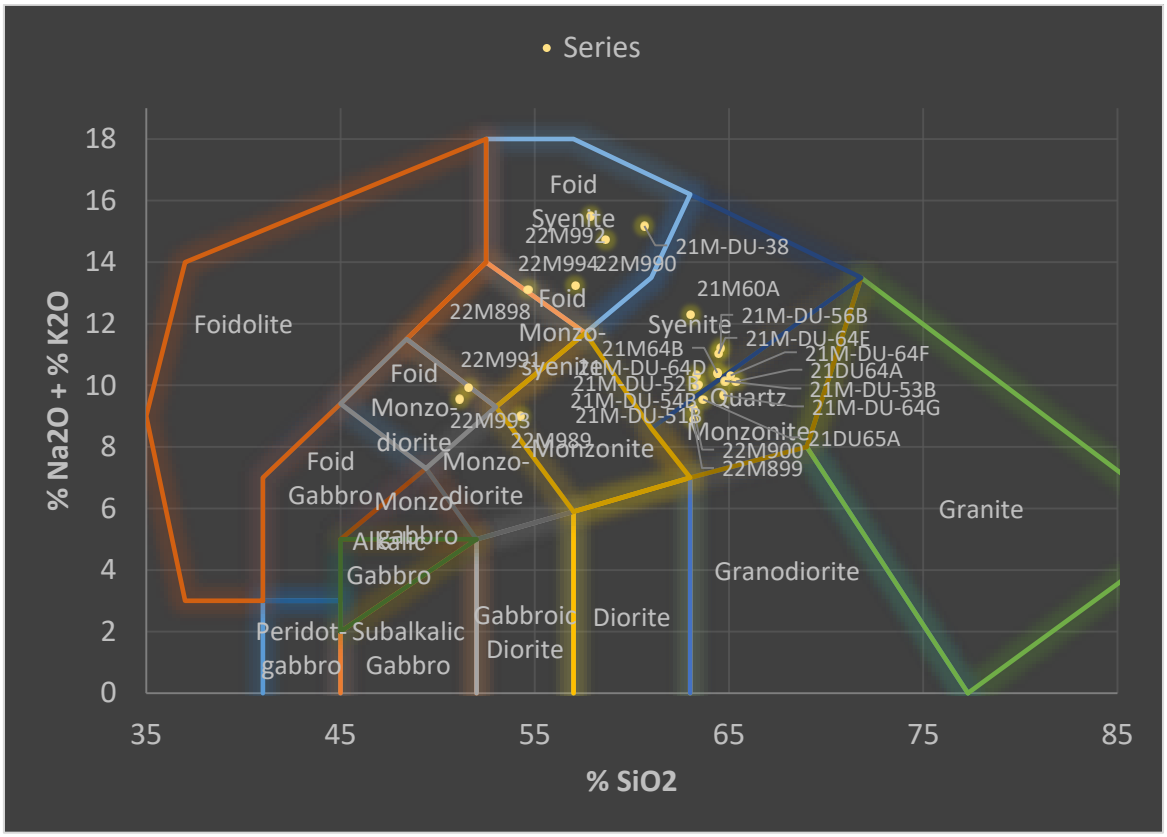


Figure 3. Total alkali silica diagram of the analysed samples

Garnet group minerals exhibit high spectrometric readings due to their crystal system symmetry and silicate structure (Akçe and Kadıoğlu, 2020). In sample 22M990, the garnet mineral previously marked under a polarized microscope (Figure 4) at the first point in the calcsilicate hornfels foid diorite matrix was selected. The Raman spectrum obtained from the selected mineral showed the composition of Andradite (873.63–369.04–351.71 cm^{-1} Raman shift) (Figure 5).

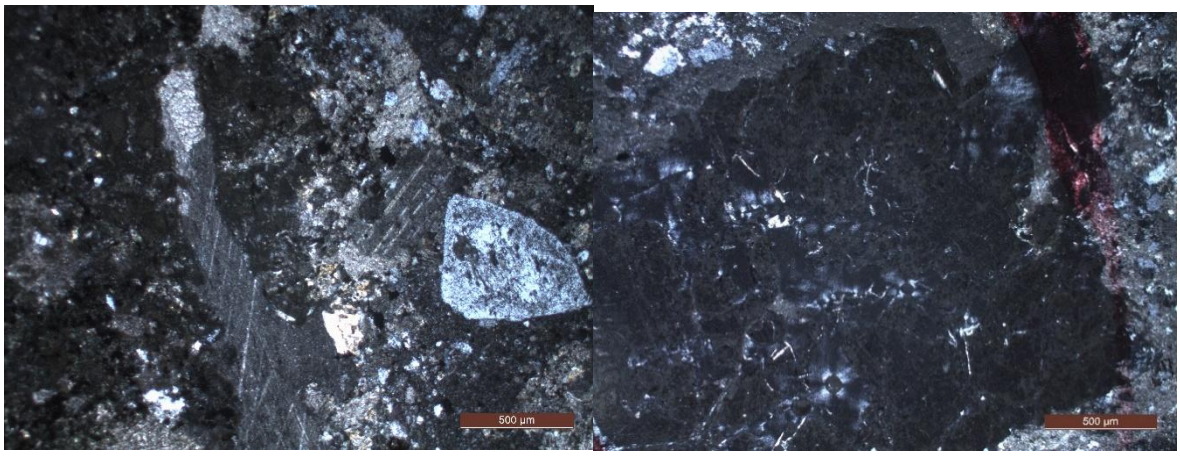


Figure 4. Photomicrogrphs of the foid syenite of the host rock.

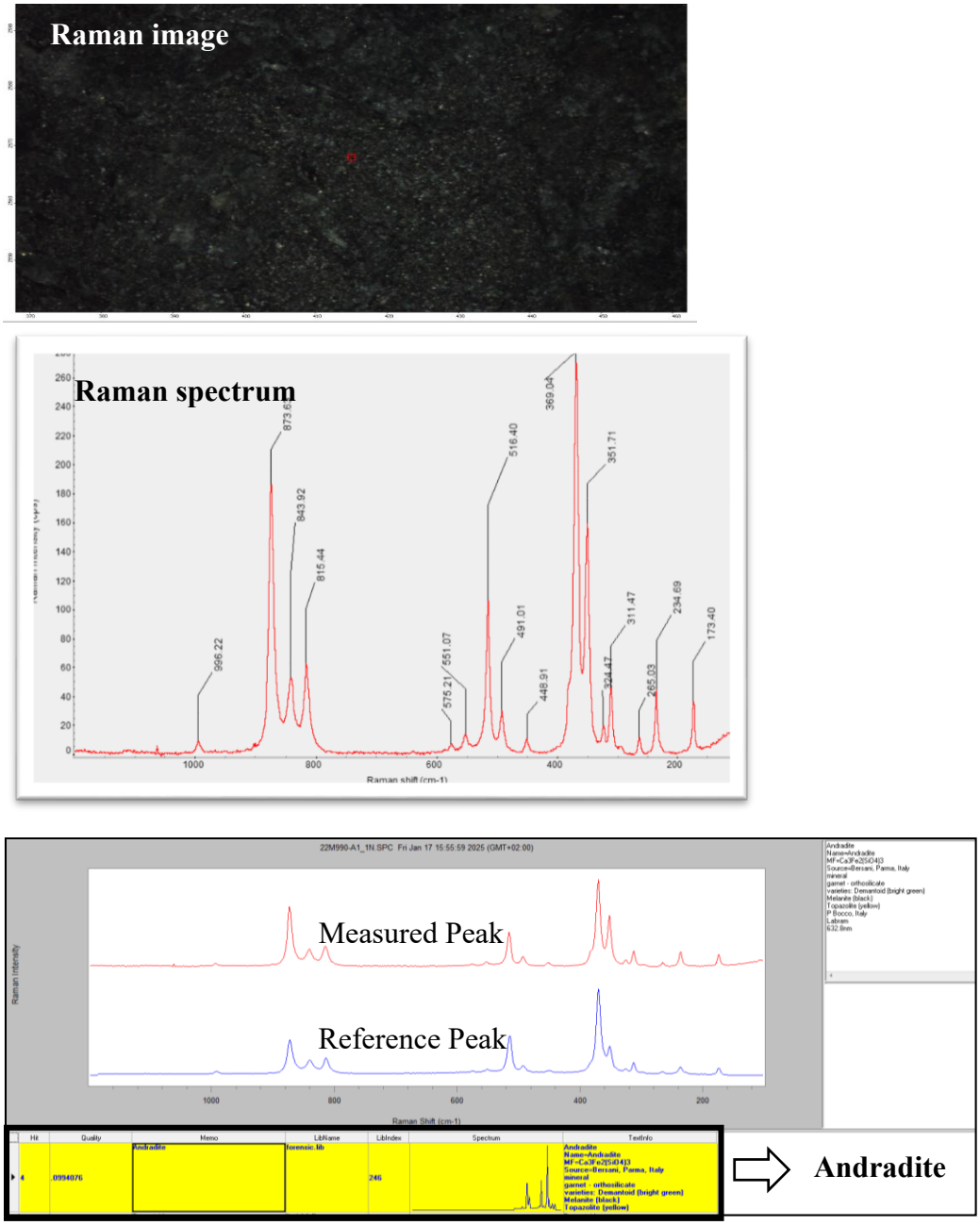
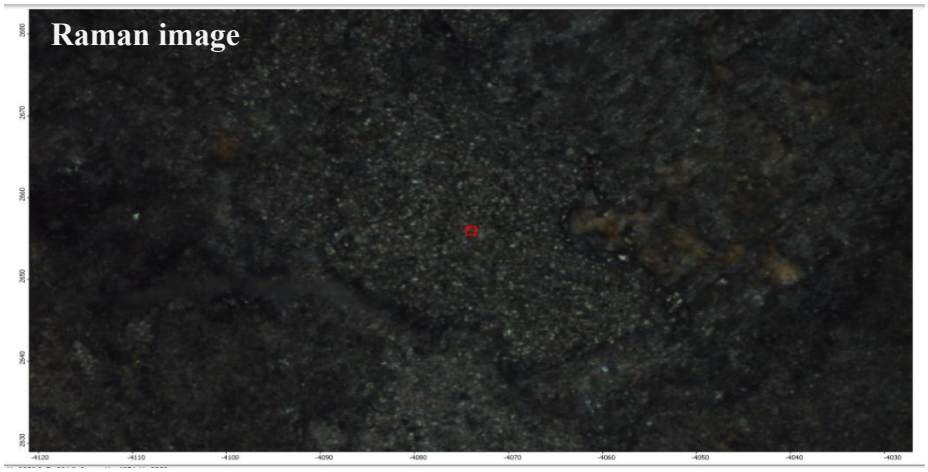
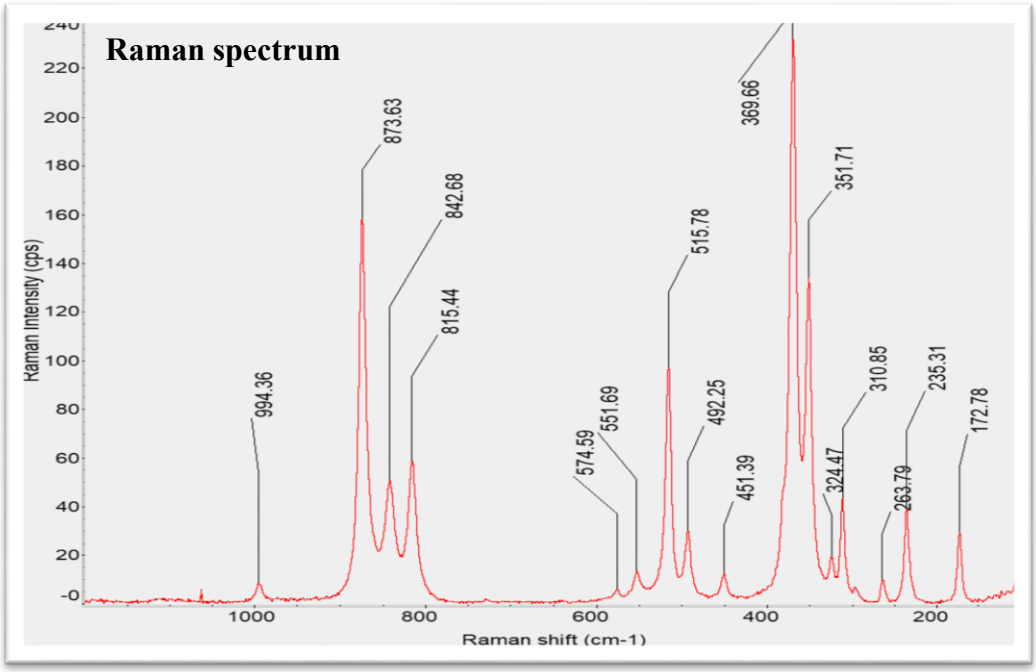


Figure 5. Raman shift of garnet of the sample 22M990

In sample 22M990, the second point was selected from the area marked as garnet. The selected garnet mineral was identified as Andradite (873.63–369.666–351.71 cm^{-1} Raman shift) (Figure 6).





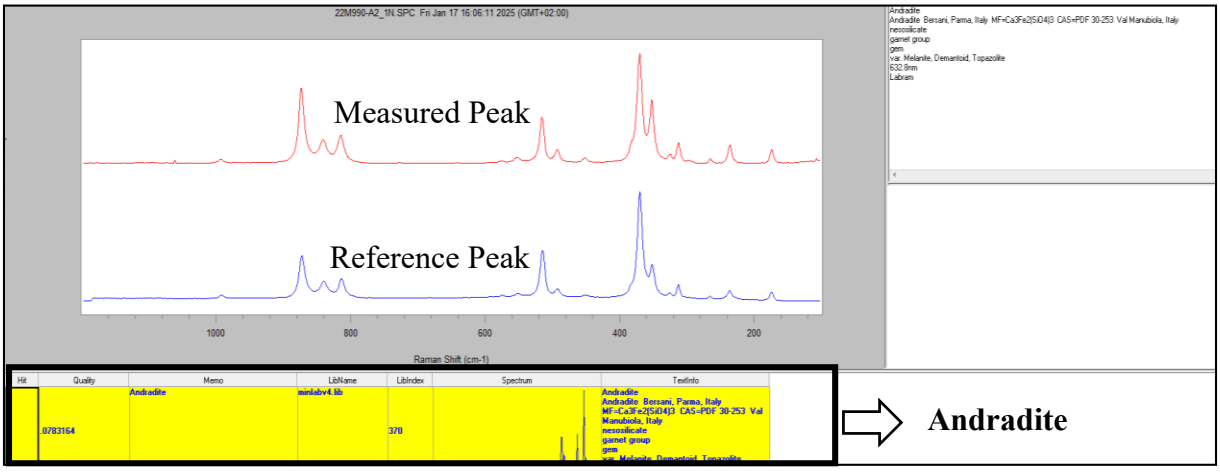


Figure 6. Raman shift of garnet selected from point 2 in sample 22M990

As part of the Raman spectroscopy studies, a garnet mineral was again selected in sample 22M991. The selected garnet mineral was identified as demantoid (873.63–369.666–351.71 cm^{-1} Raman shift) (Figure 7).

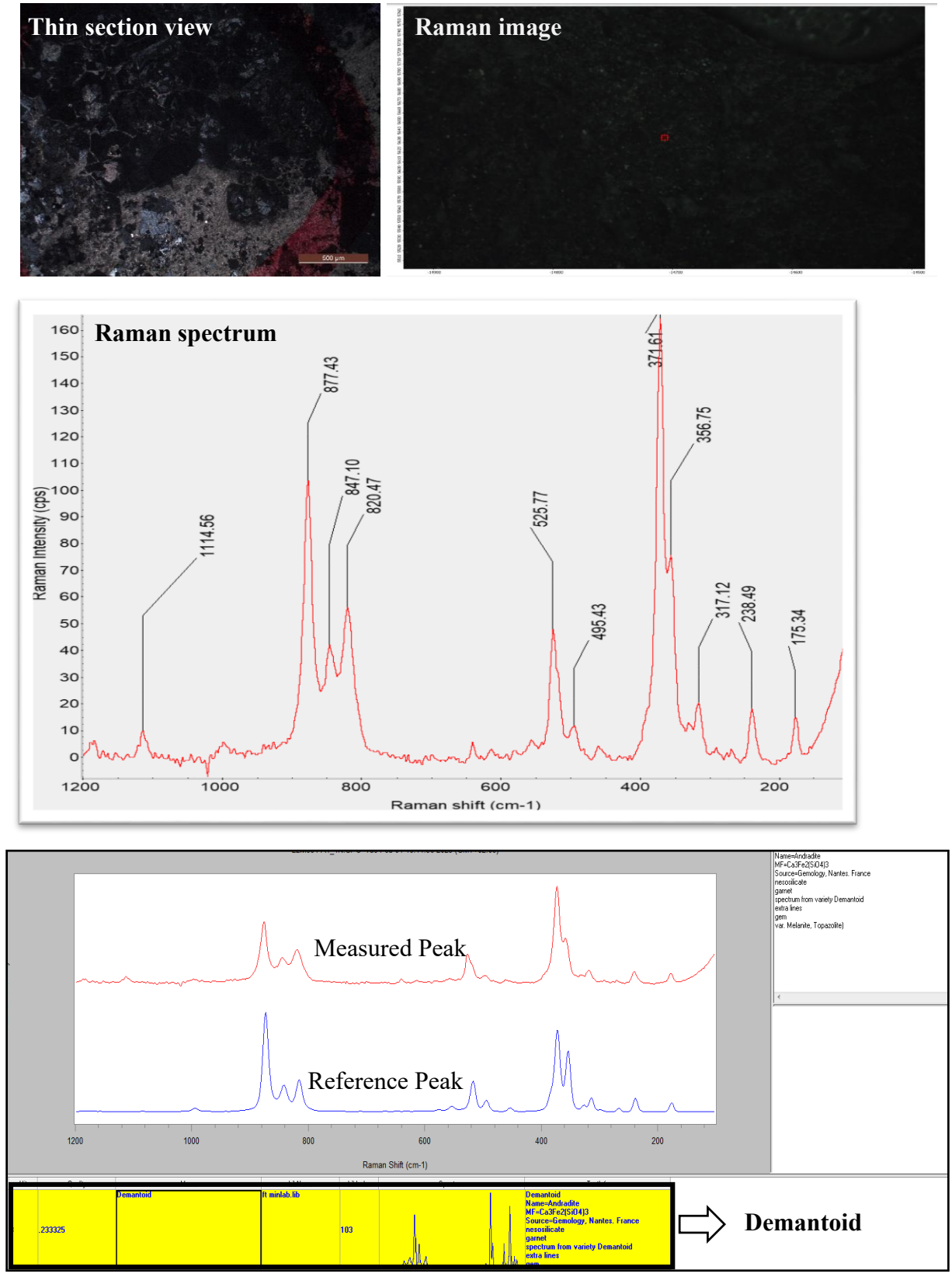


Figure 7. Raman shift of garnet mineral in sample 22M991

In sample 22M992, the selected garnet mineral showed the composition of demantoid (873.01–370.28–351.71 cm^{-1} Raman shift) (Figure 8).

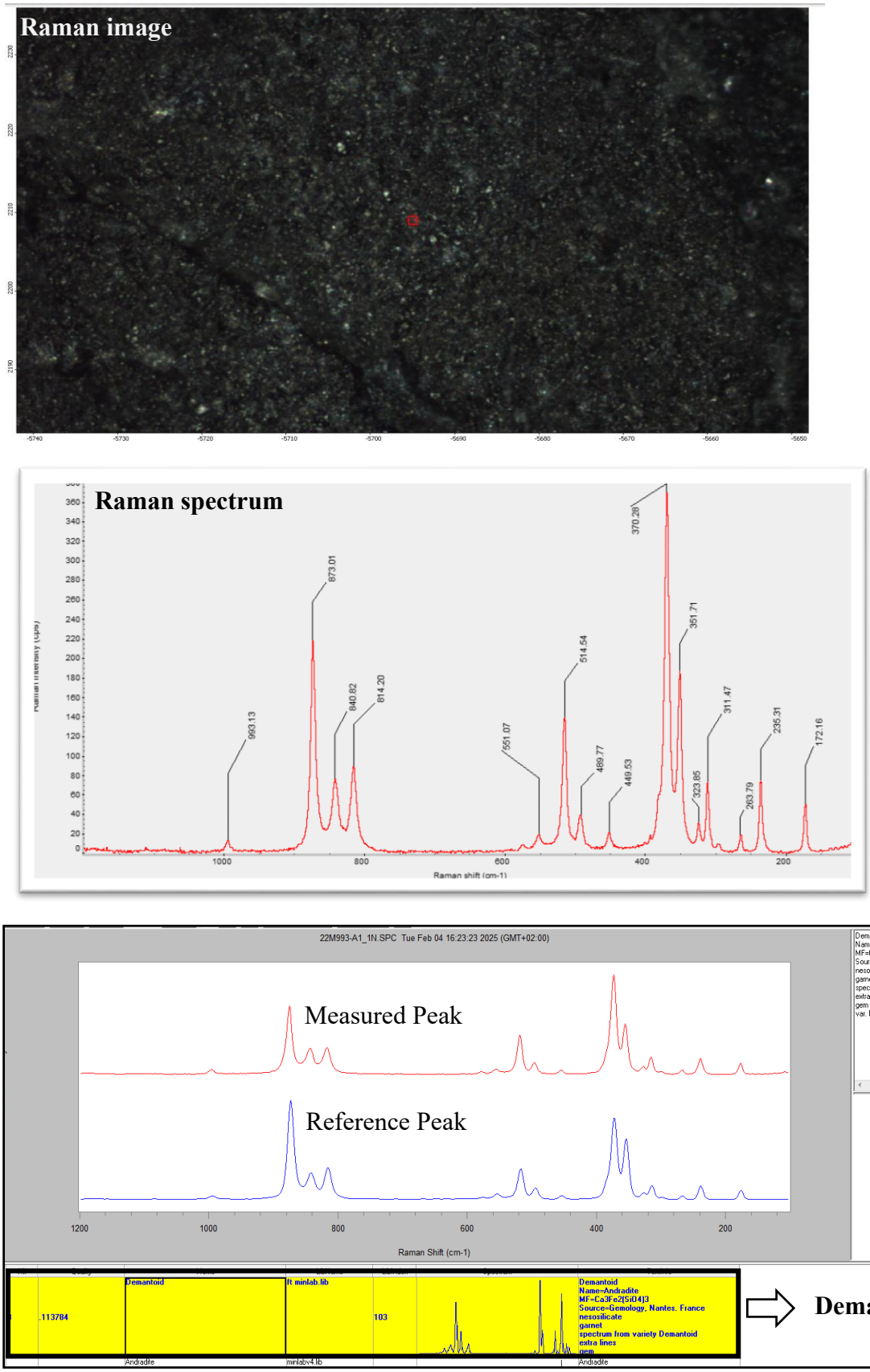


Figure 8. Raman shift of garnet mineral in sample 22M992

In sample 22M993, the selected garnet mineral showed the composition of demantoid (873.01–370.28–351.71 cm^{-1} Raman shift) (Figure 9).

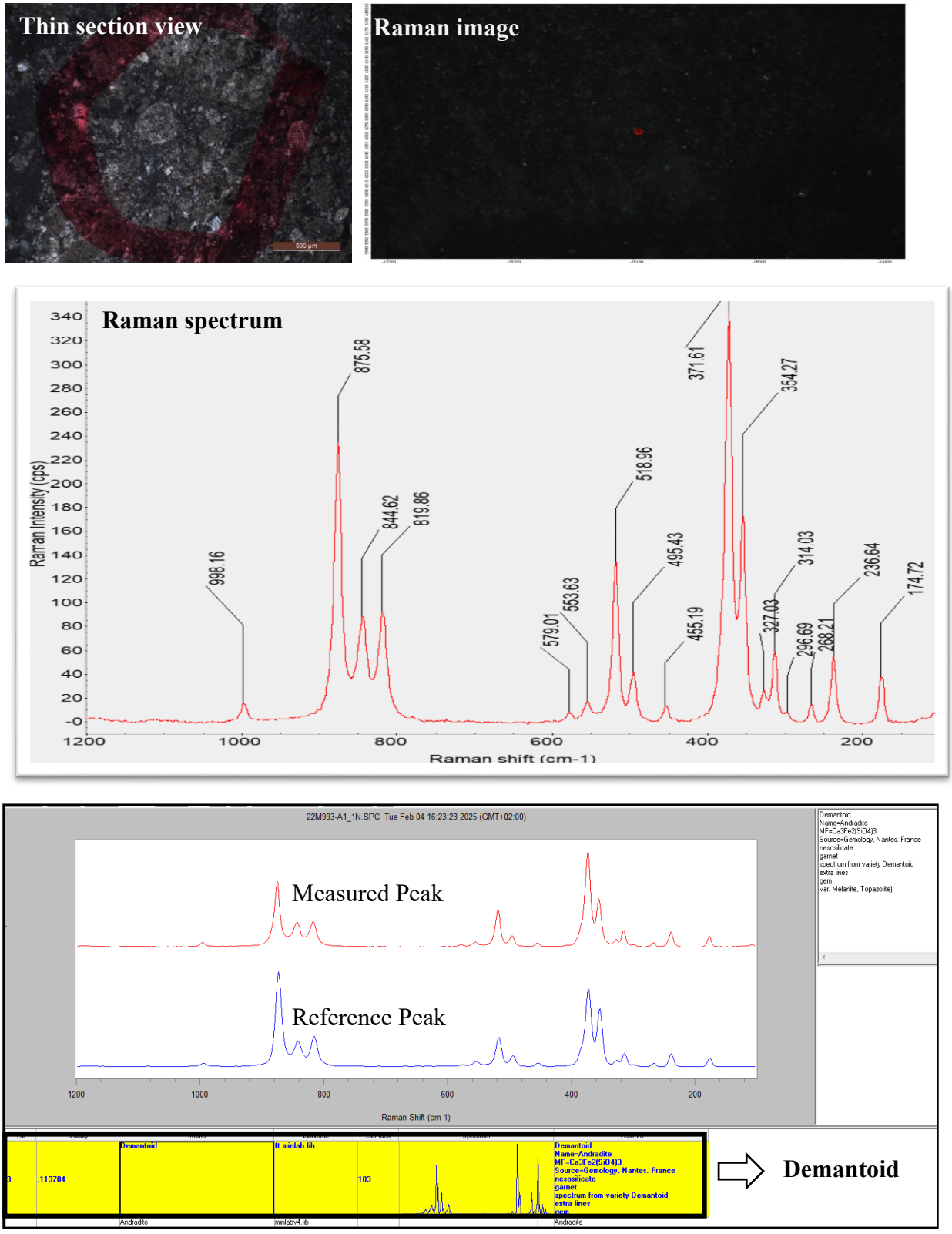


Figure 9. Raman shift of garnet mineral in sample 22M993

Finally, in sample 22M994, the type of plagioclase mineral was identified. The Raman shift values of the plagioclase in the selected area corresponded to the composition of labradorite (873.01–370.28–351.71 cm^{-1} Raman shift) (Figure 10).

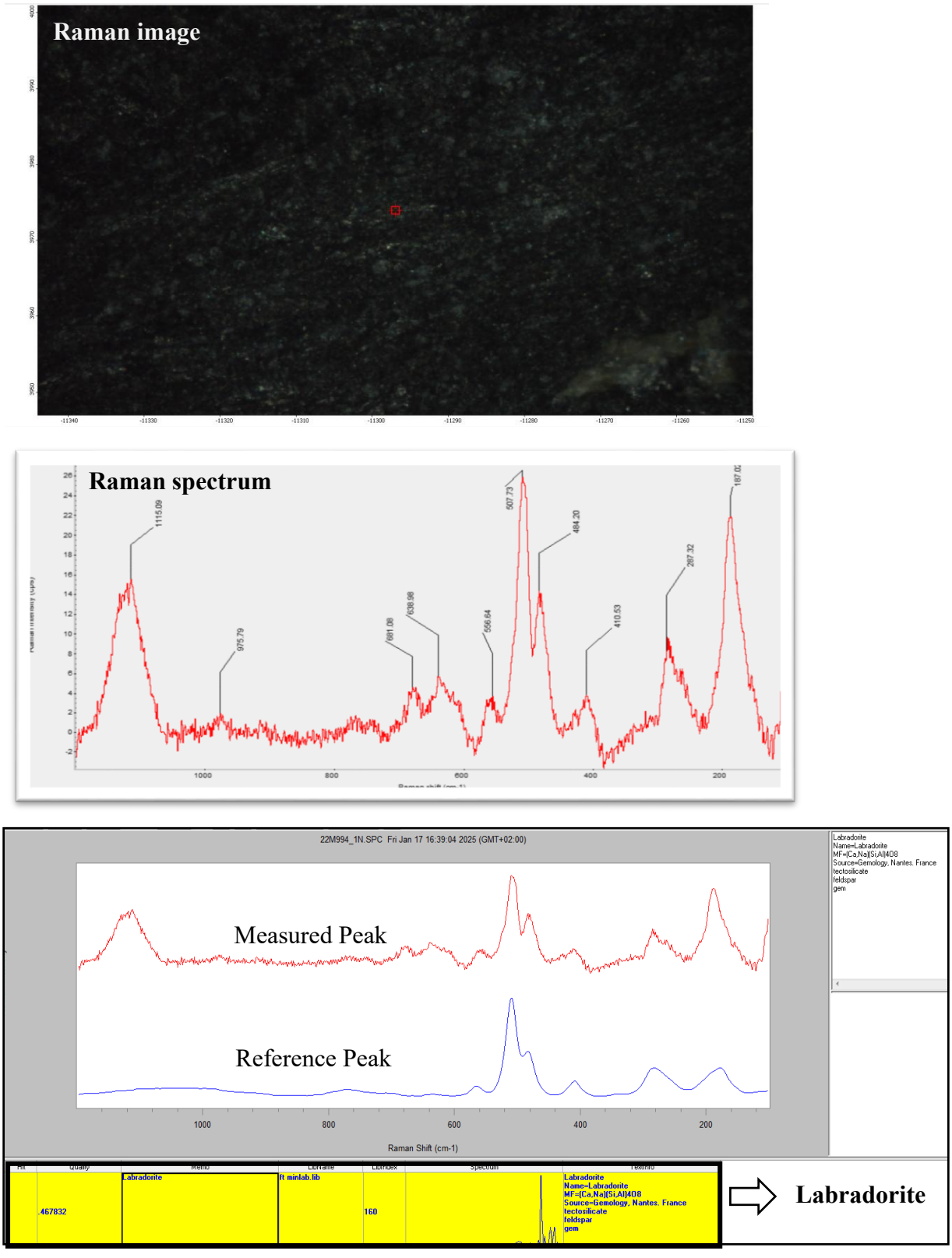


Figure 10. Raman characteristics of garnet mineral in sample 22M994

Raman spectrometry analyses show that the garnet types are andradite (873.63–369.04–351.71 cm^{-1} Raman shift) and demantoid (876.20–515.24–371.61–351.80 cm^{-1} Raman shift), and the plagioclase type is labradorite (1115.09–507.73–484.20–187.02 cm^{-1} Raman shift). The petrographic and geochemical results indicate that the analyses identify transition zones in contact with each other. The xenolitic enclaves have metamorphic texture in hand specimen and under the polarizing microscope. Whereas the hos rock has igneous texture. The xenolitic

enclave represents the forigen rock fragnments of the Wall rock caught up by the host rock magma during their intrusion into the Wall rock unit. The xenitic enclaves are totaly different mineral compositions and textural features than the host rock unit.

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INVESTIGATION OF THE MECHANICAL PROPERTIES OF ADDITIVELY MANUFACTURED POLYMER COMPOSITE MATERIALS WITH DIFFERENT INFILL GEOMETRIES

FARKLI DOLGU GEOMETRİLERİNE SAHİP EKLEMELİ İMALAT İLE ÜRETİLMİŞ POLİMER KOMPOZİT MALZEMELERİN MEKANİK ÖZELLİKLERİNİN İNCELENMESİ

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ÖZET

Eklemeli imalat (AM), geliştirilmiş mekanik özelliklere sahip düşük yoğunluklu numuneler üretme imkanı sunmaktadır. Son yıllarda, Markforged Onyx sistemi, otomotiv, savunma ve havacılık sektörlerinde polimer kompozitlerin yüksek performanslı üretimi açısından büyük ilgi görmektedir. Alüminyum ve alaşımları, endüstride en yaygın kullanılan malzemeler arasında yer almakla birlikte, düşük korozyon direnci önemli bir dezavantaj olarak değerlendirilmektedir. Bu nedenle, AM teknolojisi, daha dayanıklı ve üstün performansa sahip alternatif malzemeler geliştirmeyi amaçlamaktadır. Ancak, bu malzemelerin mekanik davranışlarını karşılaştıran kapsamlı çalışmalar oldukça sınırlıdır. Fused Filament Fabrication (FFF) yöntemi kullanılarak üretilen Onyx kompozitlerinin darbe dayanımını farklı dolgu yapılarıyla deneysel olarak değerlendirmektedir. Bu çalışmada, karbon fiber takviyeli naylon kompozit olan Markforged Onyx kullanılarak Fused Filament Fabrication (FFF) yöntemiyle darbe testi numuneleri üretilmiştir. Numuneler, ASTM standartlarına uygun olarak tasarlanmış ve üretilmiş, böylece boyut ve yapısal homojenlik sağlanmıştır. Dikdörtgen, gyroid, üçgen, katı ve altıgen olmak üzere beş farklı dolgu geometrisi kullanılarak darbe dayanımı üzerindeki etkileri incelenmiştir. Güvenilir karşılaştırmalar yapabilmek adına baskı parametreleri sabit tutulmuştur. Eklemeli imalat ile üretilen numuneler, ilgili standartlara uygun şekilde darbe testine tabi tutulmuştur. Darbe testi sonuçları incelendiğinde, üçgen dolgu yapısına sahip numunenin kırılma gösterdiği, diğer dolgu geometrilerine sahip numunelerin ise bütünlüklerini koruduğu gözlemlenmiştir. Darbe testi bulguları, üçgen dolgu yapısının en düşük dayanımı sergilediğini, ancak diğer dolgu yapılarının endüstriyel uygulamalarda alüminyum ve alaşımlarına alternatif olarak kullanılabilecek yeterli dayanıklılığa sahip olduğunu göstermektedir..

Anahtar Kelimeler: Eklemeli İmalat, Markforged Onyx, Dolgu Geometrisi, Kompozit Malzemeler, Mekanik Özellikler

ABSTRACT

Additive manufacturing (AM) produces low-density specimens with enhanced mechanical properties. In recent years, the Markforged Onyx system has gained attention in the automotive, defense, and aerospace industries for its ability to manufacture polymer composites with improved performance. Although aluminum and its alloys are among the most widely used materials in industrial applications, their low corrosion resistance is a significant drawback.

Therefore, AM technology aims to address these limitations by developing alternative materials with superior durability and performance. However, comprehensive comparisons of their mechanical behavior remain scarce. This study experimentally assesses the impact resistance of Onyx composites produced using Fused Filament Fabrication (FFF) with different infill structures. This study utilized Markforged Onyx, a carbon fiber-reinforced nylon composite, to produce impact test specimens via the Fused Filament Fabrication (FFF) method. The specimens were designed and manufactured by ASTM standards, ensuring homogeneity in size and structure. Five infill geometries were tested to analyze their effects on impact resistance: rectangular, gyroid, triangular, solid, and hexagonal. Reliable comparisons were achieved by keeping the printing parameters constant. The additively manufactured samples were impact-tested using the standards. Upon analyzing the impact test results, it was observed that the specimen with a triangular infill structure exhibited fracture, whereas the materials with other infill geometries remained intact. The impact test outcomes indicate that, except for the triangular infill structure, which exhibited the lowest strength, the other infill geometries demonstrate sufficient durability for potential use in industrial applications as an alternative to aluminum and its alloys.

Keywords: Additive Manufacturing, Markforged Onyx, Infill Geometry, Composite Materials, Mechanical Testing.

GİRİŞ

Eklemeli İmalat (AM), modern malzeme üretiminde devrim yaratarak hafif, yüksek performanslı bileşenlerin optimize edilmiş mekanik özelliklerle üretilmesini sağlamaktadır (Altunsaray et al., 2024; Kausar, 2024). Geleneksel üretim yöntemlerinden farklı olarak AM, özelleştirilmiş dolgu yapıları ve takviye teknikleri sayesinde malzeme dağılımı üzerinde tam kontrol sunmakta ve gelişmiş mühendislik uygulamaları için ideal bir üretim yöntemi haline gelmektedir. Bu özellikleri, otomotiv, havacılık ve makine mühendisliği gibi sektörlerde polimer bazlı kompozit malzemelere olan ilgiyi artırmış ve geleneksel metal alaşımlarına uygun bir alternatif olarak değerlendirilmesine olanak tanımıştır (De Pasquale & Ursi, 2024; Wang et al., 2025).

Polimer bazlı kompozitler arasında Markforged Onyx, karbon fiber takviyeli naylon yapısıyla, üstün mukavemet-ağırlık oranı, darbe dayanımı ve korozyon direnci gibi özellikleri sayesinde dikkat çekmektedir (Astarita et al., 2025; Pasciucco et al., 2025). Alüminyum ve alaşımları, yapısal uygulamalarda yaygın olarak kullanılmasına rağmen, korozyona karşı hassasiyeti ve ağırlık ile ilgili sınırlamaları, alternatif malzemelerin geliştirilmesini gerektirmektedir (Yu et al., 2025; Lohr et al., 2025). Özellikle sürekli veya kısa karbon fiber takviyeli olarak üretilen AM kompozitleri, daha yüksek dayanıklılık, enerji emilimi ve yapısal performans sunarak yük taşıyan uygulamalar için cazip bir alternatif oluşturmaktadır (Mancia et al., 2024; Almeida Jr et al., 2025).

AM kompozitlerinin performansını etkileyen en kritik faktörlerden biri dolgu geometrisi olup, bu parametre mekanik dayanım, darbe direnci ve ağırlık verimliliği açısından önemli bir rol oynamaktadır (Selvaraj et al., 2025; Serovaev & Galkina, 2024). Çalışmalar, gyroid, altıgen, üçgen, dikdörtgen ve katı dolgu yapılarının farklı enerji emme kapasiteleri ve hasar mekanizmalarına sahip olduğunu göstermektedir (Mote & Giri, 2024; Fu et al., 2025). Ancak, bu yapıların endüstriyel uygulanabilirliği konusunda detaylı karşılaştırmalı araştırmalar sınırlıdır ve daha fazla çalışmaya ihtiyaç duyulmaktadır (Nagarajan & Farukh, 2025).

Yapılan çalışmada, Fused Filament Fabrication (FFF) yöntemi ile üretilen farklı dolgu yapılarına sahip Onyx kompozitlerinin darbe dayanımını değerlendirmektir. Elde edilen sonuçlar, yüksek performans gerektiren endüstriyel uygulamalar için AM kompozit üretim tekniklerinin optimize edilmesine katkı sağlayacaktır.

MATERYAL VE METOT

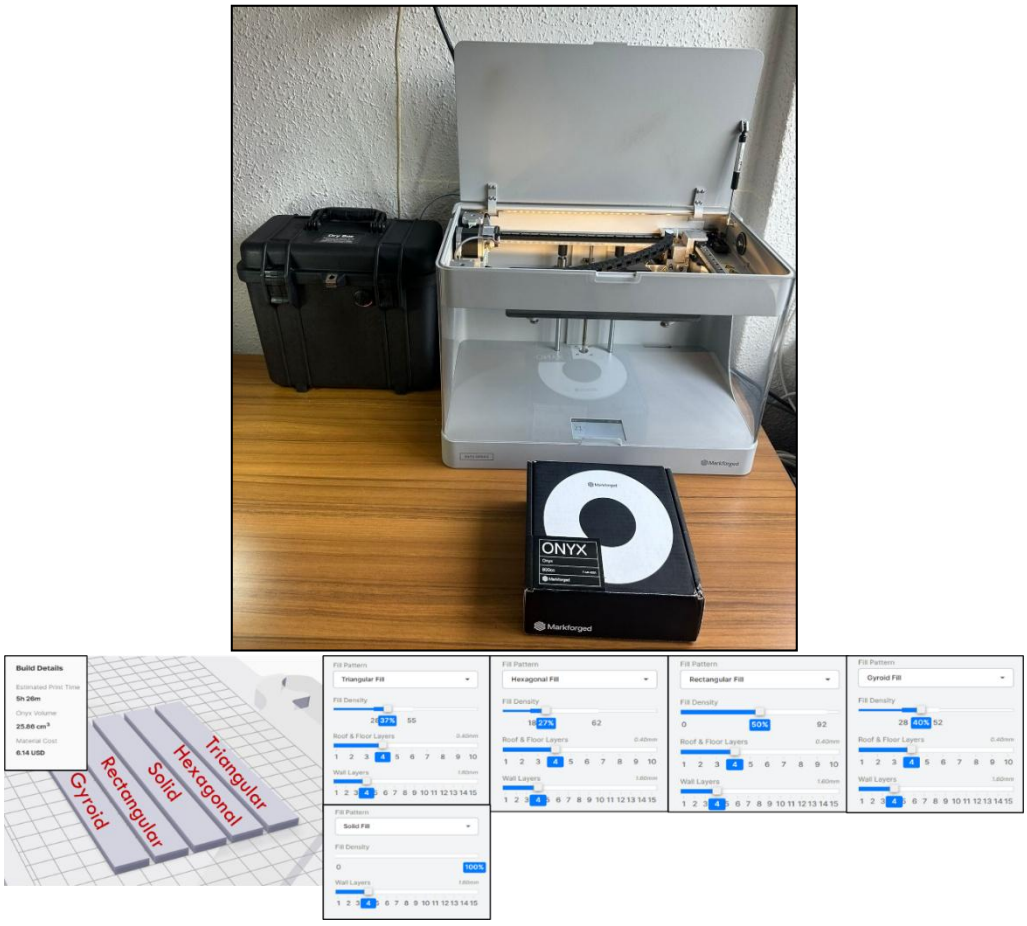
Bu çalışmada, farklı dolgu geometrilerine sahip polimer kompozit malzemelerin mekanik özelliklerini incelemek amacıyla darbe testleri gerçekleştirilmiştir. Deneysel süreç, numune tasarımı, üretimi ve mekanik test aşamalarını içermektedir.

Numune Tasarımı ve Üretimi

Numune üretimi süreci, bilgisayar destekli tasarım (CAD) ve eklemeli imalat tekniklerini içermektedir. Öncelikle, ASTM standartlarına uygun olacak şekilde test numunelerinin tasarımı gerçekleştirilmiştir. SolidWorks tasarım programı kullanılarak numuneler üç boyutlu (3D) ortamda modellenmiş ve STL formatında dışa aktarılmıştır. Daha sonra, Markforged Onyx serisi 3D yazıcısının desteklediği Eiger yazılımında, farklı dolgu yapıları belirlenerek üretim süreci optimize edilmiştir. Seçilen dolgu yapıları şunlardır:

- Rectangular (Dikdörtgen) Dolgu
- Gyroid Dolgu
- Triangular (Üçgen) Dolgu
- Solid (Tam Dolgu)
- Hexagonal (Altıgen) Dolgu

Numunelerin tasarım aşamasında, dış yüzey duvar kalınlığı ve katman kalınlığı 4 birim olarak belirlenmiştir. Numune boyutları test standardına uygun şekilde sabit tutulmuştur. Üretim süreci Markforged Onyx Serisi 3D yazıcı kullanılarak gerçekleştirilmiştir. Kullanılan malzeme, karbon fiber takviyeli poliamid bazlı Onyx filamentidir. Onyx malzemesi, yüksek mukavemeti ve hafifliği ile öne çıkmaktadır. Tüm numunelerin üretimi 5 saat 26 dakika sürmüştür.



Şekil 1. Deney numunelerin tasarımı ve üretimi

DENEYSEL SONUÇLAR

Mekanik Test

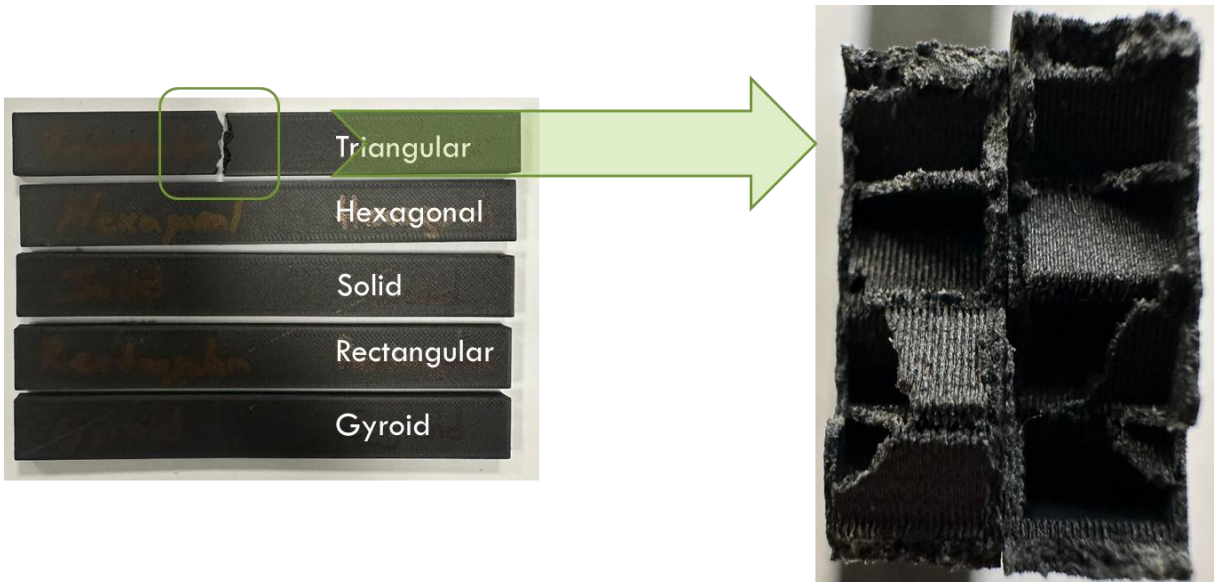
Darbe Testi

Üretilen numunelerin darbe dayanımını belirlemek için sarkaç tipi darbe testi uygulanmıştır. Darbe testleri, ASTM D256 ve ISO 179 standartları referans alınarak gerçekleştirilmiştir. Test cihazı olarak Charpy tipi bir darbe test cihazı kullanılmıştır.

Şekil 2. Darbe testi numunelerin dayanım özellikleri

Darbe Test sürecinde:

- Her numune sabit bir yatak üzerine yerleştirilmiştir.
- 5 N'luk bir yük ile sarkaç serbest bırakılmıştır.
- Sarkaç çarpma noktasından geçtikten sonra kırılma ya da deformasyon durumu kaydedilmiştir.
- Numunelerin kırılma ya da eğilme gibi mekanik davranışları analiz edilmiştir.
- Cihazdan alınan veriler doğrultusunda her bir numune için **absorbe edilen darbe enerjisi (E) değerleri** hesaplanmıştır.



Şekil 3. Darbe test sonrası numunelerin görüntüleri

- En yüksek darbe dayanımı 4.52 kJ/m² ile Gyroid dolgu yapısına ait.
- En düşük darbe dayanımı 3.43 kJ/m² ile Hexagonal dolgu yapısında gözlemlendi.
- Solid dolgu, şaşırtıcı şekilde 4.09 kJ/m² ile bazı dolguların gerisinde kaldı.
- Triangular dolgu, kırılma gösterdi ancak 4.26 kJ/m² ile iyi bir darbe tokluğuna sahiptir.

Dolgu Yapısı	E Gerçek (J)	Darbe Tokluğu (kJ/m²)	Mekanik Davranış
Rectangular	3.352	4.47	Eğilme
Gyroid	3.391	4.52	Eğilme
Hexagonal	2.572	3.43	Eğilme
Triangular	3.192	4.26	Kırılma
Solid	3.070	4.09	Eğilme

Şekil 4. Deney numunelerin darbe test sonuçları

SONUÇLAR

Çalışmada farklı dolgu geometrilerine sahip polimer kompozit malzemelerin darbe dayanımları incelenmiş ve mekanik performansları karşılaştırılmıştır. Triangular dolgu, tek kırılma gösteren yapı olarak belirlenmiş ve üçgen formdaki yapıların belirli bir yük altında kırılgan olabileceği gözlemlenmiştir. Ancak, darbe tokluğu değeri 4.26 kJ/m² ile diğer dolgu yapılarıyla benzer performans sergilemiştir.

En yüksek darbe dayanımı 4.52 kJ/m² ile Gyroid dolgu yapısında görülmüş olup, bu yapı, sürekli ve organik formu sayesinde yük dağılımını optimize ederek daha iyi enerji absorpsiyonu sağlamıştır. Deformasyon meydana gelmiş ancak kırılma gerçekleşmemiştir. Solid dolgu, beklenenden düşük bir darbe dayanımı sergileyerek 4.09 kJ/m² değerine ulaşmıştır. Genellikle en yüksek mukavemeti sunması beklenen bu yapının, polimer bazlı malzemelerde darbe emme kapasitesinin farklı olabileceği ve bunun malzeme içyapısındaki iç gerilim dağılımı ile ilişkili olduğu düşünülmektedir.

Hexagonal dolgu, 3.43 kJ/m² ile en düşük darbe dayanımına sahip olmuş ve düşük yüklerde enerji absorbe etme kapasitesinin sınırlı olduğu gözlemlenmiştir. Genel olarak, endüstride alüminyum ve alaşımlarına alternatif olarak Onyx ve benzeri polimer kompozitlerin kullanımı için darbe dayanımlarının artırılması gerekmektedir. Farklı dolgu yapılarının malzemenin darbe emme kapasitesini büyük ölçüde etkilediği belirlenmiş olup, Gyroid ve Rectangular dolgu yapıları en iyi enerji absorpsiyon performansını sergilemiştir. Triangular dolgu yapısı ise kırılganlık gösterdiğinden kritik yük taşıyan uygulamalarda dikkatle değerlendirilmelidir.

Onyx ve diğer polimer kompozit malzemeler, alüminyum ve alaşımlarının yerini tamamen alamasa da daha hafif olmaları, korozyona karşı dayanıklı olmaları, elektriksel yalıtkanlık sağlamaları, titreşim sönümleyici özellik göstermeleri ve 3D baskıya uygun olmaları gibi avantajlar sunmaktadır. Bu tür polimer kompozitler, özellikle havacılık ve drone uygulamalarında hafiflik ve rijitlik avantajı sağlayarak belirli yapısal bileşenlerde metal yerine kullanılabilir. Elektrik ve elektronik endüstrisinde, izolasyon ve hafiflik gerektiren muhafazalar için uygun olup, otomotiv endüstrisinde titreşim sönümleyici yapılar ve hafif iç mekan bileşenlerinde değerlendirilebilir. Ayrıca, kimyasallara dayanıklı ve biyouyumlu olmaları nedeniyle medikal cihaz üretiminde ve hafif mukavemetli bağlantı elemanları ile özel aparatların üretildiği robotik ve mekatronik alanlarında da etkili bir alternatif sunmaktadır.

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EFFECT OF FILLER STRUCTURE ON TENSILE PERFORMANCE OF NYLON6 COMPOSITES PRODUCED BY ADDITIVE MANUFACTURING

EKLEMELI İMALAT İLE ÜRETİLEN NYLON 6 KOMPOZİTLERİNDE DOLGU YAPISININ ÇEKME PERFORMANSINA ETKİSİ

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ÖZET

Eklemeli İmalat (AM), hafif, yüksek mukavemetli ve özelleştirilebilir kompozit malzemelerin üretimine olanak tanıyarak birçok endüstriyel uygulama için alternatif bir yöntem haline gelmiştir. Markforged Onyx, karbon fiber takviyeli naylon kompozit yapısı sayesinde yüksek mukavemet/ağırlık oranı, dayanıklılık ve üstün mekanik performans sunmaktadır. Bu özellikler, malzemenin otomotiv, havacılık ve makine mühendisliği gibi alanlarda kullanım potansiyelini artırmaktadır. Bu çalışmada, Markforged Onyx yazıcısı kullanılarak üretilen karbon fiber takviyeli naylon kompozit numunelerin çekme dayanımı incelenmiştir. Çalışma kapsamında, ASTM D638 standardına uygun olarak çekme testi numuneleri üretilmiştir. Numuneler, dikdörtgen, gyroid, üçgen, katı ve altıgen olmak üzere beş farklı dolgu yapısına sahip olacak şekilde üretilmiştir. Fused Filament Fabrication (FFF) yöntemi kullanılarak gerçekleştirilen üretim sürecinde katman kalınlığı, baskı hızı ve sıcaklık gibi baskı parametreleri sabit tutulmuş, yalnızca dolgu geometrisinin mekanik özellikler üzerindeki etkisi analiz edilmiştir. Üretilen numuneler, evrensel çekme test cihazı (UTM) kullanılarak çekme testine tabi tutulmuştur. Testler, çekme dayanımı (MPa), elastik modül (GPa) ve kopma uzaması (%) değerlerini belirlemek amacıyla gerçekleştirilmiştir. Elde edilen test sonuçları, farklı dolgu yapılarının çekme dayanımı üzerindeki etkisini karşılaştırmalı olarak incelemek ve endüstriyel uygulamalar için en uygun tasarımı belirlemek amacıyla analiz edilmiştir. Yapılan çekme testleri sonucunda, üretilen kompozit numunelerin mekanik performanslarının dolgu geometrisine bağlı olarak değiştiği belirlenmiştir. En yüksek çekme dayanımı katı dolgu yapısına sahip numunede elde edilirken, gyroid dolgu yapısına sahip numunenin de benzer bir mukavemet gösterdiği tespit edilmiştir. Çalışma sonuçları, dolgu geometrisinin üretilen kompozit numunelerde çekme dayanımını önemli ölçüde etkilediğini göstermektedir. Katı ve gyroid dolgu yapılarının, üstün mekanik özellikleri nedeniyle endüstriyel kullanıma daha uygun olduğu belirlenmiştir.

Anahtar Kelimeler: Eklemeli İmalat, Naylon 6, Dolgu Geometrisi, Çekme testi

ABSTRACT

Additive Manufacturing (AM) has become an alternative for many industrial applications by enabling the production of lightweight, high-strength, and customizable composite materials. Markforged Onyx offers a high strength-to-weight ratio, durability, and superior mechanical performance thanks to its carbon fiber-reinforced nylon composite structure. These features increase its potential for use in areas such as automotive, aerospace, and mechanical engineering. This study investigated the tensile strength of carbon fiber-reinforced nylon composite samples produced using a Markforged Onyx printer. Within the scope of the study, tensile test samples were produced by ASTM D638 standard. Samples were produced with five

different infill structures: rectangular, gyroid, triangular, katı, and hexagonal. In all samples produced using the Fused Filament Fabrication (FFF) method, printing parameters (layer thickness, printing speed, temperature, etc.) were kept constant, and the change in mechanical properties of the material depending only on the infill geometry was analyzed. The produced samples were subjected to a tensile test using a universal testing machine (UTM). Tests were carried out in order to determine tensile strength (MPa), elastic modulus (GPa) and elongation at break (%). Test results were analyzed in order to comparatively examine the effects of different infill structures on tensile strength and to determine the most appropriate design for industrial applications. When the applied tensile tests were examined, it was determined that the mechanical performance of the produced composite samples varied depending on the filling geometry. While the best value was obtained in the sample with a katı filling structure, the sample with a gyroid filling structure had a similar value. The study results determined that the infill geometry significantly affects the tensile strength in the produced composite samples. It was determined that katı and gyroid infill structures are more suitable for industrial use due to their good mechanical properties.

Keywords: Additive Manufacturing, Nylon6, Infill Geometry, Tensile Testing

GİRİŞ

Eklemeli İmalat (AM), geleneksel üretim yöntemlerine kıyasla karmaşık geometrili yapıları daha az malzeme israfıyla üretebilme avantajı sunmaktadır (Saleh Alghamdi et al., 2021). Özellikle polimer bazlı kompozit malzemeler, hafiflik, yüksek dayanım ve tasarım esnekliği sağlamaları nedeniyle otomotiv, havacılık ve savunma sanayii gibi sektörlerde giderek daha fazla tercih edilmektedir (Mahshid et al., 2023). Polimer matrisli kompozitlerin mekanik özellikleri, kullanılan malzeme bileşimi, üretim süreci ve dolgu yapısına bağlı olarak değişiklik göstermektedir (Caminero et al., 2020). Bu nedenle, polimer bazlı eklemeli imalat numunelerinin mekanik performansının belirlenmesi, mühendislik uygulamalarında güvenilirlik açısından kritik bir öneme sahiptir (Reich et al., 2019).

Çekme testi, malzemelerin mukavemet ve süneklik özelliklerini belirlemek için yaygın olarak kullanılan bir karakterizasyon yöntemidir. ASTM D638 standardına uygun olarak gerçekleştirilen çekme testleri, polimer bazlı kompozitlerin gerilme-altında davranışlarını incelemek için standart bir yöntem sunmaktadır (Veerabagu et al., 2022). Bunun yanı sıra, geleneksel metal malzemelerle kıyaslama yapılarak, kompozitlerin mekanik özellikler açısından avantajları ve sınırlamaları ortaya konulabilmektedir (Shanmugam et al., 2020). Alüminyum alaşımları, özellikle 6061-T6 gibi yüksek mukavemet ve işlenebilirlik sunan türleriyle birçok yapısal uygulamada tercih edilmektedir (Das et al., 2020). Ancak, alüminyum alaşımlarının yoğunluğu ve belirli koşullardaki sınırlı enerji emme kapasitesi, alternatif hafif malzemelerin geliştirilmesini teşvik etmektedir (Agarwal et al., 2018).

Bu çalışmada, ASTM D638 standartlarına uygun olarak üretilmiş polimer bazlı kompozit çekme test numunelerinin, geleneksel alüminyum alaşımları ile mekanik performans açısından karşılaştırılması amaçlanmaktadır. Numuneler Fused Filament Fabrication (FFF) yöntemi ile üretilmiş olup, farklı dolgu yapılarının malzeme dayanımı üzerindeki etkileri detaylı olarak incelenmiştir (Park & Fu, 2021). Çalışmanın sonuçları, polimer bazlı kompozit malzemelerin mühendislik uygulamalarındaki potansiyelini değerlendirmek açısından önemli veriler sunacaktır (Byard et al., 2019).

MATERYAL VE METOT

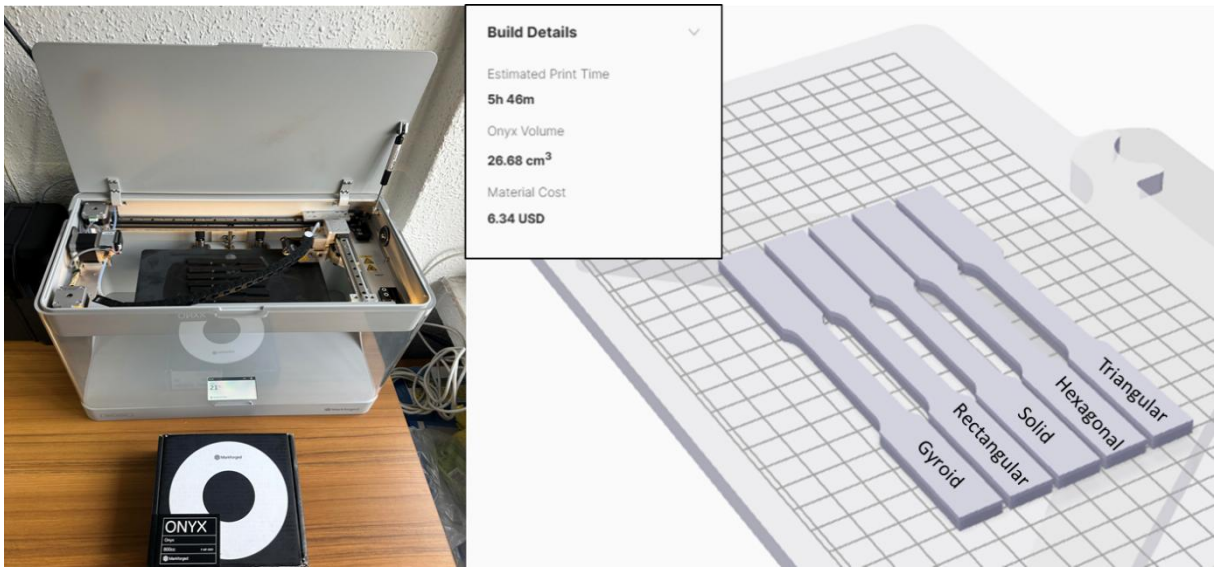
Bu çalışmada, Markforged Onyx Serisi üç boyutlu yazıcısı kullanılarak beş farklı dolgu yapısına sahip Nylon 6 kompozit çekme testi numuneleri üretilmiştir. Üretim sürecinde

kullanılan temel malzeme, yüksek dayanım, hafiflik ve esneklik sunan Nylon 6 kompozit filament olup, endüstride kullanılan alüminyum ve alaşımlarına alternatif olabilecek bir yapının oluşturulması hedeflenmiştir.

Numune tasarımları ASTM D638 standardına uygun şekilde SolidWorks tasarım programı kullanılarak hazırlanmış ve STL formatına dönüştürülmüştür. Daha sonra, yazıcının uyumlu olduğu Eiger dilimleme programında farklı dolgu yapıları belirlenerek üretim parametreleri optimize edilmiştir. Katı dolgu dışındaki tüm numuneler için duvar kalınlığı ve katman kalınlığı dört katman olacak şekilde ayarlanmıştır. Üretim süreci toplamda 5 saat 46 dakika sürmüş olup, tüm numuneler aynı baskı parametreleri ile üretilmiştir.

Üretilen numunelerin mekanik performanslarını belirlemek amacıyla çekme testleri gerçekleştirilmiştir. Çekme testleri Instron markalı evrensel çekme test cihazı kullanılarak, ASTM D638 standardına uygun şekilde yapılmıştır. Testler, 1 mm/s hızında gerçekleştirilmiş ve her dolgu yapısı için beş adet tekrar numunesi test edilmiştir. Test sürecinde gerilme-gerinim eğrileri, nihai çekme dayanımı (MPa), kopma uzaması (%) ve elastik modül (GPa) gibi temel mekanik özellikler ölçülerek kaydedilmiştir.

Çekme testi sonrasında numunelerin kırılma yüzeyleri makro optik görüntüleme teknikleri kullanılarak analiz edilmiştir. Makro görüntüler yardımıyla katmanlar arası bağlanma durumu, dolgu yapılarının kırılma üzerindeki etkisi ve kopma mekanizmaları görsel olarak değerlendirilmiştir.



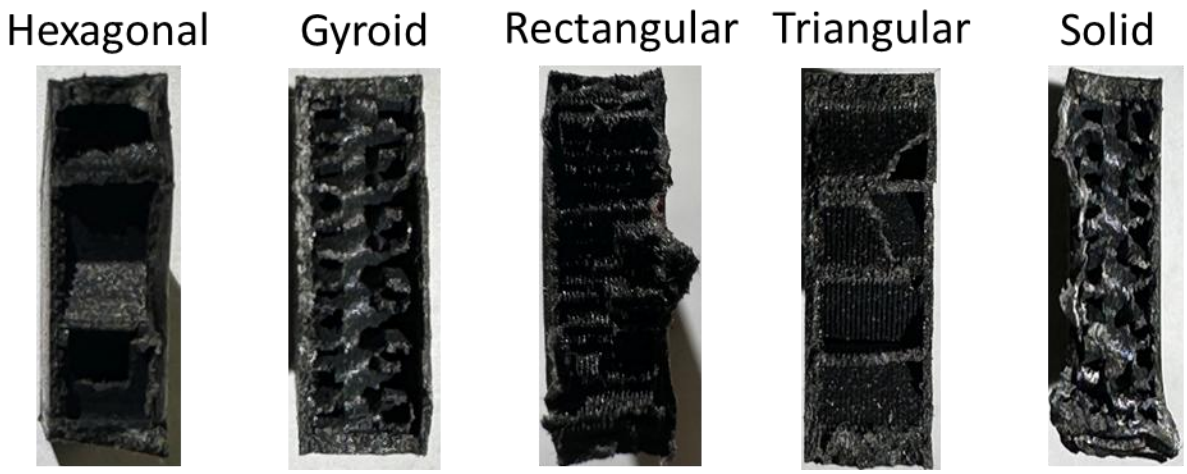
Şekil 1. Deney numunelerin tasarımı ve üretimi

DENEYSEL SONUÇLAR

Bu çalışmada, farklı dolgu yapılarının Nylon 6 kompozit numunelerin çekme dayanımı üzerindeki etkisi incelenmiştir. Çekme testi sonuçları analiz edilerek, dolgu yapısının gerilme-gerinim davranışları üzerindeki etkisi değerlendirilmiştir. Beş farklı dolgu yapısına sahip numunelerin mukavemet karşılaştırmaları yapılmış ve mekanik dayanım açısından avantajları belirlenmiştir.

Çalışmada kullanılan dolgu yapıları arasında katı, altıgen, üçgen, gyroid ve dikdörtgen yapılar bulunmaktadır. Katı dolgu yapısına sahip numuneler, tam doluluk oranına sahip oldukları için en yüksek çekme dayanımını göstermiştir. Altıgen dolgu yapısı, mekanik dayanım ile hafiflik

arasında dengeli bir yapı sunarken, üçgen dolgu yapısı, yükü farklı yönlere yayarak daha dengeli bir gerilme dağılımı sağlamıştır. Gyroid dolgu, enerjiyi emme ve darbelere karşı dayanıklılık açısından avantaj sağlamasına rağmen, belirli eksenlerde düşük çekme dayanımı sergilemiştir. Dikdörtgen dolgu yapısı ise özellikle geleneksel yük taşıyan uygulamalar için tercih edilen bir yapı olup, orta seviyede bir mekanik dayanım göstermiştir.

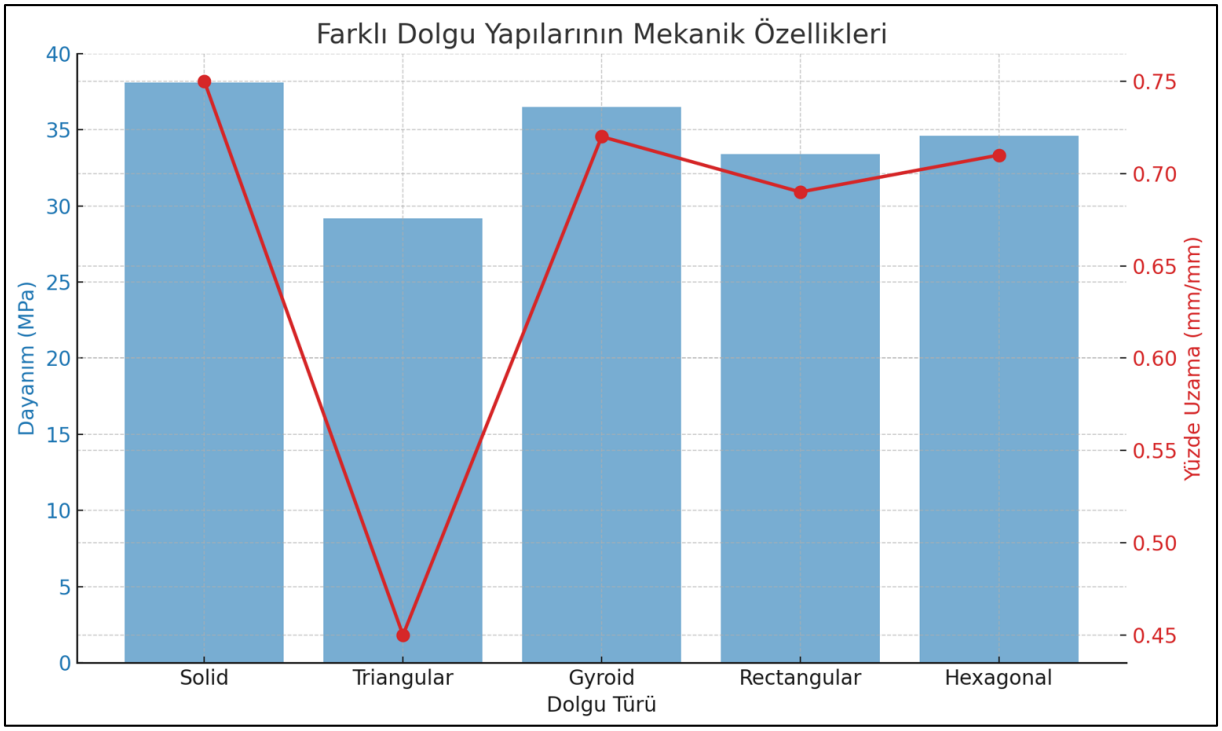


Şekil 2. Çekme testi sonrası kırık yüzey makro resim

Çalışmanın temel amacı, endüstride kullanılan alüminyum ve alaşımlarına alternatif olarak kullanılabilecek bir kompozit yapı geliştirmek olup, elde edilen mekanik veriler önceki çalışmalarla kıyaslanarak değerlendirilmiştir.

Çekme testi sonrası makro optik görüntüleme teknikleri kullanılarak numunelerin kırılma yüzeyleri analiz edilmiştir. Elde edilen makro görüntüler ışığında, farklı dolgu yapılarının kırılma mekanizmaları üzerindeki etkileri incelenmiş ve katmanlar arası bağlanma kalitesi, dolgu yapılarının kırılmaya etkisi ve kopma yüzeylerindeki deformasyon izleri görsel olarak değerlendirilmiştir. Katı dolgu yapısında daha sert ve gevrek bir kırılma davranışı gözlenirken, düşük yoğunluklu dolgu yapılarında daha sünek kırılma mekanizmaları öne çıkmıştır.

Bu deneysel çalışmalar sonucunda, dolgu yapısının Nylon 6 kompozitlerin çekme dayanımı üzerinde doğrudan etkili olduğu belirlenmiştir. Elde edilen sonuçlar, hafif ve dayanıklı polimer bazlı kompozit malzemelerin, belirli dolgu yapılarına sahip olması durumunda metal alaşımlarına alternatif olarak kullanılabileceğini göstermektedir. Çalışma, polimer bazlı eklemeli imalat teknolojilerinin sanayi uygulamalarındaki potansiyelini değerlendirme açısından önemli veriler sağlamaktadır.



Şekil 3. Çekme testi dayanım ve yüzde uzama

Şekil 3 incelendiğinde, farklı dolgu yapılarının çekme dayanımı ve yüzde uzama değerleri açısından belirgin farklılıklar gösterdiği görülmektedir. Katı dolgu, 38.1 MPa ile en yüksek çekme dayanımına sahip olup, aynı zamanda 0.75 mm/mm uzama göstererek yüksek süneklik sergilemiştir. Bu durum, tam doluluk oranının malzeme bütünlüğünü artırarak yük taşıma kapasitesini maksimum seviyeye çıkardığını göstermektedir. Gyroid dolgu, 36.5 MPa çekme dayanımı ve 0.72 mm/mm uzama değeri ile katı dolgudan sonra en iyi mekanik özellikleri sunmuştur. Bu yapı, içsel geometrisinin sağladığı avantaj sayesinde mukavemet ve sünekliği dengeli bir şekilde korumuştur. Hexagonal dolgu, 34.6 MPa dayanım ve 0.71 mm/mm uzama değerleri ile yapısal olarak Gyroid dolguyla benzer bir performans sergilemiştir. Rectangular dolgu ise 33.4 MPa çekme dayanımı ile orta seviyede bir mekanik performans göstermiş, ancak 0.69 mm/mm uzama değeri ile belirli bir süneklik sağlamıştır. Triangular dolgu, 29.2 MPa dayanım ve 0.45 mm/mm uzama değeri ile en düşük mukavemet ve sünekliği gösteren yapı olmuştur. Bu durum, üçgen dolgunun yük taşıma kapasitesinin sınırlı olduğunu ve plastik deformasyon açısından zayıf bir yapı sergilediğini ortaya koymaktadır.

SONUÇLAR

Çalışma sonuçları, dolgu yapısının polimer bazlı kompozit malzemelerin mekanik performansı üzerinde doğrudan etkili olduğunu göstermektedir. En yüksek dayanım ve süneklik özelliklerini sergileyen katı ve gyroid dolgu yapıları, yük taşıma kapasitesinin kritik olduğu mühendislik uygulamaları için uygun seçeneklerdir. Hexagonal ve rectangular dolgular, mukavemet ve süneklik açısından dengeli bir yapı sunarken, triangular dolgunun düşük mukavemet ve düşük süneklik nedeniyle daha az tercih edilmesi gereken bir yapı olduğu belirlenmiştir. Bu bağlamda, hafiflik ve dayanımın optimize edilmesi gereken mühendislik uygulamalarında, gyroid ve hexagonal dolgu yapılarının alüminyum alaşımlarına alternatif olarak değerlendirilebileceği sonucuna varılmıştır. Çalışma, polimer bazlı eklemeli imalat teknolojilerinde optimum dolgu tasarımının seçilmesinin mekanik özellikleri doğrudan etkilediğini ve farklı endüstriyel uygulamalarda bu parametrenin kritik öneme sahip olduğunu ortaya koymaktadır.

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AN INVESTIGATION ON THE EFFECT OF ERGOGENIC AIDS IN SPORT

SPORDA ERGOJENİK YARDIMCILARIN ETKİSİ ÜZERİNE BİR İNCELEME

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Özet

Bu çalışmada sporda ergojenik yardımcıların kullanımının performans üzerine etkisinin incelenmesi amaçlanmıştır. Spor ve sporcu performansını artıran her türlü madde ve olguya ergojenik yardımcılar denir. Ergojenik yardımcılar, bireylerin performanslarını artırmak veya sürdürebilmek amacıyla kullandıkları, performans kapasitesini ve antrenman verimliliğini geliştiren, aynı zamanda fiziksel aktivite ya da yarışma sonrası toparlanma sürecini hızlandıran araç, yöntem ve tekniklerden oluşmaktadır. Ergojenik takviyeler tipik olarak tablet, kapsül, yumuşak jel, sıvı, toz ve çubuk formunda piyasada bulunur. Ergojenik yardımcıların kullanımı son yıllarda önemli ölçüde artmıştır. Sporcular, beslenme eksikliği algısı, spor performansını geliştirme arzusu, antrenman sonrası toparlanma sürecini hızlandırma isteği gibi çeşitli nedenlerden dolayı ergojenik desteklere başvurmaktadır. Bu sebepten spor yapan bireylerin hangi destek ürünü kullandığı, hangi dozda aldığı bunları uzman kişilere danışarak kullanılmalıdır aksi takdirde herhangi bir etkisi olmayacaktır. Egzersiz öncesi ve sırasında alınan besinsel destekler ise vücut depolarını yeniler, sıvı dengesini sağlar ve müsabakalar arasında toparlanmayı kolaylaştırarak sportif başarıyı artırır. Ergojenik yardımcıların spor performansı üzerindeki etkileri farklı mekanizmalarda ortaya çıkmaktadır. Örneğin, kreatin monohidrat ve beta-alanin gibi besin takviyelerin kas enerji üretimi ve kas dayanıklılığını artırırken kafein gibi uyarıcılar merkezi sinir sistemi üzerinden algılanan eforu azaltarak daha uzun süreli fiziksel performans imkanı sunmaktadır. Ergojenik yardımcılar performansı arttırmaya yardımcı olabilir, ancak ihtiyacınız olan ürünleri, ihtiyacınız olduğu anda, ihtiyacınız olduğu miktarda ve bu konuda uzman kişilerden destek almanız gerekir. **Eksik veya hatalı kullanımı halinde ergojenik desteklerin herhangi bir faydası olmayacağı gibi yan etkilere de yol açabileceği unutulmamalıdır.** Sadece Amerika Birleşik Devletleri'nde 1 ila 3 milyon erkek ve kadın sporcunun anabolik steroid kullandığı tahmin edilmektedir. Literatüre bakıldığında; ergojenik takviyelerin etkilerine ilişkin kanıtlar seyrek ve çelişkilidir. Ergojenik yardımcıların spor performansı üzerindeki olumlu etkileri, bilimsel çalışmalarla desteklenmiştir; ancak bu etkiler, spor dalına özgü gereksinimler, bireysel, fizyolojik farklılıklar ve kullanım dozları gibi faktörlere bağlı olarak farklılık gösterebilmektedir. Bu amaçla incelenen makaleler doğrultusunda, bazı ergojenik madde dışında (kreatin, kafein, beta -alanin) etkilerini destekleyen çalışmalar yetersiz ve sayıca azdır. Fiziksel gelişimin, sağlığın korunmasının ve en iyi spor performansının ancak dengeli, düzenli ve hedef yönelik antrenmanlarla ve beslenme yoluyla sağlanılabileceği unutulmamalıdır. Ayrıca bu ürünler bilinçsiz bir şekilde kullanılmamalıdır, beslenme konusunda eğitimli profesyonel kişilerden yardım alınmalıdır.

Anahtar Kelimler: Beslenme, Egzersiz, Ergojenik yardımcılar

Abstract

This study aims to examine the effects of ergogenic aids on performance in sports. Any substance or phenomenon that increases sports and athlete performance is called ergogenic aids. Ergogenic aids consist of tools, methods and techniques that individuals use to increase or maintain their performance, improve performance capacity and training efficiency, and also accelerate the recovery process after physical activity or competition. Ergogenic supplements are typically available on the market in tablet, capsule, soft gel, liquid, powder and bar forms. The use of ergogenic aids has increased significantly in recent years. Athletes resort to ergogenic aids for various reasons such as perceived nutritional deficiencies, desire to improve sports performance, and desire to accelerate the recovery process after training. For this reason, individuals who do sports should consult experts about which supplements they use and at what dosage, otherwise they will not have any effect. Nutritional supplements taken before and during exercise renew body stores, provide fluid balance, and increase athletic success by facilitating recovery between competitions. The effects of ergogenic aids on sports performance occur in different mechanisms. For example, nutritional supplements such as creatine monohydrate and beta-alanine increase muscle energy production and muscle endurance, while stimulants such as caffeine reduce the perceived effort through the central nervous system, allowing for longer-term physical performance. Ergogenic aids can help increase performance, but you need to get the products you need, when you need them, in the amounts you need, and from experts in this regard. It should not be forgotten that ergogenic aids will not provide any benefit if used incompletely or incorrectly, and may also cause side effects. It is estimated that 1 to 3 million male and female athletes use anabolic steroids in the United States alone. When the literature is reviewed; evidence on the effects of ergogenic supplements is sparse and contradictory. The positive effects of ergogenic aids on sports performance have been supported by scientific studies; however, these effects may vary depending on factors such as sport-specific requirements, individual physiological differences, and dosages used. In line with the articles reviewed for this purpose, studies supporting the effects of certain ergogenic substances (creatine, caffeine, beta-alanine) are insufficient and few in number. It should not be forgotten that physical development, health protection and best sports performance can only be achieved through balanced, regular and targeted training and nutrition. In addition, these products should not be used unconsciously, and help should be sought from trained professionals in nutrition.

Keywords: Nutrition, Exercise, Ergogenic aids

EPIGALLOCATECHIN GALLATE IN ALL ITS ASPECTS

HER YÖNÜYLE EPİGALLOKATEŞİN GALLAT

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ÖZET

Epigallokateşin gallat (EGCG), çay bitkisinin (*Camellia sinensis* L.) temel fenolik bileşiklerinden biridir. Yeşil çay yapraklarının kuru ağırlığının %25-35'ini oluşturur. Çay infüzyonunun acı ve buruk tadına katkıda bulunur. Yeşil çay yapraklarının epigallokateşin gallat konsantrasyonu, çay çeşidi ve tipi, yaprağın konumu, kültürel etmenler, klimatik koşullar, toplama standardı gibi etkenlere bağlı olarak değişmektedir. Dünya genelinde en yaygın tüketilen bitkisel içeceklerden biri olan yeşil çayın epigallokateşin gallat içeriği 1 fincanda 200-300 mg'a ulaşabilmektedir. Çayın terapötik özelliği, içerdiği kateşinlerden özellikle epigallokateşin gallattan kaynaklanır. Epigallokateşin gallat, sağlık üzerine pozitif etkili bir bileşiktir. Antimikrobiyal, antioksidan, antikanser, antidiyabetik, antienflamatuar ve nöroprotektif özellikleriyle dikkat çeker. Kimyasal olarak, üç aromatik halkaya ve bir piran halkasına sahiptir. Bu yapısal özellikler, onun biyolojik aktivitelerinin temelini oluşturur. Sağlık üzerindeki etkileri arasında, yüksek kan basıncını kontrol etme, kolesterolü düşürme, obeziteyi önleme, Alzheimer hastalığı ve osteoporotik kırık riskini azaltma sayılabilir. Antioksidan mekanizması, serbest radikalleri temizleme ve metal iyonlarını şelatlama yoluyla reaktif oksijen türlerinin oluşumunu engellemeye dayanır. Antimikrobiyal etkisi, bakteriyel membranları bozma, viral replikasyonu engelleme ve fungal biyofilm oluşumunu azaltma gibi mekanizmalarla kendini gösterir. Epigallokateşin gallatın çok yönlü etkileri, onu terapötik uygulamalar için umut verici bir aday haline getirse de, biyoyararlanımı ve potansiyel toksisitesi üzerine daha fazla çalışma yapılması gereklidir. Bu makale, epigallokateşin gallatın kimyasal yapısından sağlık etkilerine kadar geniş bir perspektif sunmayı amaçlamaktadır.

Anahtar sözcük: Kateşin, EGCG, çay

ABSTRACT

Epigallocatechin gallate (EGCG) is one of the main phenolic compounds of the tea plant (Camellia sinensis L.). It constitutes 25-35% of the dry weight of green tea leaves. It contributes to the bitter and astringent taste of tea infusion. The epigallocatechin gallate concentration of green tea leaves varies depending on factors such as tea variety and type, leaf location, cultural factors, climatic conditions, and collection standards. Green tea, one of the most widely consumed herbal beverages worldwide, can contain 200-300 mg of epigallocatechin gallate in 1 cup. The therapeutic properties of tea are due to the catechins it contains, especially epigallocatechin gallate. Epigallocatechin gallate is a compound with positive effects on health. It draws attention with its antimicrobial, antioxidant, anticancer, antidiabetic, anti-inflammatory and neuroprotective properties. Chemically, it has three aromatic rings and a pyran ring. These

structural features form the basis of its biological activities. Its health effects include controlling high blood pressure, lowering cholesterol, preventing obesity, and reducing the risk of Alzheimer's disease and osteoporotic fractures. Its antioxidant mechanism is based on the inhibition of the formation of reactive oxygen species by scavenging free radicals and chelating metal ions. Its antimicrobial effect is manifested by mechanisms such as disrupting bacterial membranes, inhibiting viral replication, and reducing fungal biofilm formation. Although the multifaceted effects of epigallocatechin gallate make it a promising candidate for therapeutic applications, further studies on its bioavailability and potential toxicity are required. This article aims to provide a broad perspective from the chemical structure of epigallocatechin gallate to its health effects.

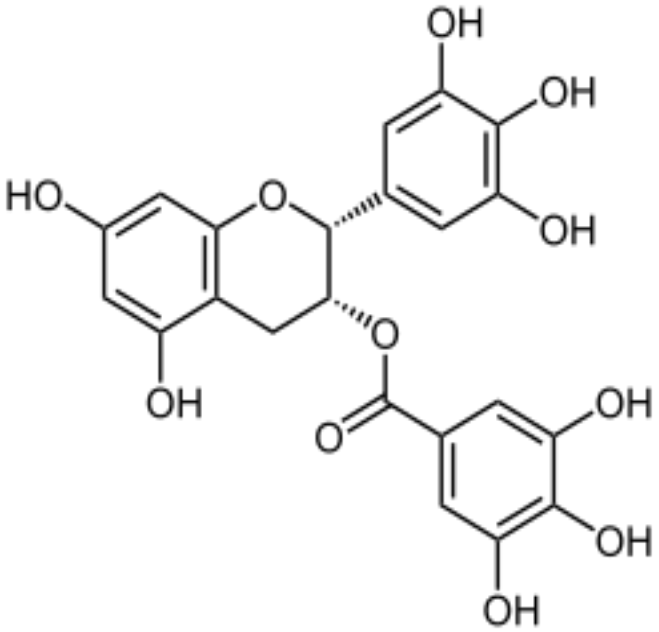
Keywords: Catechin, EGCG, tea

GİRİŞ

Çay, *Camellia sinensis* bitkisinden üretilen, dünya genelinde suyun ardından en çok tüketilen içeceklerden biridir. Çay bitkisi fenolik bileşiklerden kateşinlerce özellikle epigallokateşin gallatça (EGCG) zengindir (Bartosikova et al., 2018). Epigallokateşin gallat, yeşil çayın terapötik etkilerinin büyük kısmından sorumludur. Antioksidan kapasite, antimikrobiyal özellikler, antikanser potansiyel ve kardiyovasküler koruyucu etki gibi geniş bir biyolojik aktiviteye sahiptir (Das et al., 2014). Yeşil çay, tarih boyunca geleneksel tıpta kullanılmış ve modern bilim, bu içeceğin içindeki bileşenlerin moleküler düzeyde nasıl çalıştığını anlamaya yönelik çalışmalar yapmıştır (Tachibana, 2011). Epigallokateşin gallat, diğer ifadeyle (-)-epigallocatechin-3-O-gallate, yeşil çay yapraklarında bulunan kateşinlerin %50-80'ini oluşturur. Bu oran, bir fincan demlenmiş yeşil çayda yaklaşık 200-300 mg EGCG'ye denk gelmektedir (Das et al., 2014). Moleküler formülü $C_{22}H_{18}O_{11}$ olan epigallokateşin gallat, gallik asit ile epigallokateşinin esterleşmesiyle oluşur. Bu yapı, onun biyolojik aktivitelerinin temelini teşkil eder (Bartosikova et al., 2018). EGCG, antimikrobiyal, antienflamatuar ve antikanser özellikleriyle öne çıkar ve bu etkiler, çeşitli preklinik ve klinik çalışmalarla desteklenmiştir (Sang et al., 2011; Steinmann et al., 2013). Amerikan Gıda ve İlaç Dairesi (FDA) tarafından güvenli bir bileşik olarak sınıflandırılmıştır (Das et al., 2014). Yeşil çay tüketiminin yaygınlığı, epigallokateşin gallatın günlük diyetteki rolünü artırırken, bilimsel çalışmalar bu bileşiğin hem insan hem de hayvan modellerinde çok yönlü faydalarını ortaya koymaktadır (Steinmann et al., 2013). Özellikle kronik hastalıkların önlenmesinde ve tedavi yaklaşımlarında doğal alternatifler arayan araştırıcılar için epigallokateşin gallat, umut vadeden bir aday olarak öne çıkar (Yang et al., 2016). Bu

KİMYASAL YAPISI VE ÖZELLİKLERİ

Epigallokateşin gallat (Şekil 1), üç aromatik halka (A, B ve D) ve bir piran halkasından (C) oluşan karmaşık bir kimyasal yapıya sahiptir (Bartosikova et al., 2018). Moleküler ağırlığı 458.40 g/mol'dür ve CAS kayıt numarası 989-51-5'tir. Saf formda; kokusuz, beyaz, hafif pembe veya krem renkli bir toz ya da kristal olarak görünür. Suda (5 mg/ml'de berrak, renksiz bir çözelti), asetonda, etanolde, metanolde, piridinde ve tetrahidrofuranda çözünür (Bartosikova et al., 2018). Erime noktası 218°C'dir. Yapısındaki fenolik gruplar, özellikle B ve D halkalarındaki hidroksil grupları, antioksidan etkisinin temelini oluşturur ve bu gruplar, serbest radikallerle reaksiyona girerek oksidatif stresi azaltır (Lambert et al., 2010a). Ayrıca, B halkasındaki 5'-hidroksil grubu, *Helicobacter pylori* gibi bakterilere karşı güçlü bir inhibisyon sağlar. Kimyasal özellikleri, epigallokateşin gallatın biyolojik aktivitesini doğrudan etkiler.



Şekil 1. Epigallokateşin gallatın kimyasal yapısı *(Bartosikova et al., 2018)*

DOĞAL KAYNAKLARI

Epigallokateşin gallatın esas kaynağı Theaceae ailesine ait olan yeşil çay (*Camellia sinensis*) bitkisidir (Das et al., 2014). Yeşil çay yapraklarının kuru ağırlığının %25-35'i kateşinlerden oluşur ve bunların içinde epigallokateşin gallat, en baskın bileşendir (Bartosikova et al., 2018). Yeşil çay bitkisinde bulunan enzimlerin yüksek sıcaklıkta inaktivasyonuyla üretilen yeşil çay EGCG'nin en iyi kaynağıdır. Yeşil çay, *Camellia sinensis* var. sinensis ve *Camellia sinensis* var. assamica olmak üzere iki ana varyeteden üretilir (Yang et al., 2016). Bir fincan (yaklaşık 240 ml) yeşil çay ortalama 200-300 mg epigallokateşin gallat ve az miktarda diğer kateşinleri (örneğin, epikateşin (EC), epigallokateşin (EGC)) içerir (Das et al., 2014). Siyah çay ve oolong çay gibi diğer çay türlerinde ise oksidasyon süreci nedeniyle epigallokateşin gallat içeriği önemli ölçüde azalır (Tablo 1) (Sang et al., 2011). Yeşil çay, dünya genelinde 30'dan fazla ülkede yetiştirilir ve tüketimi, suyun ardından en yaygın bitkisel içecektir (Tachibana, 2011). Epigallokateşin gallat miktarları, çay yapraklarının işlenme yöntemine ve çevresel koşullara bağlı olarak değişebilir (Bartosikova et al., 2018).

Tablo 1. Farklı Çay Türlerinin Kateşin Oranları (Sang et al., 2011; Das et al., 2014)

Çay Türü	EGCG Oranı (%)	Diğer Kateşinler (%)
Yeşil Çay	50-80	20-50
Oolong Çay	20-40	30-50
Siyah Çay	5-10	10-20

BİYOLOJİK ÖZELLİKLERİ VE SAĞLIK ÜZERİNE ETKİSİ

Epigallokateşin gallat, yeşil çayın en aktif polifenolü olarak, insan sağlığı üzerinde çok yönlü etkiler sergiler (Tablo 2). İn vitro, in vivo, hayvan ve insan üzerinde çalışmalarda, bu bileşiğin antikanser, kardiyovasküler koruyucu, antienflamatuar, antioksidan ve nöroprotektif özelliklere sahip olduğu gösterilmiştir (Yashin et al., 2012; Bartosikova et al., 2018). Hücre membranlarıyla etkileşime girme, sinyal yollarını düzenleme ve oksidatif stresi azaltma yetenekleri bu etkilerin temel mekanizmalarını oluşturur (Singh et al., 2011). Ayrıca, diyabet önleme, kemik metabolizmasını destekleme, obeziteyi azaltma ve oral sağlık gibi faydaları da rapor edilmiştir (Das et al., 2014). Antidiyabetik özellikler, insülin sekresyonunu artırma ve beta hücrelerini sitokin kaynaklı apoptozdan koruma yoluyla kendini gösterir (Cai et al., 2009).

Nöroprotektif etkiler, reaktif oksijen türlerini temizleme ve antioksidan enzimlerin ekspresyonunu artırma mekanizmalarına dayanır. Alzheimer ve Parkinson gibi hastalıklarda koruyucu bir rol oynar (Mahler et al., 2013). Epigallokateşin gallat ayrıca kemik metabolizmasını destekler ve osteoblast farklılaşmasını teşvik ederek osteoporoz riskini azaltabilir (Shen et al., 2009). Epigallokateşin gallatın bu geniş etki yelpazesi, onu hem bireysel sağlık yönetimi hem de klinik uygulamalar için değerli bir bileşik haline getirir.

Tablo 2. Epigallokateşin Gallatın Biyolojik Özellikleri (Singh et al., 2011; Das et al., 2014; Bartosikova et al., 2018)

Özellik	Mekanizma	Etki Alanı
Antimikrobiyal	Membran bozulması, DNA giraz inhibisyonu	Bakteri, virüs, mantar
Antiinflamatuar	İnflamasyon faktörlerini baskılama	İnflamatuar yanıt
Antiproliferatif	Apoptoz indüksiyonu	Kanser hücreleri
Antidiabetik	İnsülin sekresyonunu artırma	Beta hücre koruması
Nöroprotektif	Reaktif oksijen türlerini temizleme	Nörodejeneratif hastalıklar
Kemik Metabolizması	Osteoblast farklılaşmasını teşvik	Osteoporoz önleme

ANTİKANSEROJEN ETKİ

Epigallokateşin gallat, prostat, meme, akciğer, kolorektal kanser ve melanom gibi çeşitli kanser türlerinde antitümöral etkiler sergiler (Bartosikova et al., 2018). Bu etkiler, apoptoz indüksiyonu, angiogenesis baskılanması ve metastazın önlenmesi gibi mekanizmalarla ilişkilidir (Gupta et al., 2000). DNA metiltransferaz ve telomeraz aktivitelerini inhibe ederek tümör oluşumunu engeller (Du et al., 2012). Hipoksi ile indüklenen faktör 1-alfa ve nükleer faktör kappa B gibi transkripsiyon faktörlerini baskılayarak tümör büyümesini durdurur (Granja et al., 2016). Pro-apoptotik proteinler olan BCL-2 ile ilişkili X protein ve BCL-2 homolog antagonist killer ekspresyonunu artırırken, anti-apoptotik proteinler olan B-hücre lenfoma 2 ve B-hücre lenfoma-ekstra büyük düzeylerini azaltır (Khan et al., 2006). Epigallokateşin gallatın kanser hücre döngüsünü durdurduğu ve normal hücrelere minimal etki yaptığı da rapor edilmiştir. Ancak, 1.6 milyondan fazla katılımcıyı kapsayan sistematik çalışmalar, yeşil çay tüketiminin kanser önleme üzerindeki etkisine dair kesin kanıtların yetersiz olduğunu belirtmektedir (Boehm et al., 2009).

KARDİYOVASKÜLER SİSTEM ÜZERİNE ETKİ

Epigallokateşin gallat, kardiyovasküler sistem üzerinde koruyucu etkiler sağlar. Bu etkiler, kolesterol düzeylerini düşürme, düşük yoğunluklu lipoprotein oksidasyonunu önleme ve endotel fonksiyonunu iyileştirme yoluyla gerçekleşir (Babu et al., 2008). Klinik çalışmalarda, kolesterol sentezini inhibe ettiği ve bağırsaklarda kolesterol emilimini azalttığı gözlemlenmiştir. Bu, hepatik lipid metabolizmasını düzenleyerek düşük yoğunluklu lipoprotein kolesterolünü azaltır (Bursill et al., 2006). Damarlarda düz kas proliferasyonunu baskılayarak ateroskleroz gelişimini önler ve aterogenezle ilişkili patolojik süreci yavaşlatır. Kan basıncını düşürme ve platelet agregasyonunu azaltma kapasitesi, hipertansiyon ve tromboz riskini azaltır (Tachibana, 2011). Randomize kontrollü çalışmalarda, epigallokateşin gallat içeren yeşil çay ekstraktlarının kardiyovasküler risk faktörlerini iyileştirdiği rapor edilmiştir. Obez bireylerde egzersizle birlikte abdominal yağ kaybını artırdığı bulunmuştur (Maki et al., 2009). Ayrıca, nitrik oksit üretimini artırarak sağlıklı bireylerde kan damarlarının elastikiyetini destekler (Hooper et al., 2008). Epigallokateşin gallatın kardiyovasküler etkileri (Tablo 3), onu kalp-damar hastalıklarının önlenmesinde etkili bir bileşik yapar.

Tablo 3. Epigallokateşin Gallatın Kardiyovasküler Etkisi (Babu et al., 2008; Hooper et al., 2008; Tachibana, 2011)

Etki Alanı	Mekanizma	Çalışma Bulguları
Kolesterol Düşürme	Kolesterol sentez inhibisyonu	LDL kolesterolünde azalma
Endotel Fonksiyonu	Damar proliferasyonunun baskılanması	İyileşmiş vasküler fonksiyon
Kan Basıncı	Hipertansif etki	Kan basıncında düşüş
Platelet Agregasyonu	Agregasyon inhibisyonu	Azalmış tromboz riski

ANTİENFLAMATUAR ETKİ

Antienflamatuar etkisi, ultraviyole radyasyon kaynaklı inflamasyonu ve tümör nekroz faktör üretimini azaltma kapasitesine dayanır. Ancak bazı çalışmalar pro-inflamatuar özellikler de bildirmiştir (Bartosikova et al., 2018).

ANTİOKSİDAN ETKİ

Epigallokateşin gallat, yeşil çayın en güçlü antioksidan bileşenlerinden biri olarak, serbest radikalleri temizleme ve oksidatif stresi azaltma kapasitesiyle öne çıkar. Bu bileşik, süperoksit ve hidroksil radikalleri gibi reaktif oksijen türlerini nötralize eder ve böylece hücre hasarını önler (Ruch et al., 1989). Ayrıca, 1,1-difenil-3-pikrilhidrazil radikali, peroksil radikalleri, nitrik oksit ve lipid serbest radikalleri gibi çeşitli radikalleri de etkisiz hale getirir (Nanjo et al., 1999; Kelly et al., 2001). Antioksidan etkisi, fenolik gruplarının oksidasyonu yoluyla gerçekleşir; bu gruplar, B ve D halkalarında semikinon ve kinon üretimine yol açarak elektron transferini sağlar. Epigallokateşin gallat aynı zamanda metal şelasyon özelliklerine sahiptir. Özellikle demir ve bakır gibi geçiş metallerini bağlayarak, Fenton reaksiyonları yoluyla reaktif oksijen türlerinin oluşumunu engeller (Grinberg et al., 1997). Bu özellik, onun C ve E vitaminden daha etkili bir antioksidan olmasını sağlar (Zhao et al., 1989). Beyin mitokondriyal membranlarında demir-askorbat bağımlı lipid peroksidasyonunu inhibe etme kapasitesi, nöroprotektif etkilerinin de temelini oluşturur (Singh et al., 2016). Antioksidan mekanizmaları, kronik hastalıkların önlenmesinde epigallokateşin gallatın kritik bir rol oynadığını göstermektedir (Forester et al., 2011).

ANTİMİKROBİYAL ETKİ

Epigallokateşin gallat, bakteri, virüs ve mantarlara karşı geniş bir antimikrobiyal etkinlik gösterir. Antibakteriyel etkisi, metisiline dirençli *Staphylococcus aureus* gibi klinik izolatlara karşı membran bozulması yoluyla gerçekleşir. Negatif yüklü epigallokateşin gallat, pozitif yüklü lipidlere bağlanarak membran yapısını bozar ve hücre içeriğinin sızmasına neden olur (Das et al., 2014). Penisilinaz enzim aktivitesini inhibe ederek beta-laktam antibiyotiklerin etkinliğini artırır. Bu etki, 10 µg/mL minimum inhibisyon konsantrasyonu ile ölçülmüştür. *Helicobacter pylori*'ye karşı ise tümör nekroz faktör alfa üretimini baskılayarak ve toll-benzeri reseptör 4 sinyal yolunu bloke ederek gastrik sitotoksisiteyi önler (Lee et al., 2004).

Epigallokateşin gallatın antimikrobiyal etkisi, bakteriyel membranları bozarak, viral replikasyonu engelleyerek ve fungal biyofilm oluşumunu azaltarak ortaya çıkar. Örneğin, *Staphylococcus aureus*'a karşı membran lipidlerini parçalayarak hücre ölümüne yol açar ve DNA giraz enzimini inhibe ederek bakteriyel büyümeyi durdurur (Gradisar et al., 2007).

Viral enfeksiyonlarda, Hepatit B virüsünün spesifik antijen sekresyonunu baskılar ve Epstein-Barr virüsünün litik döngüsünü bloke eder (He et al., 2011; Chang et al., 2003). Antiviral etkisi, Hepatit C virüsünün hücreye tutunmasını ve RNA replikasyonunu engelleyerek kendini gösterir (Chen et al., 2012). Influenza virüsüne karşı hemaglutinasyon inhibisyonu sağlar ve

replikasyonu durdurur (Song et al., 2005). Antifungal etkinlik, *Candida albicans* ve *Trichophyton mentagrophytes* gibi türlerde biyofilm oluşumunu bozar ve dihidrofolat redüktaz enzimini inhibe ederek fungal büyümeyi engeller (Navarro-Martinez et al., 2006). Epigallokateşin gallatın antimikrobiyal potansiyeli, onu antibiyotik direncine karşı doğal bir alternatif olarak konumlandırır (Steinmann et al., 2013).

TOKSİSİTE

Epigallokateşin gallat, genellikle güvenli bir bileşik olarak kabul edilse de yüksek dozlarda çeşitli toksik etkiler gösterebilir (Tablo 4). Bu etkiler, tüketim miktarı, kullanım şekli ve bireyin fizyolojik durumuna bağlı olarak değişir. Özellikle karaciğer toksisitesi, epigallokateşin gallatın yüksek dozda kullanımında dikkat çeken bir yan etkidir. Bunun yanı sıra, demir emilimini etkileme potansiyeli gibi metabolik yan etkiler de rapor edilmiştir.

Tablo 4. Epigallokateşin Gallatın Toksisitesi

Toksisite Türü	Doz Aralığı	Bulgular	Açıklama	Kaynak
Yüksek Doz Yan Etkiler	800-1600 mg/gün	Hafif gastrointestinal rahatsızlıklar (bulantı, karın ağrısı), baş ağrısı, yorgunluk	Sağlıklı bireylerde 800 mg/gün'e kadar tolere edilebilir, 1600 mg tek dozda yan etkiler artar	Chow et al., 2003
Karaciğer Toksisitesi	500-1000 mg/gün	Transaminaz ve bilirubin düzeylerinde anormal yükselmeler (normalin 140 katına kadar)	Yeşil çay takviyesiyle ilişkilendirilen 34 hepatit vakası; hepatoselüler (%62.5), kolestatik (%18,75)	Mazzanti et al., 2009
Güvenli Doz Sınırı	200-300 mg/gün	Yan etki gözlenmedi	Günlük çay tüketimiyle alınan standart doz, FDA tarafından güvenli kabul edilir	Das et al., 2014
Uzun Süreli Yüksek Doz	500 mg/gün ve üzeri	Karaciğer enzimlerinde artış, potansiyel metabolik yüklenme	Takviye formunda uzun süreli kullanımda karaciğer üzerinde stres artışı gözlenebilir	Lambert et al., 2010b
Demir Emilim Bozukluğu	200 mg (yemekle birlikte)	Demir emiliminde %25 azalma	Özellikle demir eksikliği riski olan bireylerde (hamileler, vejetaryenler) dikkat gerektirir	Frei & Higdon, 2003

Epigallokateşin gallatin toksisitesi, özellikle yeşil çay ekstraktlarının veya takviyelerinin aşırı tüketimiyle bağlantılıdır. Klinik raporlara göre, yüksek dozda epigallokateşin gallat alımı bazı bireylerde gastrointestinal rahatsızlıklar, baş ağrısı ve yorgunluk gibi hafif yan etkilere yol açabilir (Chow et al., 2003). Daha ciddi durumlarda ise bu bileşiğin yoğun kullanımı karaciğer fonksiyonlarında bozulmalara neden olabilir. Örneğin, yeşil çay bazlı takviyelerin uzun süreli ve yüksek dozda tüketimi, bazı kişilerde karaciğer enzimlerinde anormal yükselmeler ile ilişkilendirilmiştir (Mazzanti et al., 2009). Bu durum, epigallokateşin gallatın metabolik dönüşüm süreçlerinde karaciğer üzerindeki yükü artırabileceğini düşündürmektedir. Ancak, normal çay tüketimiyle (günlük 2-3 fincan) bu tür etkilerin görülmesi oldukça nadirdir ve genellikle güvenli kabul edilir (Mereles et al., 2011). Yüksek doz kullanımın riskleri, bireysel hassasiyetlere ve tüketim şekline bağlı olarak değişkenlik gösterir.

Epigallokateşin gallatin karaciğer üzerindeki toksik etkileri, özellikle 1999-2008 yılları arasında yapılan bir derlemede dikkat çekmiştir. Bir çalışmada, yeşil çay ekstraktlarının tüketimiyle ilişkilendirilen 34 hepatit vakası incelenmiş ve karaciğer enzimlerinde (transaminazlar ve bilirubin) belirgin yükselmeler gözlenmiştir (Mazzanti et al., 2009). Vakaların %62.5'i hepatoselüler, %18.75'i kolestatik ve %18.75'i karışık tipte sınıflandırılmıştır. Bu etkiler, genellikle 500-1000 mg/gün gibi yüksek dozlarla ilişkilendirilmiş olup, standart çay içiminden ziyade konsantre takviyelerin kullanımından kaynaklanmıştır. Araştırmalar, epigallokateşin gallatın karaciğer toksisitesinin oksidatif stres ve metabolik aşırı yüklenmeyle bağlantılı olabileceğini öne sürmektedir (Lambert et al., 2010b). Bu durum, epigallokateşin gallatın güvenli tüketim sınırlarının belirlenmesi gerektiğini vurgular ve bireylerin takviye kullanımında dikkatli olmaları önerilir.

Epigallokateşin gallatın güvenli dozaj sınırları, klinik çalışmalar ve gözlemsel verilerle değerlendirilmiştir. Amerikan Gıda ve İlaç Dairesi (FDA) tarafından güvenli bir bileşik olarak sınıflandırılan EGCG, günlük 200-300 mg gibi çaydan alınan dozlarda genellikle yan etki göstermez (Das et al., 2014). Ancak, randomize kontrollü bir çalışmada, sağlıklı bireylerde 800 mg/gün'e kadar olan dozların tolere edilebildiği, fakat daha yüksek dozlarda (örneğin 1600 mg tek doz) hafif gastrointestinal rahatsızlıkların ortaya çıktığı rapor edilmiştir (Chow et al., 2003). Uzun süreli kullanımda ise 500 mg/gün üzerindeki dozlar bazı bireylerde karaciğer enzimlerinde artışa yol açabilir (Mazzanti et al., 2009). Bu veriler, epigallokateşin gallatın toksisite riskinin doz bağımlı olduğunu ve günlük tüketimin bireysel ihtiyaçlara göre ayarlanması gerektiğini göstermektedir. Özellikle karaciğer hastalığı öyküsü olan kişilerde dikkatli olunması önerilir. Epigallokateşin gallat, demir iyonlarıyla şelat oluşturma yeteneğine sahiptir. Bu özellik, diyetle alınan demirin emilimini azaltabilir. Bir çalışmada, 200 mg epigallokateşin gallatın yemekle birlikte alınmasının demir emilimini %25 oranında düşürdüğü gözlenmiştir. Bu etki, özellikle demir eksikliği anemisi riski taşıyan bireylerde (örneğin, hamile kadınlar veya vejetaryenler) önemli bir sorun olabilir. Ancak, epigallokateşin gallatın yemeklerden ayrı zamanlarda alınması bu riski minimize edebilir. Demir emiliminin en az etkilendiği zaman dilimi, yemeklerden 1-2 saat sonrasıdır (Frei & Higdon, 2003).

BİYOYARAYIŞLILIĞININ ARTIRILMASI

Epigallokateşin gallatın sağlık üzerindeki etkilerinden tam anlamıyla faydalanabilmek için biyoyararlanımını artırmak, özellikle gıda mühendisliği açısından önemli bir hedeftir. Yeşil çaydan elde edilen bu polifenolün gastrointestinal sistemdeki düşük emilimi ve stabilitesi, etkinliğini sınırlayan temel faktörlerdir (Mereles et al., 2011). Çeşitli teknolojik ve formülasyon yaklaşımları, epigallokateşin gallatın plazma düzeylerini ve biyolojik etkilerini iyileştirebilir. Bu yöntemler, gıda ürünlerinin geliştirilmesinde ve takviye formülasyonlarında uygulanabilir özelliktedir (Chow et al., 2003). Gıda mühendisleri, epigallokateşin gallatın işleme süreçlerindeki hassasiyetini ve nihai üründe tüketiciye sunduğu faydayı optimize etmek için bu teknikleri kullanabilir. Bu amaçla geliştirilen başlıca yöntemler, Tablo 5'te özetlenmiştir.

Tablo 5. Epigallokateşin Gallatın Biyoyararlanımını Artırma Yöntemleri (*Zhao et al., 2001; Chow et al., 2003; Mereles et al., 2011; Granja et al., 2016)*

Yöntem	Mekanizma	Avantaj	Uygulama alanı
Soğuk ve Kuru Depolama	Oksidasyonu önleme	Stabilite artışı	Yeşil çay ekstraktları
Açlık Koşullarında Tüketim	Gastrointestinal inaktivasyonu azaltma	Emilimde artış	Takviye kapsülleri
C Vitamini ile Kombinasyon	Oksidatif bozunmayı önleme	Antioksidan etkinlikte artış	Fonksiyonel içecekler
Balık Yağı ve Piperin	Lipit bazlı emilim artışı	Plazma düzeylerinde yükselme	Yağ bazlı gıda takviyeleri
Mikroenkapsülasyon	Bozunmaya karşı koruma, kontrollü salım	Hedefe yönelik teslim	Kapsüllenmiş gıda katkı maddesi
Nanopartiküller	Hücre içi teslim artışı	Seçici biyolojik etki	Nano-formüle edilmiş takviyeler

Epigallokateşin gallatın biyoyararlanımını artırmada depolama ve tüketim koşulları kritik bir rol oynar. Soğuk ve kuru depolama, oksidasyonu önleyerek bileşiğin stabilitesini korur ve plazma düzeylerini yükseltir (Mereles et al., 2011). Örneğin, yeşil çay ekstraktlarının soğuk ortamda saklanması, epigallokateşin gallatın kimyasal yapısının bozulmasını engeller. Daha önce de vurgulandığı gibi, aç durumda tüketim ise gastrointestinal inaktivasyonu azaltır ve emilimi artırır. Çalışmalarda, aç karnına alınan epigallokateşin gallatın biyoyararlanımının tok karnına alınana göre %20.3 daha yüksek olduğu bulunmuştur (Chow et al., 2003). Bu strateji, özellikle takviye kapsüllerinin kullanımında uygulanabilir ve gıda mühendisleri tarafından ürün talimatlarında önerilebilir. Epigallokateşin gallatın biyoyararlanımı, gıda matrisleriyle veya yardımcı bileşenlerle kombinasyon yoluyla artırılabilir. Albumin gibi proteinlerle birlikte kullanımı, epigallokateşin gallatın stabilitesini güçlendirir ve oksidatif bozunmayı önler. Bu, protein bazlı gıda formülasyonlarında avantaj sağlar (Mereles et al., 2011). C Vitamini ile kombinasyon, antioksidan kapasiteyi artırır ve serbest radikal temizleme etkinliğini yükseltir. Bu etkiden yararlanılarak fonksiyonel içecekler geliştirilebilir (Zhao et al., 2001). Balık yağı ve piperin gibi lipofilik maddeler de emilim oranını artırır. Balık yağı, lipit bazlı bir taşıyıcı olarak epigallokateşin gallatın bağırsak geçişini kolaylaştırırken, piperin metabolik dönüşümleri azaltır (Mereles et al., 2011). Bu kombinasyonlar, yağ bazlı gıda takviyeleri veya emülsiyonlar tasarlanırken dikkate alınabilir. Nanopartikül sistemleri, epigallokateşin gallatın biyoyararlanımını artırmada en gelişmiş teknolojik yaklaşımlardan biridir. Bu yöntem, epigallokateşin gallatın hücre içi teslimini artırır ve özellikle hedefe yönelik uygulamalarda etkilidir (Granja et al., 2016). Nanopartiküller, epigallokateşin gallatın küçük boyutlu partiküller halinde formüle edilmesini sağlayarak emilim yüzey alanını genişletir ve biyolojik bariyerleri aşma kapasitesini güçlendirir. Örneğin, nano-formüle edilmiş epigallokateşin gallat, kanser hücrelerinde seçici apoptoz indükleyebilir. Takviye ürünlerinde terapötik bir avantaj sunar (Granja et al., 2016). Gıda mühendisleri, bu teknolojiyi nano-formüle edilmiş içecekler veya takviyeler geliştirmek için kullanabilir. Ancak, üretim maliyeti ve güvenlik standartları dikkate alınmalıdır.

SONUÇ

Epigallokateşin gallat, yeşil çayın en etkili ve çok yönlü polifenolik bileşeni olarak, sağlık üzerinde geniş bir fayda yelpazesi sunan doğal bir molekül olarak öne çıkar. Üç aromatik halka ve bir piran halkasından oluşan kimyasal yapısı, biyolojik aktivitelerinin temelini oluşturur ve serbest radikalleri temizleme, metal iyonlarını şelatlama gibi mekanizmalarla hücreleri koruma kapasitesini sağlar. Yeşil çayda bol miktarda bulunan epigallokateşin gallat, bir fincan demlenmiş çayda 200-300 mg kadar mevcut olup günlük diyette kolayca erişilebilir bir seçenek sunar. Bu bileşik, bakteriyel enfeksiyonlara karşı membran bozucu etkisiyle mücadele eder, viral replikasyonu engelleyerek antiviral bir kalkan oluşturur ve fungal biyofilm oluşumunu

azaltır. Antikanser potansiyeli, hücre döngüsünü durdurma, apoptozu tetikleme ve tümör yayılımını önleme gibi mekanizmalarla kendini gösterirken, kardiyovasküler sistemde kolesterolü düşürme, kan basıncını düzenleme ve damar elastikiyetini artırma gibi koruyucu roller üstlenir. Antioksidan etkisi, oksidatif stresi azaltarak kronik hastalıkların önlenmesine katkıda bulunur. Nöroprotektif özellikleri beyin sağlığını desteklerken, kemik metabolizmasını teşvik etmesi osteoporoz gibi durumların riskini düşürür. Bununla birlikte, epigallokateşin gallatın faydaları bazı sınırlamalarla dengelenmelidir. Yüksek dozlarda, özellikle konsantre takviye formunda alındığında, karaciğer üzerinde toksik etkiler gösterebilir ve bu durum, genellikle standart çay tüketiminden ziyade aşırı kullanımla ilişkilidir. Ayrıca, demir iyonlarıyla etkileşime girerek emilimini azaltma potansiyeli, demir eksikliği riski taşıyan bireyler için dikkat edilmesi gereken bir noktadır. Bu etki, yemeklerden ayrı tüketimle hafifletilebilir. Biyoyararlanımı düşük olması, epigallokateşin gallatın sağlık etkilerinden tam anlamıyla faydalanmayı zorlaştırır. Ancak, soğuk ve kuru depolama, açlık koşullarında tüketim, C vitamini ile kombinasyon veya nanopartikül sistemleri gibi yöntemler bu sorunu iyileştirebilir. Epigallokateşin gallat, doğal bir sağlık destekçisi olarak büyük bir potansiyel taşısa da, toksisite riskleri, metabolik yan etkiler ve biyoyararlanımı artırma yolları üzerine daha fazla araştırmaya ihtiyaç duyulmaktadır.

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THE MULTIDISCIPLINARY IMPACT OF ERAS PROTOCOLS ON LAPAROSCOPIC CHOLECYSTECTOMY OUTCOMES: A RETROSPECTIVE COHORT STUDY

ERAS PROTOKOLLERİNİN LAPAROSKOPİK KOLESİSTEKTOMİ SONUÇLARINA MULTİDİSİPLİNER ETKİSİ: RETROSPEKTİF KOHORT ÇALIŞMASI

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ÖZET

Amaç: Bu çalışma Laparoskopik kolesistektomi uygulanan hastalarda multidisipliner ERAS (Hızlandırılmış Cerrahi Sonrası İyileşme) protokollerinin klinik etkinliğini değerlendirmeyi amaçlamaktadır.

Yöntem: Bu retrospektif çalışmada, 2023-2024 yılları arasında elektif cerrahi geçiren 1.024 hasta; kontrol grubu ile karşılaştırılmıştır. ERAS grubunda, cerrahi öncesi karbonhidrat desteği ve hasta bilgilendirmesi, ameliyat sırasında analjezi kullanımını azaltan anestezi teknikleri ile sıvı replasmanı, sonrasında ise 2. saatte mobilizasyon, 4. saatte beslenme ve ağrı kontrolü uygulanmıştır. Kontrol grubunda standart protokol (12 saat açlık, analjezi) takip edilmiştir.

Bulgular: ERAS protokolü, hastanede kalış süresini 1.2±0.5 güne (kontrol: 2.8±1.1 gün; $p<0.001$) indirirken, komplikasyon oranında anlamlı azalma (%8 vs. %18; $p=0.002$), VAS ağrı skorunda düşüş (2.4±1.1 vs. 5.6±1.8; $p<0.001$) ve analjezi tüketiminde 4 kat azalma sağlamıştır. Hasta memnuniyeti ERAS grubunda 4.7/5 (kontrol: 3.1/5; $p<0.001$) olarak bulgulanmıştır. Cerrahi, anestezi ve hemşirelik ekiplerinin koordineli çalışması sonucunda uygulanan erken mobilizasyon, klinik sonuçları iyileştirdiği ve hasta odaklı bakım standartlarını güçlendirdiği bulgulanmıştır.Sonuç: Bu sonuçlar; ERAS protokollerinin komplikasyon riskini azaltığını ve postoperatif iyileşme sürecini hızlandırdığını ortaya çıkarmaktadır.

Anahtar Kelimeler: ERAS, laparoskopik kolesistektomi, multidisipliner ekip, perioperatif bakım

Abstract

Objective: This study aimed to evaluate the clinical efficacy of multidisciplinary Enhanced Recovery After Surgery (ERAS) protocols in patients undergoing laparoscopic cholecystectomy.

Methods: In this retrospective study, 1,024 patients who underwent elective surgery between 2023–2024 were compared with a control group. The ERAS group received preoperative carbohydrate loading and patient education, opioid-sparing anesthesia techniques with goal-directed fluid therapy intraoperatively, and early mobilization (2nd postoperative hour), oral intake (4th hour), and multimodal analgesia postoperatively. The control group followed standard protocols (12-hour fasting, opioid-based analgesia).

Results: The ERAS protocol significantly reduce hospital stay to 1.2 ± 0.5 days (control: 2.8 ± 1.1 days; $p<0.001$) and complication rates (8% vs. 18%; $p=0.002$). Pain scores (VAS: 2.4 ± 1.1 vs. 5.6 ± 1.8; $p<0.001$) and opioid consumption are fourfold lower in the ERAS group. Patient satisfaction is higher in the ERAS group (4.7/5 vs. 3.1/5; $p<0.001$). Coordinated efforts among surgical, anesthesia, and nursing teams improve clinical outcomes and reinforce patient centere care standards.

Conclusion: ERAS protocols reduce complication risks and accelerate postoperative recovery in laparoscopic cholecystectomy. Multidisciplinary collaboration is critical to optimizing perioperative outcomes.

Keywords: ERAS, laparoscopic cholecystectomy, multidisciplinary team, perioperative care, patient centered care

GİRİŞ

Hızlandırılmış Cerrahi Sonrası İyileşme (ERAS) protokolleri, cerrahi stres yanıtını en aza indirerek organ fonksiyonlarını optimize etmeyi ve hastaların ameliyat sonrası iyileşme süreçlerini hızlandırmayı hedefleyen, kanıta dayalı multidisipliner uygulamalardır [1]. İlk olarak majör cerrahi girişimlerde (örneğin kolorektal cerrahide) kullanılmaya başlanan ERAS protokolleri; preoperatif dönemde hasta eğitimi ve hasta hazırlığı, intraoperatif dönemde en uygun anestezi yöntemi ve uygun cerrahi tekniklerin kullanılması, postoperatif dönemde ise erken mobilizasyon ve beslenme gibi çok çeşitli multidisipliner yaklaşımları içermektedir [2]. Bu protokoller, cerrahi stres yanıtını azaltarak komplikasyon oranlarını düşürmekte ve hastanede kalış süresini kısaltmaktadır [3].Laparoskopik cerrahi teknikler, minimal invaziv olmaları sebebiyle, ameliyat sonrası dönemde daha az ağrı, daha hızlı mobilizasyon ve daha kısa iyileşme süreleri sağlarlar [4]. Örneğin, kolorektal cerrahide yapılan LAFA çalışması gibi randomize kontrollü araştırmalar, laparoskopik cerrahi ile ERAS protokollerinin beraber kullanılmasının, geleneksel yaklaşımlara göre daha iyi postoperatif sonuçlar sağladığını göstermiştir [5].Laparoskopik kolesistektomi, semptomatik safra kesesi taşları ve kolesistit tedavisinde kabul edilen altın standart bir minimal invaziv cerrahi yöntemdir [6]. Bu teknik, açık cerrahiden daha kısa hastanede kalış süreleri, daha az postoperatif ağrı ve daha hızlı işe dönüş gibi önemli avantajlar sunmaktadır [7]. Ancak geleneksel ameliyat sonrası bakım uygulamaları (uzun süreli açlık ve geç mobilizasyon gibi) iyileşme süreçlerini uzatarak hasta konforunu olumsuz etkilemektedir [8].Son yıllarda yapılan araştırmalar, ERAS protokollerinin laparoskopik kolesistektomi gibi daha küçük cerrahi girişimlerde de önemli faydalar sağladığını ortaya koymaktadır [9]. Bu protokoller, hastanede kalış sürelerini kısaltmakta, postoperatif ağrı ve analjezi kullanımını azaltmakta, ayrıca minör komplikasyon oranlarını düşürmektedir [10]. Bununla birlikte, bu alanda gerçekleştirilen çalışmaların sayısı sınırlıdır ve özellikle multidisipliner ekip çalışmasının etkilerini değerlendiren araştırmalara ihtiyaç duyulmaktadır [11].Bu çalışmanın amacı, laparoskopik kolesistektomi uygulanan hastalarda ERAS protokollerinin perioperatif sonuçlar üzerindeki etkisini retrospektif bir kohort analizi ile incelemektir. Özellikle hastanede kalış süresi, postoperatif komplikasyon oranları, postoperatif ağrı düzeyi, analjezik ihtiyaçları ve hasta memnuniyeti gibi parametreler değerlendirilecektir. Ayrıca, ERAS protokollerinin farklı yaş grupları ve risk profillerindeki etkinliği alt grup analizleri ile araştırılacaktır. Bu çalışma, ERAS yaklaşımının laparoskopik kolesistektomi sonrası hasta bakımına yönelik klinik uygulamalara önemli katkılar sunmayı hedeflemektedir.

GEREÇ VE YÖNTEMLER

Çalışma Tasarımı ve Hasta Seçimi Bu retrospektif ve karşılaştırmalı kohort çalışması, Ocak 2023 - Ağustos 2024 tarihleri arasında Amasya Üniversitesi Sabuncuoğlu Şerefeddin Eğitim ve Araştırma Hastanesi'nde gerçekleştirilmiştir. Elektif laparoskopik kolesistektomi geçiren 1024 hasta iki gruba ayrılmıştır: ERAS protokolü uygulananlar (n=512) ve geleneksel bakım alanlar (n=512) **Dahil Etme Kriterleri:**18 yaş ve üzeri hastalar,ASA I-III olan hastalar,Semptomatik safra kesesi taşı veya kronik kolesistit nedeniyle elektif laparoskopik kolesistektomi planlanan hastalar.**Dışlama Kriterleri:**Akut kolesistit atağı veya perforasyon nedeniyle acil cerrahi gerektiren hastalar,Koledok taşı nedeniyle ERCP veya laparoskopik eksplorasyon gerektiren hastalar,Malignite şüphesi bulunan vakalar,Laparoskopiden açık cerrahiye dönüş gerçekleşen hastalar,ERAS protokolüne uyum sağlayamayacak ek hastalıkları olan hastalar.**ERAS Protokolü Müdahaleleri** ERAS protokolü, preoperatif, intraoperatif ve postoperatif süreçleri kapsayan multidisipliner bir yaklaşımı içermektedir:**Preoperatif Dönem:** Hasta eğitimi sağlanmış, uzun süreli açlık önlenmiş, son 8-12 saat içinde oral karbonhidrat içeren sıvılar verilmiştir. Tromboz önleme amaçlı düşük molekül ağırlıklı heparin ve kompresyon çorapları kullanılmıştır. Premedikasyon sürecinde opioidlerden kaçınılmıştır.**İntraoperatif Dönem:** Genel anestezi altında dört trokar ile laparoskopik kolesistektomi uygulanmıştır. Pnömoperitoneum basıncı 10–12 mmHg ile sınırlandırılmış, dren kullanımı sadece gerekli vakalarla sınırlandırılmış, trokar giriş yerlerine lokal anestezik uygulanmıştır.**Postoperatif Dönem:** İlk 2 saat içinde sıvı alımı, 4–6 saat içinde mobilizasyon başlatılmıştır. İlk 6 saatte sıvı gıda, 12 saatte yumuşak diyete geçiş sağlanmıştır. Ağrı yönetimi için düzenli parasetamol ve NSAİD kullanılmış, opioid ihtiyacı en aza indirilmiştir. En az 3 kez mobilizasyon teşvik edilmiştir. Taburculuk kriterleri arasında bağımsız mobilizasyon, iyi ağrı kontrolü (VAS ≤3) ve komplikasyon olmaması yer almıştır.**Kontrol Grubu (Geleneksel Yöntem) Ameliyat Sonrası Bakım** Geleneksel bakım alan hastalara ERAS protokolü uygulanmamış, standart cerrahi prosedürler takip edilmiştir.Ameliyat öncesinde rutin bilgilendirme yapılmış ancak hasta eğitimi verilmemiştir.Gece yarısından itibaren tam açlık uygulanmış, karbonhidrat yüklemesi yapılmamıştır.Laparoskopik kolesistektomi sırasında pnömoperitoneum basıncı 12–14 mmHg olarak belirlenmiştir.Postoperatif dönemde hastalar ilk gün ağızdan beslenmemiş, ikinci gün sıvı alımına, üçüncü gün katı gıdaya geçilmiştir. İlk mobilizasyon ertesi gün başlatılmıştır.Ağrı yönetiminde ihtiyaç halinde opioid analjezikler kullanılmış ancak düzenli NSAİ enjeksiyonu uygulanmamıştır.Bulantı-kusma profilaksisi uygulanmamış, semptomatik tedavi sağlanmıştır.Komplikasyon gelişmeyen hastalar genellikle 2. veya 3. günde taburcu edilmiştir.**Multidisipliner Koordinasyon** ERAS protokolünün etkili uygulanabilmesi için cerrah, anestezi uzmanı, hemşire, diyetisyen ve fizyoterapistler iş birliği içinde çalışmıştır.Anestezi ekibi, düşük opioidli multimodal analjezi ve erken uyanmayı destekleyen bir plan oluşturmuştur.Cerrahi ekip, operasyon süresini en aza indirmek için minimal invaziv teknikleri optimize etmiştir.Hemşireler erken mobilizasyon ve beslenme süreçlerini yönlendirmek üzere eğitilmiştir.Diyetisyenler erken beslenme planlamasını yaparken, fizyoterapistler solunum egzersizleri ve mobilizasyon desteği sağlamıştır.Görüntüleme birimi ile iş birliği yapılarak elektif cerrahiye uygun hasta hazırlığı sağlanmıştır.

Veri ve Tanımlar: Hastaların demografik ve perioperatif verileri sistematik olarak kaydedilmiştir. Birincil sonuç ölçütü, ameliyat bitiminden taburculuğa kadar geçen hastanede kalış süresi olarak belirlenmiştir. İkincil ölçütler arasında postoperatif komplikasyon oranları, ağrı seviyeleri, opioid analjezik kullanımı ve hasta memnuniyeti bulunmaktadır. Komplikasyonlar Clavien-Dindo sınıflamasına göre derecelendirilmiştir. Ağrı yönetimi VAS skorları ile 6., 12. ve 24. saatlerde değerlendirilmiş, opioid tüketimi toplam morfin dozu olarak hesaplanmıştır. Hasta memnuniyeti, 1-5 ölçekli anket ile ölçülmüştür.

İstatistiksel Analiz: Veriler SPSS 25.0 ile analiz edilmiştir. Sürekli değişkenler ortalama ± standart sapma olarak sunulmuş, normallik dağılımı Shapiro-Wilk testi ile değerlendirilmiştir. Normal dağılım gösteren gruplar bağımsız t-testi, normal olmayanlar Mann-Whitney U testi ile

karşılaştırılmıştır. Kategorik veriler için Ki-kare veya Fisher'in kesin testi uygulanmıştır.

BULGULAR

ERAS ve kontrol grubu hastalar arasında yaş, cinsiyet, VKİ ve ASA skorları açısından anlamlı fark bulunmamıştır (p>0.05). ERAS grubunun yaş ortalaması 48.5 ± 12.3 yıl, kontrol grubunun 49.1 ± 11.8 yıl olup, hastaların %60'ı kadındır. VKİ ortalaması ERAS grubunda 28.4 ± 4.2 kg/m², kontrol grubunda 28.1 ± 4.5 kg/m² olarak bulunmuştur.İntraoperatif dren kullanımı ERAS grubunda %5, kontrol grubunda %20 olup (p=0.01), kanama miktarı ve konversiyon oranları benzer bulunmuştur (Tablo 1).

ERAS grubunda ortalama 30.2 ± 9.9 saat (1.3 gün), kontrol grubunda 42.5 ± 11.6 saat (1.8 gün) olarak ölçülmüştür (p<0.001). 24 saat içinde taburculuk oranı ERAS grubunda daha yüksektir.**Gastrointestinal İyileşme:** İlk gaz çıkarma süresi ERAS grubunda 18 ± 6 saat, kontrol grubunda 24 ± 8 saat (p=0.01), ilk dışkılama süresi ise ERAS grubunda 1.1 ± 0.3 gün, kontrol grubunda 1.6 ± 0.5 gün olarak belirlenmiştir (p<0.05).**Ağrı ve Analjezi İhtiyacı:** ERAS grubunda VAS ağrı skoru 6. saatte 3.2 ± 1.1, kontrol grubunda 5.0 ± 1.3 (p<0.01); 24. saat VAS skoru ise ERAS grubunda 2.5 ± 1.0, kontrol grubunda 4.0 ± 1.2 (p<0.001) olarak ölçülmüştür. Opioid tüketimi ERAS grubunda 12.6 ± 4.2 mg, kontrol grubunda 18.9 ± 7.1 mg bulunmuştur (p=0.005).**Postoperatif Komplikasyonlar:** Minör komplikasyon oranları ERAS grubunda %10, kontrol grubunda %18 olarak belirlenmiştir (p=0.08). Postoperatif bulantı kusma ERAS grubunda %5, kontrol grubunda %15 olarak kaydedilmiştir (p=0.04). Majör komplikasyonlar açısından iki grup arasında anlamlı fark bulunmamıştır. ERAS grubunda hasta memnuniyet skoru 4.8 ± 0.4, kontrol grubunda ise 4.3 ± 0.6 olarak ölçülmüştür (p=0.02). ERAS protokolü uygulanan hastaların %95'i bakım sürecinden "çok memnun" olduğunu belirtmiştir. Bu bulgular, ERAS protokolünün laparoskopik kolesistektomi sonrası hastanede kalış süresini kısalttığını, ağrıyı ve opioid ihtiyacını azalttığını ve hasta memnuniyetini artırdığını göstermektedir (Tablo 2).

Tablo 1. Demografik ve Perioperatif Özellikler

Özellikler	ERAS Grubu (n=512)	Kontrol Grubu (n=512)	p-değeri
Yaş (yıl)	48.5 ± 12.3	49.1 ± 11.8	0.78
Kadın/Erkek (n)	308/204	315/197	0.65
VKİ (kg/m²)	28.4 ± 4.2	28.1 ± 4.5	0.70
ASA I/II/III (%)	35/50/15	32/52/16	0.50
Komorbidite (%)*	%25	%30	0.40
Ameliyat Süresi (dk)	45 ± 15	47 ± 14	0.60
Dren Kullanımı (n,%)	25,%5	102,%20	0.01

Tablo 2. **.** Laparoskopik kolesistektomide ERAS ve geleneksel bakım gruplarının sonuçlarını karşılaştırılması

Sonuç Ölçütü			ERAS Grubu	Kontrol Grubu	p-değeri
Hastanede Kalış (saat)			30.2 ± 9.9	42.5 ± 11.6	<0.001
İlk Gaz Çıkarma (saat)			18 ± 6	24 ± 8	0.01
6.Saat VAS Skoru	3.2± 1.1	5.0± 1.3			
24. Saat VAS Skoru			2.5 ± 1.0	4.0 ± 1.2	<0.001
Opioid Tüketimi (mg)			12.6 ± 4.2	18.9 ± 7.1	0.005
Bulantı Kusma (%)			%5	%15	0.04
Komplikasyon Oranı (%)			%10	%18	0.08
Hasta Memnuniyeti (1-5)			4.8 ± 0.4	4.3 ± 0.6	0.02

ERAS grubunda hastanede kalış süresi 2.0 gün, kontrol grubunda 3.1 gün olarak ölçülmüştür (p<0.05). Minör komplikasyon oranları ERAS grubunda %12, kontrol grubunda %20 olarak

belirlenmiştir. ERAS grubunda 6. ve 24. saat ağrı skorları, kontrol grubuna kıyasla anlamlı derecede düşük bulunmuştur ($p<0.01$). Bu bulgular, ERAS protokolünün laparoskopik kolesistektomi sonrası hastanede kalış süresini kısalttığını, ağrıyı ve opioid ihtiyacını azalttığını ve hasta memnuniyetini artırdığını göstermektedir.

TARTIŞMA

Bu retrospektif kohort çalışması, laparoskopik kolesistektomiye ERAS protokolünün entegrasyonunun postoperatif sonuçlarda belirgin iyileşmelere yol açtığını göstermektedir. ERAS grubundaki hastalar, geleneksel gruba kıyasla daha kısa hastanede kalış süresi, daha düşük postoperatif ağrı skorları, azalmış opioid tüketimi ve bağırsak fonksiyonlarına daha hızlı dönüş sergilemiştir. Ayrıca, ERAS uygulaması minör komplikasyon oranlarını azaltırken, majör komplikasyonlarda veya yeniden hastaneye yatış oranlarında anlamlı bir değişikliğe yol açmamıştır. Hasta memnuniyet skorları da ERAS grubunda belirgin olarak daha yüksek bulunmuştur. Bu sonuçlar, minimal invaziv teknikler ile kanıta dayalı perioperatif bakımın entegrasyonunun cerrahi sonuçları iyileştirdiğini göstermektedir. Önceki çalışmalar da ERAS protokolünün laparoskopik kolesistektomide olumlu etkilerini desteklemektedir. Kumar ve arkadaşlarının (12) çalışmasında, ERAS grubunda hastanede kalış süresinin daha kısa, minör komplikasyonların daha düşük ve postoperatif ağrının daha az olduğu gösterilmiştir. Benzer şekilde, Zhang ve arkadaşları (13), ERAS protokolünün inflamatuar stres yanıtını azalttığını ve postoperatif süreçleri hızlandırdığını bildirmiştir. Rajareddy(14) ve Kamel'in (15) çalışmaları da ERAS protokolünün güvenli olduğunu ve iyileşme sürecini hızlandırdığını doğrulamaktadır. Çalışmamız, epidural analjezi yerine trokar yerlerine lokal anestezik enjeksiyonu gibi değişimlerle ERAS protokolünün esnekliğini vurgulamaktadır. ERAS protokolü, ameliyat sonrası bakım süreçlerini standart hale getirerek hasta yönetiminde öngörülebilirliği artırır ve bakım kalitesindeki değişkenliği azaltır.Sonuç olarak, bu çalışma ERAS protokolünün laparoskopik kolesistektomi sonrası hasta bakımına sağladığı önemli faydaları ortaya koymaktadır.

SONUÇ

Elektif laparoskopik kolesistektomi uygulanan hastalarda ERAS protokollerinin uygulanması, ameliyat sonrası iyileşme sürecini belirgin şekilde hızlandırmaktadır. Çalışmamızda ERAS grubunda; hastanede kalış süresi kısalmış, ameliyat sonrası ağrı azalmış, opioid ihtiyacı azallmış ve minör komplikasyonların sayısını azaltarak sorunsuz bir iyileşme sağlanmıştır. Bu bulgular, sadece cerrahinin teknik başarısına bağlı olmayıp, aynı zamanda perioperatif dönemde sunulan multidisipliner çözümlere bağlı olduğunu ortaya koyuyor.ERAS protokolünün uygulanmasında , cerrah, anestezi uzmanı, hemşirelik ekibi, fizik tedavi hizmetleri gibi farklı braşların uyum içinde çalışmaları önemlidir. Bu uyum sayesinde, ERAS protokolünün her aşaması,hastaların iyileşmesine katkı sunar ve sonunda bütüncül bir iyileşme sağlar. Geleneksel yöntemlerin aksine, ERAS protokolü hastayı; pasif bir nesne olarak görmek yerine, iyileşme sürecinin aktif bir öznesi haline getirir. Laparoskopik kolesistektomi gibi sık yapılan, güvenli bir cerrahide dahi ERAS protokollerinin başarılı olduğu görülmüştür.Sonuç olarak, elde ettiğimiz veriler, laparoskopik kolesistektomi geçiren hastaların ameliyat sonrası bakımında ERAS protokolünün etkisini güçlü biçimde destekliyor. ERAS, sadece büyük ameliyatlar için değil, tüm cerrahi girişimler için hedeflenen “hızlı ve güvenli iyileşme” amacına ulaşmada etkili bir araçtır. Bu protokollerin yaygınlaştırılması, hasta bakımına önemli katkılar sağlayacağını düşünüyoruz. Multidisipliner ekip koordinasyonunun üst düzeyde olduğu ERAS protokolerinin, bakımın standart bir parçası haline gelmesi, geleceğin cerrahi pratiğinde kritik bir rol oynayacaktır.

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QUORUM SENSING INHIBITION AND ANTIBIOFILM ACTIVITY OF LACTIC ACID BACTERIA SUPERNATANTS IN *SALMONELLA* TYPHIMURIUM 14028

LAKTİK ASİT BAKTERİLERİ SÜPERNATANTLARININ *SALMONELLA TYPHİMURİUM* 14028 SUŞUNDA QUORUM SENSİNG İNHİBİSYONU VE ANTİBİYOFİLM AKTİVİTESİ

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ÖZET

Giriş ve Amaç: Bakteriler başta olmak üzere birçok mikroorganizma, quorum sensing (QS) adı verilen sinyal iletişimi ile kendi davranışlarını düzenlemekte, çevredeki diğer mikroorganizmalarla bir haberleşme ağı oluşturmaktadır. Bu mekanizmayı kullanan mikroorganizmalardan biri de *Salmonella* Typhimurium'dur. İnatçı enfeksiyonlarıyla bilinen *Salmonella*'nın biyofilm yapılarıyla mücadele amacıyla farklı yöntemler geliştirilmiş olsa da biyolojik bazlı yaklaşımların çevre dostu ve güvenilir olmaları nedeniyle önemi büyüktür. Bu bağlamda tasarlanan çalışmada, laktik asit bakterilerinin *Salmonella* biyofilm yapılarıyla mücadelesi, QS yolağının inhibe edilmesi yoluyla araştırılmıştır.

Materyal ve Metot: Çalışma kapsamında öncelikle, QS mekanizmasında önemli bir gen olan *luxS*'in ifade ettiği AI-2 sinyal yolağının laktik asit bakterileri tarafından inhibisyonu incelenmiştir. Farklı gıda ürünlerinden izole edilen laktik asit bakterilerinin kültür süpernatantları, santrifüj işlemiyle elde edilmiş ve filtrasyon yöntemiyle hücrelerden arındırılmıştır. *Salmonella* Typhimurium 14028 suşu ve bu suşun *luxS* geni bakımından mutantının süpernatantları da aynı yöntemle hazırlanmıştır. Kontrol suş olarak *Vibriyo harveyi* BB170 kullanılmıştır. Biyolüminisens analizleri 495 nm'de lüminometre cihazı kullanılarak gerçekleştirilmiştir. Ayrıca laktik asit bakterilerinin *Salmonella* suşları üzerindeki antibiyofilm etkisinin değerlendirilmesi amacıyla, kristal viyole boyama yöntemi uygulanmış ve 595 nm'de ELİSA cihazında ölçümler yapılmıştır.

Sonuçlar: Laktik asit bakterileri kültür süpernatantlarının tamamının, *Salmonella* Typhimurium 14028 doğal suşu ve mutantının QS mekanizması üzerinde baskılayıcı bir etkisinin olduğu belirlenmiştir. *Salmonella* suşlarının AI-2 sinyal üretiminde anlamlı düzeyde azalma tespit edilmiştir. Biyofilm aktivitesi değerlendirildiğinde ise tüm kültür süpernatantlarının antibiyofilm etki gösterdiği ve *Salmonella* suşlarının biyofilm oluşumunu azalttığı gözlemlenmiştir.

Tartışma ve Sonuç: Bu çalışma ile laktik asit bakterilerinin metabolitlerinin, *Salmonella'*nın QS mekanizmasında etki göstererek bakterinin hücresel iletişim yolaklarını bozabileceği belirlenmiştir. QS mekanizmasının inhibisyonu, *Salmonella*'nın biyofilm oluşturma kapasitesini azaltması açısından önemli bir strateji olarak öne çıkmaktadır. Sonuç olarak laktik asit bakterilerinin *Salmonella* kaynaklı enfeksiyonlarla mücadeleye yönelik etkili alternatifler sunabileceği düşünülmektedir. Laktik asit bakterilerinin bu patojen üzerinde hem anti-QS hem

de antibiyofilm aktivite göstermesi, gıda güvenliği ve enfeksiyonla mücadele bakımından umut verici bir yaklaşım olarak literatürdeki yerini alacaktır.

Anahtar Kelimeler: *Salmonella*, quorum sensing, *luxS*, antibiyofilm, kültür süpernatantı

ABSTRACT

Introduction and Purpose: Many microorganisms, most notably bacteria, modulate their conduct through signal communication known as quorum sensing (QS), and establish a communication network with other microorganisms in the environment. *Salmonella* Typhimurium is one of the microorganisms utilizing this mechanism. Despite the development of diverse methodologies to combat the biofilm structures of *Salmonella*, which are recognized for their persistent infections, biological-based approaches are of considerable significance due to their environmental sustainability and reliability. In the present study, the antibacterial activity of lactic acid bacteria against *Salmonella* biofilm structures was investigated by targeting the QS pathway.

Materials and Methods: In this study, the inhibition of the AI-2 signaling pathway expressed by *luxS*, an important gene in the QS mechanism, by lactic acid bacteria was investigated. Culture supernatants of lactic acid bacteria isolated from different food products were obtained by centrifugation and purified from cells by filtration. Supernatants of the *Salmonella* Typhimurium 14028 strain and its mutant in terms of *luxS* gene were prepared by the same method. *Vibriyo harveyi* BB170 was used as a control strain. Bioluminescence analyses were performed using a luminometer at 495 nm. In addition, to evaluate the antibiofilm effect of lactic acid bacteria on *Salmonella* strains, the crystal violet staining method was applied and measurements were made at 595 nm using ELISA device.

Results: The results of the study indicated that all lactic acid bacteria culture supernatants exhibited a suppressive effect on the QS mechanism of the *Salmonella* Typhimurium 14028 natural strain and mutant. A significant decrease in AI-2 signal production of *Salmonella* strains was detected, suggesting that lactic acid bacteria may have the potential to interfere with the QS mechanism of *Salmonella*. When biofilm activity was evaluated, it was observed that all culture supernatants showed antibiofilm effect and reduced biofilm formation of *Salmonella* strains, indicating a possible strategy for combating *Salmonella* infections through the use of lactic acid bacteria.

Discussion and Conclusion: The present study determined that metabolites of lactic acid bacteria can disrupt the cellular communication pathways of *Salmonella* by acting on the QS mechanism of *Salmonella*. Inhibition of the QS mechanism is an important strategy to reduce the biofilm formation capacity of *Salmonella*. In conclusion, it is hypothesized that lactic acid bacteria may offer effective alternatives for the fight against *Salmonella*-induced infections.

Key Words: *Salmonella*, quorum sensing, *luxS*, antibiofilm, culture süpernatant

GİRİŞ

Salmonella Typhimurium, quorum sensing mekanizmasında üç farklı sinyal yolağı kullanır. Bunlardan ilki N-Asetil homoserine laktonların (AHL) kullanıldığı AI-1 olarak adlandırılan sinyal moleküllerinin mevcut olduğu yoldur (Huang vd. 2016). AHL bileşikleri, S-adenosil-L-metiyonin (SAM) aracılığıyla sentezlenen ve 4 ila 14 karbon atomu içeren yapılar olarak tanımlanmaktadır. İlk olarak *Vibrio fischeri*'de tanımlanan bu sistemde, sinyal düzenleyici proteinler LuxI/LuxR olarak bilinmektedir. AHL moleküllerinin sentez işleminden LuxI, moleküllerin reseptörlerce tanınıp hücre içerisine alınmasından ise LuxR proteini sorumludur. Ancak *Salmonella*'da LuxI bulunmaz. Bu nedenle de bakteri, AHL sentezi yapamaz. Ancak LuxR ile homoloji gösteren ve SdiA adlı bir protein sayesinden dış ortamda bulunan AHLleri

algılayabilir ve kendi genetik yapısını buna göre düzenleyebilmektedir (Ahmer 2004, Shrout ve Neresberg 2012).

QS mekanizmasının ikinci yolunda furonasil borat diesterler tarafından türetilen AI-2 sinyal molekülleri bulunmaktadır. Bu moleküller, *luxS* geni tarafından kodlanan LuxS enzimlerince s-ribozil-homosistein adlı bir bileşikten sentezlenir. Reaksiyon neticesinde DPD olarak bilinen 4,5-dihidroksi-2,3-pentadion oluşur. DPD, stabil bir bileşik olmadığından su ile reaksiyona girer ve AI-2 molekülleri meydana gelir. Patojen, exponensiyel fazda iken AI-2 bileşiklerini üretir ve hücre içi ve dışı taşıma için lsrB proteinlerini kullanır. Dış ortamdan hücre içerisine alınan AI-2 sayesinde çeşitli virülens genler aktive edilir. Bu aktivasyon neticesinde daha fazla AI-2 üretilerek dışarı salınır. Bu sayede bakteri hem kendi hem de diğer organizmaların genlerinin regülasyonunda etki gösterir (Schauder vd. 2001). *Salmonella* patojenitesinde görev alan genlerin çoğu *Salmonella* Patojenite Adalarında organize olmuştur. Yapılan çeşitli çalışmalarda *luxS* geni aktivitesinin bu adalardaki çeşitli genlerin aktivitesini etkilediği belirlenmiştir (Xue vd. 2009, Jesudhasan vd. 2010, Habyarimana vd 2014).

Salmonella patojenitesinde aktif olan üçüncü QS yolağında pirazinon metabolitlerinden türetilen AI-3 sinyal molekülleri kullanılmaktadır. Bu sistemde QseC ve QseB adlı iki düzenleyici proteinin görev aldığı bilinmektedir. Bu sistemin *Salmonella*'nın konakçı savunmasından kaçışta görev aldığı düşünülmektedir (Zhou vd. 2020).

Laktik asit bakterileri fermente gıdaların oluşmasında görevli mikroorganizmalardır. Bulundukları ortamlardaki karbonhidratları sindirerek yaşamsal faaliyetlerini gerçekleştirmektedirler. Karbonhidratları fermente etmelerinin neticesinde ortamda bir takım organik asitlerin oluşmasına neden olurlar. Bu durum ortamın pH'ını düşürmektedir. Patojen mikroorganizmaların çoğu nötral pH şartlarında gelişebildiklerinden bu durumdan olumsuz etkilenmektedirler. Ayrıca laktik asit bakterileri metabolik faaliyetleri sonucunda hidrojen peroksit, karbondioksit gibi çeşitli gazlar da açığa çıkarmaktadırlar. Bu durum da çoğu patojenin gelişimini sınırlandırmaktadır. Ancak en önemli metabolik ürün bakteriyosin bileşikleridir. Laktik asit bakterileri; nisin, laktolisin gibi farklı moleküler yapılarda bakteriyosinler üretirler. Bu bakteriyosinler patojen mikroorganizmalar üzerinde inhibisyon etkisi oluşturmakta ve patojenlerin gelişimini durdurabilmektedir (Jati vd. 2012, Özoğlu vd. 2022, Korcan vd. 2023).

Literatür verileri ışığında tasarladığımız çalışmamızda farklı kaynaklardan (süt, peynir, bitkisel) izole edilmiş laktik asit bakterileri kullanılarak *Salmonella* Typhimurium 14028 suşunun QS yolağı inhibe edilmeye çalışılmıştır. Bu durumun doğal yoldan biyofilm oluşumunu da baskılaması hedegflenmiş ve bu sayede patojenle mücadelede güvenilir, alternatif stratejilerin geliştirilmesi hedeflenmiştir.

MATERYAL VE METOT

S. Typhimurium'da AI-2 aktivitesinin tespiti

S. Typhimurium'da AI-2 aktivitesini tespit etmek amacıyla kültür süpernatantları çalışılmıştır. Deney kapsamında hem doğal suş hem de mutant suşlar LB besi yeri içeren kültür ortamına eklenmiş ve mutant suşlar kloramfenikol içeren LB besiyeri kullanılarak 37°C'de 18 saat inkübe edilmiştir. İnkübasyon akabinde tüm şuşlar 4427 g'de 10 dk santrifüj edilmiş ardından hücrelerden arındırmak amacıyla 0.22 μm por çapına sahip mikrobiyal filtreden geçirilmiştir. Suşların AI-2 aktivitesi tespit edilirken *Vibrio harveyi* BB170 kontrol organizma olarak kullanılmıştır. Bu suşun kendisi AI-2 üretiminden yoksundur, ancak ortamda AI-2 sinyal molekülü bulunduğunda lüminens bir ışıma yayar. Bu özellikleri nedeniyle kontrol olarak değerlendirilen *V. harveyi* suşu, gelişimi için özel bir besiyeri olan otoindüktör biyoanaliz ortamında (AB broth) 30°C'de 175 rpm'de 18 saat boyunca inkübe edilmiştir. İnkübasyondan sonra yine AB besi yeri kullanılarak 1:5000 oranında seyreltilmiş ve 96 kuyulu lüminesan

mikro plakalara (Nunc™F96 MicroWell™ # 236108. Nunc, Danimarka) 90 µL hacimde dağıtılmıştır.

Salmonella suşlarının AI-2 üretimlerini kıyaslamak amacıyla, *V. harveyi* bulunan kuyulara, 10 µL *Salmonella* süpernatantı eklenmiş ve 4 saat 30°C'de 200 rpm'de inkübasyona bırakılarak her saat başı 495 nm'de lüminometrik ölçümler alınmıştır (Perkin-Elmer Victor V3). Sadece *V. harveyi* içeren kuyular pozitif kontrol olarak, AB besiyeri içeren kuyucuklar negatif kontrol olarak kullanılmıştır (Sivakumar vd. 2011).

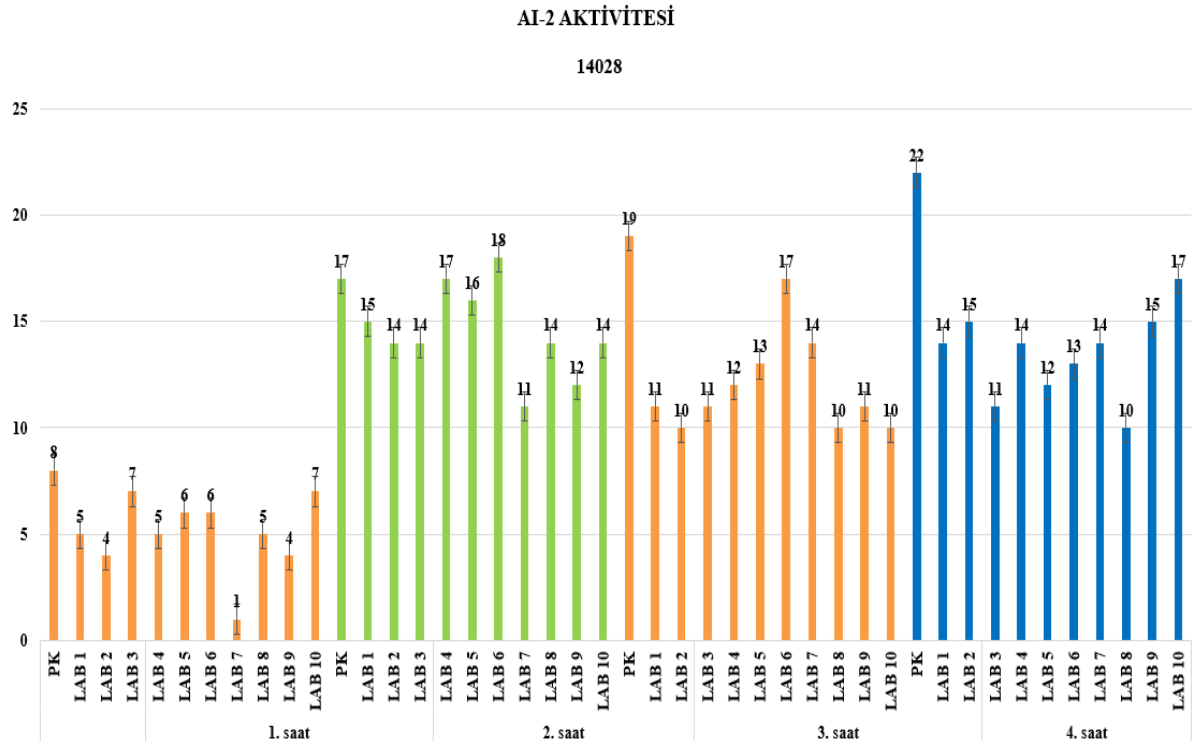
Çalışmanın ikinci aşamasında, *Salmonella* suşlarının AI-2 üretimleri üzerinde laktik asit bakterilerinin kültür süpernatantlarının (LAB-CFCS) etkisi değerlendirilmiştir. Bu amaçla *V. harveyi* BB170 kültürleri 1:5000 oranında seyreltilerek 96 kuyucuklu lüminesan mikro plakalara dağıtılmıştır. Her bir kuyucuğa 5 µL *Salmonella* süpernatantı ve 5 µL LAB-CFCS eklenmiştir. İnkübasyon amacıyla plakalar 4 saat 30°C'de 200 rpm çalkalamalı koşullarda tutulmuştur. Her saat başı ölçümler alınarak analizler yapılmıştır. 5 µL *Salmonella* süpernatantı ve 5 µL AB ortamının bir karışımı pozitif kontrol, sadece 10 µL AB ortamı ise negatif kontrol olarak kullanılmıştır (Widmer vd. 2007).

Laktik asit bakterilerinin antibiyofilm aktivitesi

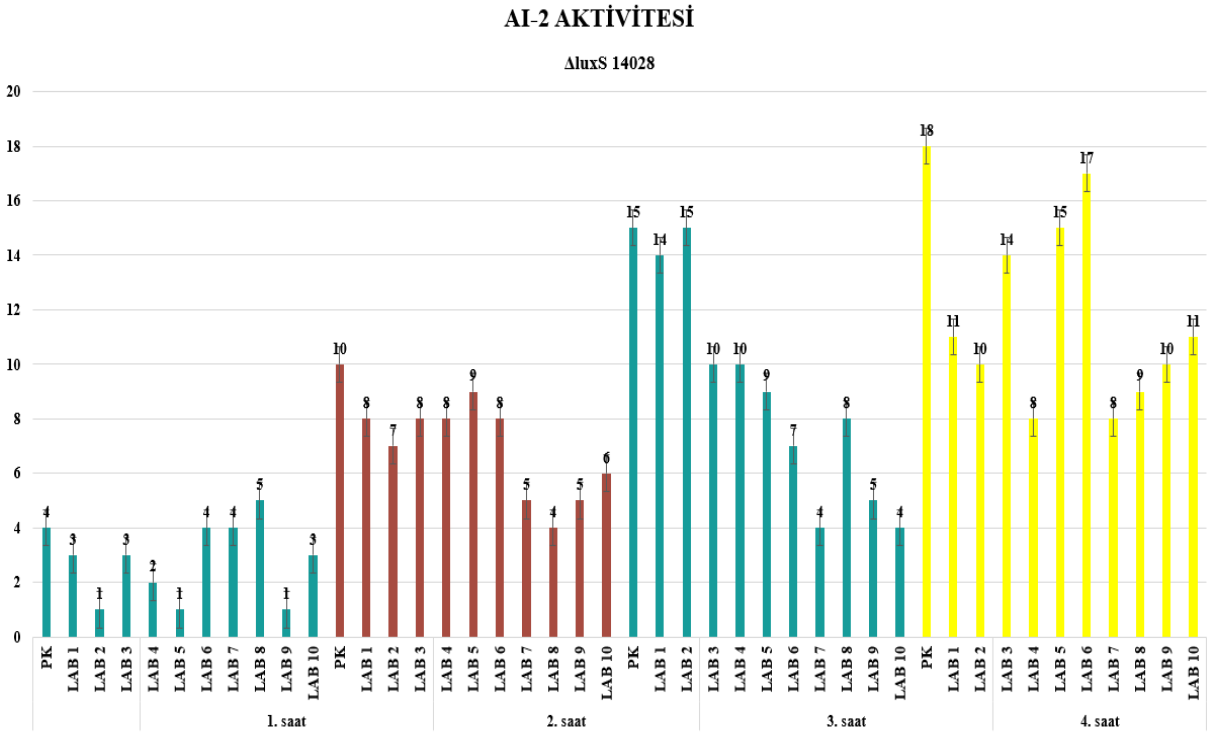
Laktik asit bakterilerinin kültür süpernatantları 4427 g'de 10 dk santrifüj işleminin sonunda elde edilmiştir. Süpernatantlar mikrobiyal filtrelerden geçirildikten sonra nötralleştirmek amacıyla 2 M NaOH ile muamele edilmiştir. *Salmonella* suşları LB (mutantlar için kloramfenikol içeren LB) besiyerinde 37°C'de 18 saat geliştirilmiş ve 96 kuyulu well platelere dağıtılmıştır. Kuyulara aynı oranda laktik asit bakterilerinin kültür süpernatantları eklenmiştir. Laktik asit bakterilerinin kültür süpernatantlarının ilave edilmediği kuyular pozitif kontrol olarak değerlendirilmiştir. Plateler 3 gün boyunca 20°C'de inkübe edilmiştir. İnkübasyondan sonra kuyular distile su ile yıkanmış % 95'lik metanol ile fikse edilmiş ve kristal viyole ile boyanmıştır. Boya çözücü olarak asetik asit kullanılmış ve sonuçlar OD595 nm'de okunarak biyofilm oluşumları ve inhibisyonları tespit edilmiştir.

SONUÇ VE TARTIŞMA

Laktik asit bakterileri kültür süpernatantlarının tamamının, Salmonella Typhimurium 14028 doğal suşu ve mutantının QS mekanizması üzerinde baskılayıcı bir etkisinin olduğu belirlenmiştir. Salmonella suşlarının hem doğal hem de mutantlarında AI-2 sinyal üretiminde anlamlı düzeyde azalma tespit edilmiştir. (Şekil 1 ve 2).

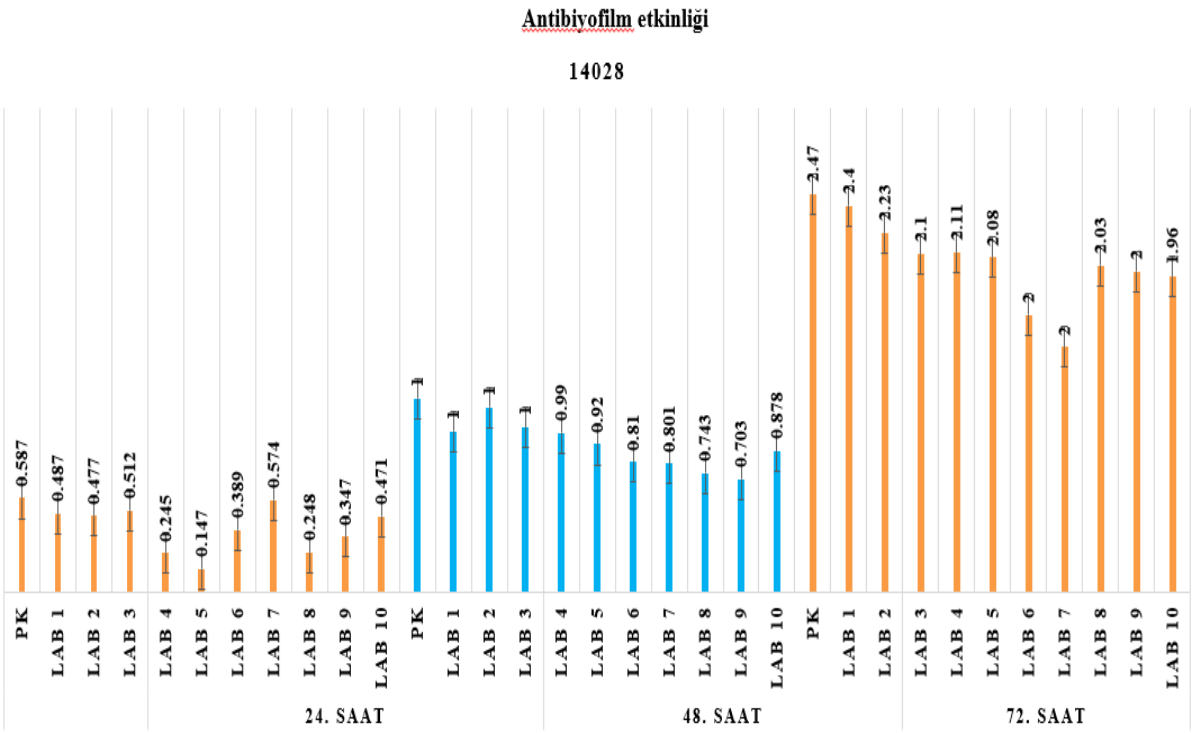


Şekil 1. 14028 doğal suşuna ait AI-2 aktivitesi (OD_{495})

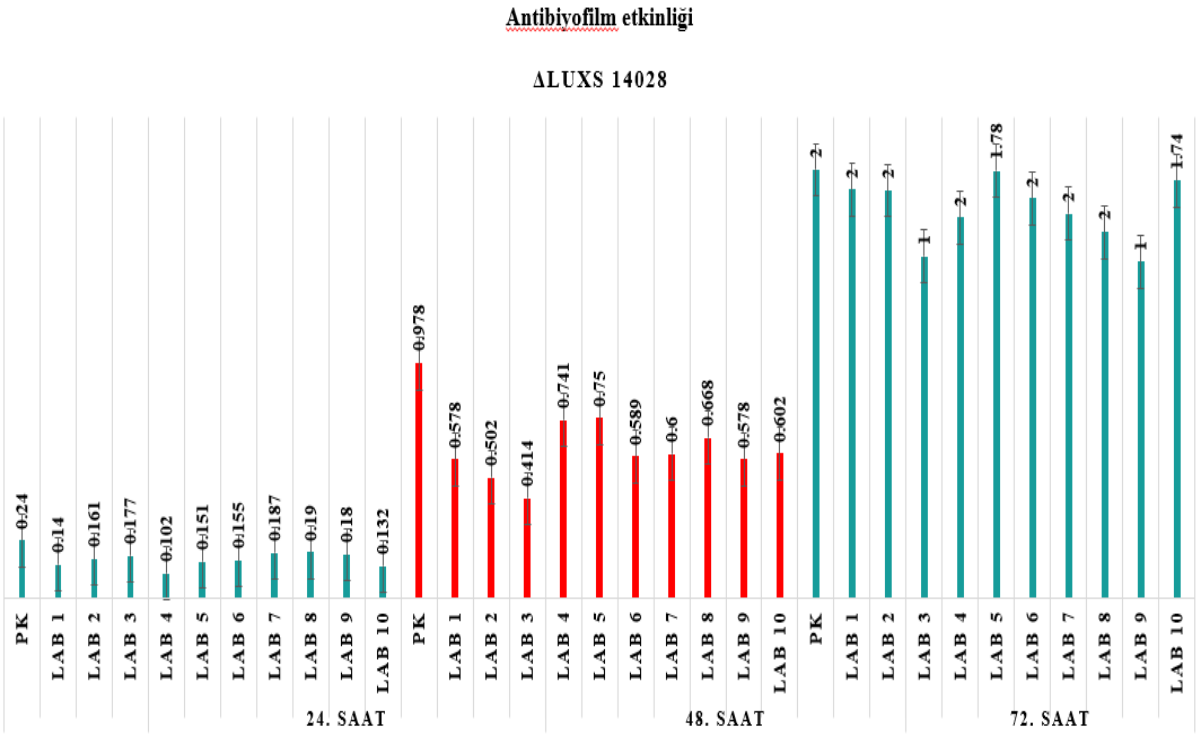


Şekil 2. 14028 mutant suşuna ait AI-2 aktivitesi (OD_{495})

Biyofilm aktivitesi değerlendirildiğinde ise tüm kültür süpernatantlarının antibiyofilm etki gösterdiği ve *Salmonella* suşlarının biyofilm oluşumunu azalttığı gözlemlenmiştir (Şekil 3 ve 4).



Şekil 3. 14028 doğal suşunun biyofilm inhibisyonu



Şekil 4. 14028 mutant suşunun biyofilm inhibisyonu

Literatürdeki veriler incelendiğinde laktik asit bakterilerinin antimikrobiyal, antibakteriyal, antibiyofilm etkinlikleri ile alakalı birkaç çalışmaya rastlanmaktadır (Etöz 2006, Pfeiler ve Klaenhammer 2007, Holzapfel vd. 2007). Bizim çalışmamızda kullanılan Türk kökenli LAB suşlarının ise bugüne kadar yapılan çalışmalardan daha yüksek antibiyofilm aktivitelerine sahip olması, biyofilm yapılarının oluşumunun engellenmesi ve olgun biyofilmlerin eradike edilmesinde ciddi uygulama potansiyeline sahip olduklarını göstermektedir. Araştırmamızın diğer aşamasında, *Salmonella* suşlarının LAB-CFCS varlığındaki AI-2 aktiviteleri incelenmiştir. *luxS* genindeki her iki mutant suşta da doğal tip suşlara kıyasla daha düşük AI-

2 aktivitesi tespit edilmiştir. *luxS* genindeki mutasyon, AI-2'nin hücre dışı salınımını ve hücre dışı algılanmasını önemli ölçüde azaltmıştır. Bu durum biyofilm aktivitesindeki azalmaya paraleldir.

Çalışmamızın neticesinde elde edilen bulgular, literatürdeki verilerle paralellik göstermekte olduğundan laktik asit bakterilerinin *Salmonella* patojenitesine karşı kullanılabilecek alternatif bir kaynak olduğu doğrulanmaktadır.

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DIGITAL TRANSFORMATION AND SUSTAINABILITY IN PARTICIPATION BANKING: A COMPREHENSIVE COMPARATIVE ANALYSIS FOR THE PERIOD 2015-2024

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ABSTRACT

Introduction and Purpose: In recent years, the banking sector has been undergoing a rapid transformation driven by digitalization and sustainable finance practices. While digitalization enables financial services to reach a broader audience, sustainable finance has shaped banks' investment strategies within the framework of climate change and social responsibility.

In this context, examining the differences between participation banks and conventional banks in terms of digitalization and sustainable finance investments is of significant importance. This study aims to analyze the impact of digitalization and sustainable finance investments on growth in participation and conventional banks based on publicly available data from 2015 to 2024.

Materials and Methods: The study utilizes data from institutions such as the Banking Regulation and Supervision Agency (BRSA), the Participation Banks Association of Türkiye (TKBB), the Central Bank of the Republic of Türkiye (CBRT), and the World Bank for the period 2015-2024. The key variables examined include bank asset size, the number of digital customers, digital transaction volume, green sukuk investments, and renewable energy financing.

The statistical analyses employed in the study include:

- Correlation analysis: Used to determine the linear relationships between variables.
- Regression analysis: Applied to measure the impact of digitalization and sustainable finance investments on bank growth.
- Independent sample t-test: Conducted to test whether the differences between participation and conventional banks are statistically significant.

Results: According to the analysis results:

- The number of digital customers and the volume of digital transactions are the most influential factors affecting bank growth.
- Conventional banks have demonstrated faster growth in digitalization, with significant increases in digital transaction volume and customer numbers.
- Sustainable finance investments have positively influenced the growth of participation banks; however, their impact has remained more limited compared to conventional banks.
- The digitalization processes of participation banks have progressed more slowly than those of conventional banks, resulting in a lower market share.

Discussion and Conclusion: The findings indicate that participation banks need to enhance their digitalization investments by focusing more on mobile banking and fintech collaborations. Increasing digital transaction volume and customer accessibility is crucial for maintaining a competitive advantage.

Furthermore, promoting sustainable finance investments, particularly through the issuance of green sukuk and the financing of renewable energy projects, can strengthen the growth dynamics of participation banks.

In conclusion, participation banks must take strategic steps in both digitalization and sustainable finance. To compete with conventional banks, innovative financial solutions and new investment instruments must be developed.

Key Words: Participation Banking; Conventional Banking; Digital Transformation; Sustainable Finance; Fintech; Blockchain; Green Sukuk

MINERAL, Sr-Nd-O ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY OF THE LAMPROPHYRES IN THE SAMSUN, CENTRAL PONTIDES (TÜRKİYE)

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ABSTRACT

The Pontides extend from the northwest to the northeast of Türkiye along the İzmir–Ankara–Erzincan Suture Zone (IAESZ). They are divided into three main parts: western, central, and eastern Pontides according to the differences in basement units. Pontides are formed due to the closure of the Neo-Tethyan Ocean, have experienced intense magmatic activity, and play an important role in the geological formation of Anatolia. Magmatic units in Pontides show different geochemical characteristics ranging from calc-alkaline to alkaline in nature. Alkaline products representing the last stage of magmatism in the study area are observed locally in the Kadıköy, Yeniköy, and Kulacadağ locations of Samsun. Lamprophyres have an alkaline character and are observed as sills and dykes cutting through sedimentary units such as marn-claystone (flysch), limestone, and clayey limestone. The contact between lamprophyre and clayey limestone is sharp, and mineral formations indicating contact metamorphism have not been clearly observed. Lamprophyre sills's thickness varies from 4 to 7 m. This study aims to explain the petrogenesis and origin of magmatic rocks that we identified as having a lamprophyre composition for the first time. Despite the genesis of felsic and mafic products being well understood, there is a lack of petrogenetic explanation, especially for lamprophyres. In accordance with these purposes, we have carried out detailed petrographic, mineral, whole rock, and Sr-Nd-O isotope geochemistry and geochronological ($^{40}Ar/^{39}Ar$) studies of the rocks

in the Samsun to unravel the magmatic history of the Central Pontides and thus constrain the tectonic history. Lamprophyres are dark green in color and have porphyritic texture in hand specimen. They have holocrystalline/hypocrystalline hipidiomorph/idiomorph porphyritic texture and are mainly composed of pyroxene (diopsite and hedenbergite), amphibole (actinolite), biotite (magnesium- and ferro-biotite), plagioclase (bytownite and anorthite), orthoclase, analcime, nosean, zeolite (thomsonite) and opaque minerals (magnetite and pyrite). Different types of xenolitic enclaves are observed within rocks. Based on their mineralogical and petrographical properties, these rocks have been identified classified as camptonite. The mineral chemistry of the plagioclase and orthoclase refer to 800°C and 600°C for their crystallization degrees. The biotite minerals are crystallized at 596-671°C, 2.12-3.09 kbar, and 8.2-12 km depth, whereas pyroxene minerals are crystallized at 997-1083°C, 6.9-9.2 kbar, and 27-38 depth. MORB normalized trace element variation diagrams suggest enrichment in LIL elements concerning HFS elements. Lamprophyres have low $^{87}Sr/^{86}Sr$ (0.70524–0.70682) and high $^{143}Nd/^{144}Nd$ (0.51264–0.51267), which may indicate ocean island basalt-like mantle sources. $\delta^{18}O$ values of pyroxene xenocrystals range from 6.5 to 11.0 ‰, indicating relatively deeper and higher temperature conditions. The results show that these rocks have experienced fractional crystallization coupled with crustal assimilation with an enriched mantle source (lithospheric mantle) enriched with slab-derived components (subduction fluids and subduction sediments). Samsun lamprophyres may have been generated from partial melting in the phlogopite-peridotitic mantle related to the extensional regime after the collision during the Eocene (37-45 Ma).

Keywords: Alkaline Lamprophyre, camptonite, Sr-Nd-O isotope geochemistry, Ar-Ar dating, Samsun, Pontides, Türkiye.

INTRODUCTION

The Pontides continue from the northwest to the northeast of Turkey along the İzmir–Ankara–Erzincan Suture Zone (İAEKZ) and are divided into three parts as the Western, Central and Eastern Pontides according to the differences in their basement units (Şengör and Yılmaz 1981, Okay and Şahintürk 1997; Yılmaz et al., 1997; Temizel, 2014). The Pontides played an important role in the formation of the region under the influence of intense magmatic activities due to the closure of the Neotethys Ocean. These magmatic activities exhibit characteristics ranging from calc-alkaline to alkaline. Alkaline products represent the last stage of magmatism and are observed locally in almost all tectonic units of Turkey, such as the Pontides, Anatolides, and Taurides. Some of the alkaline products may show ultrapotassic properties due to their excessive potassium richness. Ultrapotassic products may generally be in lamprophyre composition. Rocks with lamprophyre composition can generally be encountered as dykes and sills within the mentioned tectonic units. In the Pontides, these products crop out along the IAEKZ in Kalecik (Gülmez and Genç 2015, Gülmez et al. 2016), Sinop (Asan et al. 2014), Bolu (Ustaömer and Kipman 1998), Gümüşhane (Karslı et al. 2014) and Trabzon (Oğuz et al. 2017). Apart from these locations, lamprophyres, which constitute the subject of the study, have also been detected in the Samsun area (Deniz et al., 2017). In the region determined as the study area, lamprophyre dykes cut marl, limestone and clayey limestones. The contact of clayey limestones with lamprophyre is sharp, and hot contact minerals can be observed in some places. Unlike the other regions mentioned above, alkaline lamprophyres are observed only in the Central Pontides.

Lamprophyres can form in environments where rifting, subduction, or post-collision extensional tectonism occurs (McKenzie, 1989; Foley, 1992; Mitchell and Bergman, 1991; Rock, 1991). Since they can be found together with magmas of different characters in active arc environments where subduction occurs, it is curious what processes can form such rocks.

This study covers the rocks with lamprophyre composition cutting the Cankurtaran and Akveren formations located approximately 30 km southwest of Samsun province and the lithological units where these rocks intrude. Lamprophyres are formed at the latest mafic intrusives of central Pontides and do not directly relate to the area's main lithology. Their petrological implication is quite important in solving the magmatotectonic evolution of central Pontides. Furthermore, their geochemical signature may also explain the young mafic intrusions within the Pontides in the evolution of the Late Cenozoic magmatism of Turkey. This study aims to explain the petrogenesis and origin of magmatic rocks that we identified as having a lamprophyre composition for the first time. Despite the genesis of felsic and mafic products being well understood, there is a lack of petrogenetic explanation, especially for lamprophyres. In accordance with these purposes, we have carried out detailed petrographic, mineral, and Sr-Nd-O isotope geochemistry and geochronological ($^{40}Ar/^{39}Ar$) studies of the rocks in the Samsun to unravel the magmatic history of the Central Pontides and thus constrain the tectonic history.

MATERIAL AND METHODS

Point Electron microprobe (EPMA) analyses were performed on polished thin sections from the pyroxene, amphibole, biotite, plagioclase, analcime, zeolite, and opaque minerals using a JEOL JXA–8230 instrument, which is equipped with 5 wavelength dispersive spectrometers. Operating conditions were 20 kV accelerating voltage, 10 nA beam current, and a 1 μm spot size. Natural oxide and mineral reference materials were used for calibration and measurements. The matrix effects were corrected with the ZAF software provided by JEOL. Carbon coating was made using Quorum Q150T ES machine. Mole fractions, end–member components, pressure (P), temperature (T), depth (D), and oxygen fugacity values are calculated using the ExcelTM spreadsheet from EPMA data. EPMA analyses are performed at the Earth Sciences Application and Research Centre (YEBIM) of Ankara University.

Strontium, Neodymium, and Lead isotope geochemistry experiments were carried out at the METU Central Laboratory (R&D Training and Measurement Center, Radiogenic Isotope Laboratory) by applying the in-laboratory experiment instructions based on the methods detailed and conditions given in Köksal et al. (2017). Mineral (pyroxene) oxygen (O) isotope analyses of samples were performed at the GNS laboratory in New Zealand.

Geochronology (Ar–Ar) analyses were performed at the UVM Noble Gas Laboratory of the University of Vermont.

RESULTS AND CONCLUSIONS

Lamprophyres are dark green in color and have a porphyritic texture in hand specimens (Deniz et al., 2017). They have hypocrystalline/holocrystalline porphyritic textures and are mainly composed of pyroxene, amphibole, biotite, plagioclase, orthoclase, analcime, nosean, zeolite, and opaque minerals (Figure 1). The mineralogical and petrographical properties indicate that lamprophyres have been identified and classified as camptonite (Deniz et al., 2017). These lamprophyres consist of different types of xenolitic enclaves (Deniz et al., 2017).

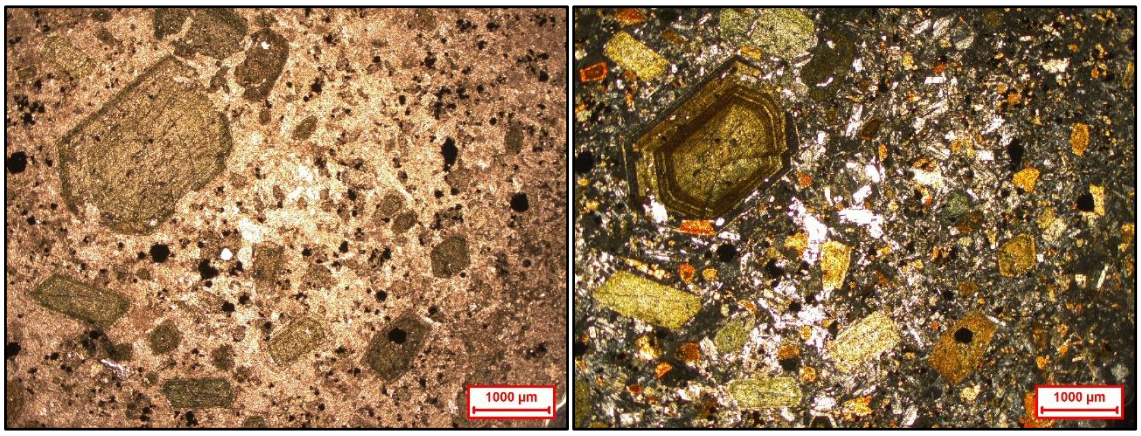

Figure 1. The microphotographs of the lamprophyre samples from Samsun

According to the mineral chemistry results, the pyroxene minerals are diopside and hedenbergite in composition. Due to the alteration, the amphibole minerals within these lamprophyres are actinolite in composition. The biotite minerals are primary and re-equilibrated primary biotites and magnesium— and ferro-biotite in composition. The mineral chemistry of these biotite minerals reveals the crust-derived and crust-mantle-derived mantle sources for these minerals. Plagioclase minerals bytownite and anorthite in composition. Primary and secondary zeolite minerals are both thomsonite in composition. The opaque minerals are generally magnetite and rarely pyrite in composition. The mineral chemistry of the plagioclase and orthoclase refer to 800°C and 600°C for their crystallization degrees. The biotite minerals are crystallized at 596-671°C, 2.12-3.09 kbar, and 8.2-12 km depth, whereas pyroxene minerals are crystallized at 997-1083°C, 6.9-9.2 kbar, and 27-38 depth.

The 87Sr/86Sr ratio of the lamprophyres are changing from 0.70524 to 0.70682 whereas the 143Nd/144Nd ratio are between 0.51264 to 0.51267. These isotope values suggest lithospheric mantle sources and ocean island basalt-like mantle sources. The δ18O values of pyroxene xenocrystals range from 6.5 to 11.0 ‰. Accordingly, it can be said that there are two different pyroxene minerals, one of which is formed in deeper mantle depths, and the other is formed in crustal depths where the crustal effect is present. This situation is supported by petrographically found pyroxenes in the form of mesocrystals and microcrystals.

Ar-Ar geochronological results obtained from whole-rock analyses, the plateau ages determined for the formation of lamprophyre rocks are between 37.6 ± 0.3 and 45.7 ± 1.3 Ma (Figure 2).

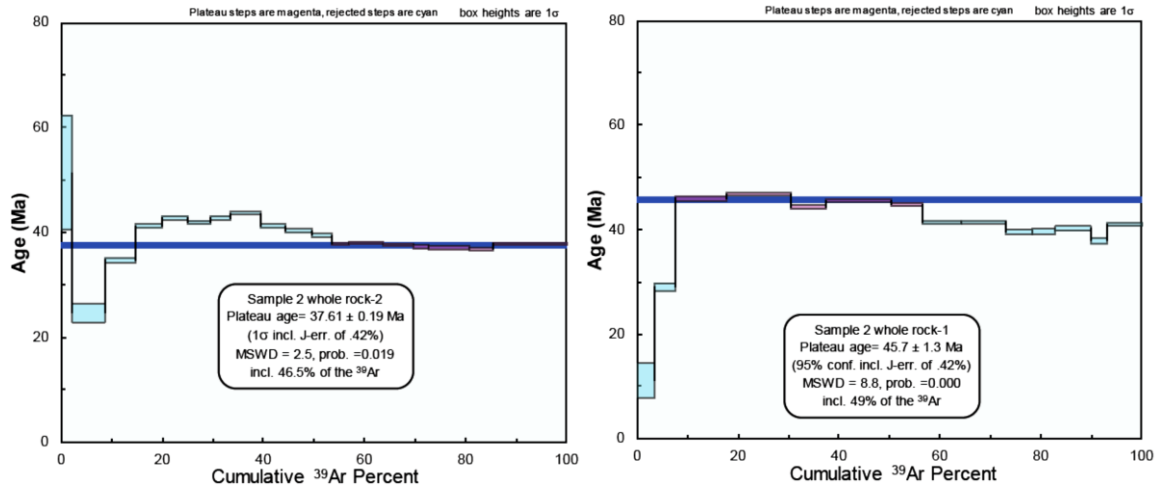

Figure 2. The Ar-Ar data of the lamprophyre samples from Samsun

The results show that these rocks have experienced fractional crystallization and crustal assimilation with an enriched mantle source (lithospheric mantle) enriched with slab-derived components (subduction fluids and subduction sediments). Samsun lamprophyres may have been generated from partial melting in the phlogopite-peridotitic mantle related to the extensional regime after the collision during the Eocene (37-45 Ma).

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A STUDY ON THE PROPAGATION OF SINGLE-BUD CUTTINGS OF SOME LOCAL GRAPE VARIETIES CULTIVATED UNDER ŞANLIURFA CONDITIONS

ŞANLIURFA KOŞULLARINDA YETİŞTİRİLEN BAZI YEREL ÜZÜM ÇEŞİTLERİNE AİT TEK GÖZLÜ DAL ÇELİKLERİNİN ÇOĞALTILMASI ÜZERİNE BİR ARAŞTIRMA

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ÖZET

Günümüzde asmaların çoğaltılması amacıyla birçok farklı yöntem kullanılmaktaysa da Türkiye'de üreticilerin bir bölümü halen odun çelikleriyle çoğaltım yapmaktadır. Ancak literatürde, yıllık dallardan alınan odun çeliklerinin üzerindeki gözlerin boğum düzeylerine göre çelik gelişiminin farklılaşabildiği bildirilmiştir. Bu araştırmada, yarı kurak iklim koşullarında yetiştirilen, kuraklığa toleransı nispeten iyi olan ve kendi kökleri üzerine yetiştirilen bazı yerel üzüm çeşitlerinin (Kabarcık, Çiloreş, Çilorut, Hönüsü ve Yediveren) yıllık dallarının farklı boğum (göz) düzeylerinden alınan ve tek göz içeren çeliklerinin köklendirilmesiyle elde edilmiş bitkilerde bazı büyüme ve gelişme parametrelerine ilişkin ölçümler yapılarak, bu çeşitlerin tek gözlü çeliklerle çoğaltılabilme performanslarını incelemek amaçlanmıştır. Çalışmada aynı zamanda yıllık daldan alınacak tek gözlü çeliklerin dalın hangi konumundan alınmasının bitki gelişimi açısından daha doğru olacağını belirlemek de hedeflenmiştir. Araştırma kapsamında tek gözlü çeliklerden elde edilmiş bitkilerin çelik randımanı, çelik yaş ağırlığı, sürgün yaş ağırlığı, sürgün uzunluğu, sürgün çapı, kök yaş ağırlığı, kök sayısı, kök uzunluğu, yaprak sayısı ve yaprak yaş ağırlığı özelliklerindeki değişimler incelenmiş ve çalışma kapsamında incelenen çeşitlerin tek gözlü çeliklere çoğaltılmaya elverişlilikleri değerlendirilmiştir. Bu anlamda Kabarcık çeşidine ait tek gözlü çeliklerinin vejetatif gelişimi, incelenen diğer çeşitlere göre daha iyi bulunmuş ancak Çiloreş çeşidi hem çelik randımanı hem de vejetatif gelişim özellikleri bakımından incelenen diğer çeşitlerden daha düşük performans sergilemiştir. Öte yandan çalışma kapsamında incelenen gelişim parametrelerinin üzüm çeşitlerine ve göz düzeylerine göre farklılık gösterebildiği saptanmıştır. Elde edilen bulgular ışığında çoğaltma için alınacak çeliklerin yıllık dalların 4.-8. göz düzeyleri de dahil olmak üzere bunlar arasında kalan diğer göz düzeylerinden en az birini içerecek şekilde alınmasının uygun olacağı kanısına varılmıştır.

Anahtar Kelimeler: Çelik randımanı, vejetatif gelişim, boğum düzeyi

ABSTRACT

Although many different methods are used to propagate grapevines today, some producers in Turkey still propagate using wood cuttings. However, the literature has reported that cutting development may differ depending on the node levels of the buds on wood cuttings taken from

annual offshoots. In this study, the propagation performance of some local grape varieties (Kabarcık, Çiloreş, Çilorut, Hönüsü, and Yediveren) grown in semi-arid climate conditions, with relatively good drought tolerance and grown on their own roots, was investigated by measuring some growth and development parameters in plants obtained by rooting single-bud cuttings taken from different node (bud) levels of annual offshoots. Additionally, it aimed to determine which position of the offshoot the single-bud cuttings should be taken from for optimal plant development. The research examined changes in the cutting propagation success ratio, cutting fresh weight, shoot fresh weight, shoot length, shoot diameter, root fresh weight, root number, root length, leaf number, and leaf fresh weight characteristics of plants obtained from single-bud cuttings. It also evaluated the suitability of the varieties examined for propagation from single-bud cuttings. In this sense, the vegetative development of single-bud cuttings of the Kabarcık variety was found to be better than the other grape varieties examined. However, the Çiloreş variety showed the lowest performance in terms of both cutting propagation success ratio and vegetative development characteristics. On the other hand, it was determined that the development parameters examined within the scope of the study may differ according to grape varieties and bud levels. In light of the findings, it has been concluded that it would be appropriate to take cuttings for propagation from the 4th to the 8th node levels of annual shoots, including at least one of the other bud levels in between.

Keywords: Cutting propagation success, vegetative development, node level

GİRİŞ

Asma; Dünya genelinde çeşitli iklim kuşaklarında yayılım gösteren, birbirinden farklı özelliklere sahip birçok türü bulunan, *Vitaceae* familyasına ait bitkilere verilen genel isimdir (Çelik ve ark., 1998). Bununla birlikte günümüzde 10-20 °C izotermleri arasında yetiştiriciliği sürdürülen kültür asmalarının kökeninin, Kuzeydoğu Anadolu'yu da içine alan Kafkasya coğrafyasına dayandığı bildirilmektedir (Ağaoğlu, 1999). Günümüzde kültürü yapılan asmalar arasında en geniş yayılım alanına sahip olan tür *Vitis vinifera* L.'dır. Bu türe ait üzüm çeşitlerinin meyveleri taze veya kuru üzüm olarak tüketilmekte, şarap üretiminde kullanılmakta ve şırası kullanılarak farklı gıda ürünlerinin eldesinde değerlendirilmektedir (Çelik, 2011; Gazioğlu Şensoy & Akcan, 2014). Dünya genelinde 7 milyon hektarı aşkın bir bağ alanı mevcuttur ve bağ alanlarının önümüzdeki yıllarda giderek artması beklenmektedir (Çetin ve ark., 2024; FAOSTAT, 2024). Bununla birlikte, zaman zaman üzüm üreticileri ekonomik ölçekte verimliliği azalan bağlarını yenilemek ya da mevcut bağlarındaki omca sayısını arttırmak istemektedir. Bu durum hem her yıl yeni bağ tesisleri hem de yeterli ekonomik kazanç sağlanamayan bağlarda verimliliğin arttırılması amacıyla yeniden dikimler için gerekli olan bitki materyali ihtiyacının artması sorununu da beraberinde getirmektedir. Bu nedenle kolay bir şekilde çoğaltılan, sağlıklı, kaliteli ve düşük maliyetli dikim materyallerinin üretimini yapmak için bağcılıkta bazı stratejilerin geliştirilmesi gerektiği kanaati oluşmuştur (Aslan ve ark., 2015; Alpaslan ve ark., 2016). Genel olarak asmalar; aşılama, *in vitro* çoğaltım, çelikle çoğaltım teknikleri de dahil olmak üzere birçok farklı yöntemle çoğaltılmaya uygun bitkilerdir (Tangolar ve ark., 2021; Karabulut & Çelik, 2022; Çelik ve ark., 2023; Çelik & Odabaşıoğlu, 2024). Öte yandan asmalara uygulanan bu çoğaltma yöntemleri; genetik çeşitliliği, bitkinin hastalık ve zararlılara karşı direncini, bitki büyüme-gelişimini ve üzüm kalitesini önemli ölçüde etkileyebilmektedir (Murashige & Skoog, 1962; Blazina ve ark., 1991; Dardeniz, 2001; Erkoyuncu & Yorgancılar, 2015; Balı ve ark., 2020). Dolayısıyla bazı araştırmacılar bir çoğaltma yöntemi seçerken bu hususları değerlendirmek gerektiğini bildirmiştir (Sabır, 2002; Çakır ve ark., 2013; İşçi ve ark., 2015; Yağcı ve Gökkaynak, 2016). Bununla birlikte; bu hususları destekleyen bir başka grup araştırmacı; kaliteli bir dikim materyali üretiminde bağlarda, fidanlıklarda ve damızlık materyallerin yetiştirildiği alanlarda kalite kontrolü sağlamayı, teknik anlamda bitki çoğaltımı konusunda beceri geliştirmeyi ve çoğaltma yönteminin gerektirdiği ekonomik hususlar gibi konuların birlikte değerlendirilmesi gerektiğini

bildirmişler ve ayrıca bitki çoğaltımında genel bir başarının sağlanması için bunları ön koşullar olarak kabul etmişlerdir (Hunter ve ark., 2004; Dardeniz ve ark., 2008). Öte yandan bazı araştırmacılar; çoğaltma materyali alınacak bitkinin seçiminden, uygulanacak yöntemin pratik-hızlı çoğaltıma elverişliliğine, zaman verimliliğine ve çoğaltımın maliyet-etkin olmasına kadar birçok noktanın çoğaltma başarısı üzerinde etkili olduğuna değinmişlerdir (Bilir Ekbiç ve ark., 2015; Abebe, 2017; Özdemir Memiş & Sağlam, 2024).

Asma çoğaltmada kullanılan eski yöntemlerden biri tek gözlü dal çeliği ile çoğaltma yöntemidir. Elde çok kıymetli ve az sayıda çoğaltma materyali alınabilecek bir üzüm çeşidi varsa veya ıslah sonucu elde edilmiş yeni bir çeşitten kısa süre içerisinde çok sayıda bitki elde etmek istendiğinde başvurulan yöntemlerden biridir (Çelik, 2011). Bununla birlikte kültürü yapılan *Vitis* türlerine ait çeşitlerin çoğaltımı üzerine literatür değerlendirildiğinde; hızlı, pratik, kolay ve maliyet-etkin oluşundan dolayı tek gözlü dal çelikleri ile çoğaltma yönteminin, asmaların çoğaltımında kullanılan hem geleneksel hem de modern yöntemleri şekillendirecek önemli bir çoğaltım tekniği olduğunu söylemek mümkündür (Oraman, 1972; Fidan, 1985; Çelik ve ark., 2023; Köse ve ark., 2023).

Sürdürülebilir ve yüksek kaliteli üzüm yetiştiriciliği için dünyada yaygın olarak kültürü yapılan üzüm çeşitlerinin çoğaltımına bütünsel ve detaylı bir yaklaşım sağlayarak bağ yetiştiricilerine, araştırmacılara ve ilgili endüstri kollarına katkı sağlaması amacıyla yürütülen bu çalışmada; Güneydoğu Anadolu'da yetiştiriciliği yapılan beş yerel üzüm (*Vitis vinifera* L.) çeşidinden, yıllık dalda bulundukları boğum düzeyine göre alınan tek gözlü (kış gözü) dal çeliklerinin çoğaltma başarısı ve bunlardan elde edilen bitkilerin bazı büyüme ve gelişme özellikleri incelenmiştir. Elde edilen bulgulara dayanarak hem çalışmada incelenen yerel üzüm çeşitlerinin tek gözlü çeliklerle çoğaltım başarıları hem bu yöntemle üretilmiş bitkilerin erken dönemdeki gelişimleri hem de asmalarda tek gözlü çeliklerle çoğaltımda en uygun üretim materyalinin yıllık dalların hangi boğumundan alınması gerektiği değerlendirilmiştir.

MATERYAL ve YÖNTEM

Çalışmada bitkisel materyal olarak kullanılan yıllık dallar (çubuklar), Şanlıurfa ili Karaköprü ilçesine bağlı Yarımtepe köyünde yer alan bir çiftçi bağında yetiştirilen; Çiloreş, Çilorut, Kabarcık, Hönüsü ve Yediveren üzüm (*Vitis vinifera* L.) çeşitlerinden, 2023 yılı Şubat ayı içerisinde yapılan kış budaması esnasında alınmıştır (Şekil 1.).

Çilorut *Çiloreş* *Yediveren* *Kabarcık* *Hönüsü*

Şekil 1. Çalışmada çubukları kullanılan üzüm çeşitlerinin vejetasyon periyodunda yazlık sürgünlerinin, yapraklarının ve salkımlarının görünümü (Orijinal fotoğraflar)

Budama esnasında alınan çubuklar etiketlenmiş ve dikim öncesinde 24 saat suda bekletilmiştir. Bu esnada köklendirme kasası parsellendirilerek içerisine torf eklenmiştir. Daha sonra çubuklar kış gözlerinin dal üzerinde bulundukları boğumun konumuna göre (1.'den 9.'a kadar) ayrı ayrı kesilerek tek gözlü dal çelikleri hazırlanmış ve bunlar köklendirme kasasına dikilmiştir. Dikimden söküm yapılana kadar belirli periyotlarla köklendirme kasasındaki tek gözlü çelikler sulanmış, hava sıcaklığının arttığı dönemlerde hem sulama sıklığı arttırılmış hem de kasanın üzeri %70'lik net örtü ile örtülerek gölgeleme yapılmıştır. 20 Şubat tarihinde köklendirme kasasına dikilen tek gözlü çelikler 5 Temmuz tarihinde sökülmüştür. Sökümü yapılan bitkilerin çelik randımanı (%) ve bazı morfolojik parametreleri (çelik yaş ağırlığı, sürgün yaş ağırlığı, sürgün uzunluğu, sürgün çapı, yaprak sayısı, yaprak yaş ağırlığı, kök yaş ağırlığı, kök uzunluğu, kök sayısı) incelenmiştir (Şekil 2.).

Şekil 2. Söküm sonrası tek gözlü dal çeliklerinde ölçüm ve incelemelerin yapılmasına ilişkin görüntüler

İncelenen Özellikler

Çalışmada incelenen üzüm çeşitlerinin tek gözlü dal çeliklerinin çelik randımanı değerleri; başlangıçta dikilen çelik sayısının, tutan (kök ve sürgün oluşturan) çelik sayısına oranlanmasıyla (%) belirlenmiştir (Cangi & Etker, 2019). Bitkilerin; çelik (gövde), kök, sürgün ve yaprakları birbirinden ayrı ayrı olacak şekilde hassas terazide tartılıp yaş ağırlıkları belirlenmiş ve mg biriminden değerleri kayıt altına alınmıştır (Çelik ve ark., 2023). Sürgün çapı dijital kumpas ile 1. boğum üzerinden ölçülmüş ve mm biriminden değerleri kaydedilmiştir. Sürgün uzunluğu ve en uzun kökün uzunluğu şerit metreyle ölçülmüş ve cm biriminden değerleri kaydedilmiştir (Odabaşıoğlu ve ark., 2018). Kök sayısı ve yaprak sayısı basit sayma yöntemiyle tek tek sayılarak belirlenmiş ve kaydedilmiştir (İşlek ve ark., 2021).

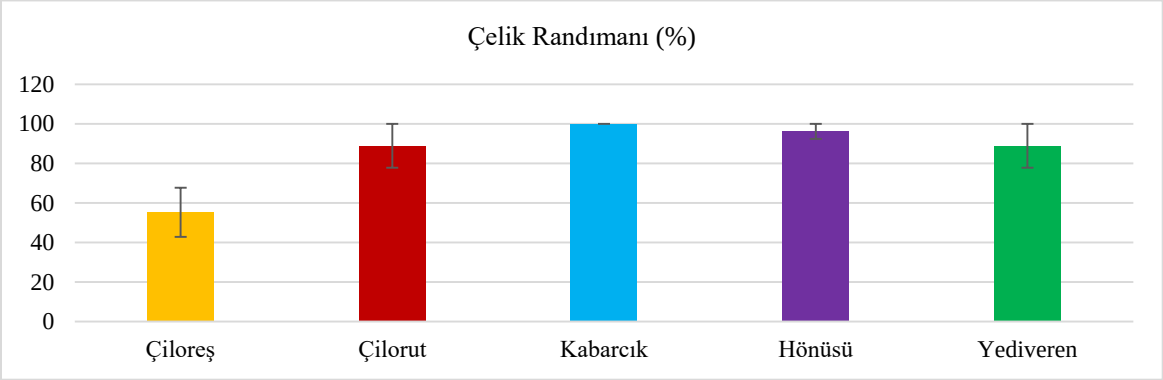
Deneme Deseni ve Verilerin Değerlendirilmesi

Deneme tesadüf parselleri deneme desenine göre 3 tekerrürlü olarak tasarlanmış ve her tekerrürde 3 sert odun dal çeliği kullanılmıştır. 5 yerel üzüm çeşidi için alınan her çeliğin üzerinde de 9 kış gözü bulunduğundan totalde 405 adet tek gözlü çeliği kullanılmıştır. Yapılan inceleme ve ölçümlerden elde edilen veriler, Minitab (ver. 18) istatistik programında varyans analizine tabi tutulmuş ve ortalamalar arasındaki anlamlı farklılıklar Tukey çoklu karşılaştırma testi ile belirlenmiştir.

ARAŞTIRMA BULGULARI ve TARTIŞMA

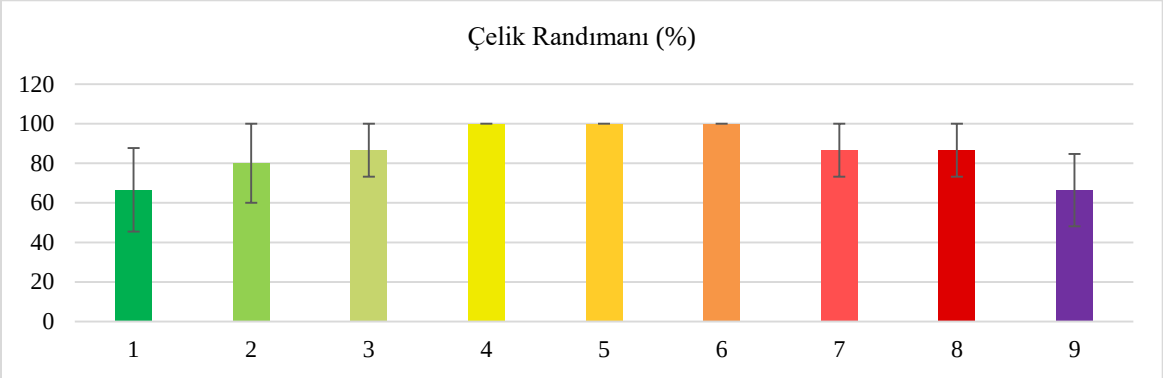
Çalışma kapsamında farklı boğum (göz) düzeyine ait tek gözlü çelikleri köklendirilmeye alınan üzüm çeşitlerinin, göz düzeyleri inceleme dışı bırakıldığında ortalama çelik randımanlarına ait bulgular Şekil 1.'de sunulmuştur. Elde edilen bulgulara göre incelenen üzüm çeşitlerinde tek

gözlü çeliklerin randımanları %55.3 ile % 100.0 arasında değişim göstermiş ancak üzüm çeşitleri arasında bu özellik bakımından istatistiksel olarak anlamlı farklılıklar saptanmamıştır. Kabarcık çeşidi %100 çelik randımanı değeri ile incelenen çeşitler arasında en iyi performansı sergileyen üzüm çeşidi olarak belirlenmiştir. Buna karşın Çiloreş çeşidi %55.3 çelik randımanı ile en düşük çelik tutma oranına sahip çeşit olmuştur. Bulgularımızdan yola çıkarak, üzüm çeşitleri arasında görülen bu farklılığın tek gözlü çeliklerin alınmış olduğu omcalardan kaynaklı bir dizi endojen (genotipik varyasyon, karbonhidrat rezervleri, hormonal denge) ve eksojen (sıcaklık, ışık, su düzeyi vb.) faktörlerden ileri geldiği söylenebilir (Srinivasan & Mullins, 1981; Vasconcelos ve ark., 2009; Ağaoğlu ve ark., 2010; Çelik, 2011; Li-Mallet ve ark., 2016).



Şekil 1. Üzüm çeşitlerine ait çeliklerin ortalama randımanı (%)

Tek gözlü dal çeliklerinin köklenerek yeni bir bitki oluşturma kapasitesinin ve bunlardan elde edilen genç bitkilerde büyüme ve gelişme durumlarının değişim göstermesinin temelinde, gözlerin alınmış olduğu yıllık dallardaki depolanmış karbonhidrat rezervinin (çözünür şekerler ve nişasta) değişkenlik göstermesi yatmaktadır (Zapata ve ark., 2004; Vaillant-Gaveau ve ark., 2014). Üzüm çeşitlerinde, karbonhidrat rezervinin yıllık dalların genellikle orta boğumlarında pik yaptığı birçok araştırmacı tarafından da bildirilmiştir (Scholefield ve ark., 1978; Vaillant-Gaveau ve ark., 2014). Öte yandan bu durum her üzüm çeşidinde aynı boğum düzeylerinin aynı seviyede karbonhidrat rezervine sahip olduğu anlamına da gelmemektedir (Çelik, 2011; Keller, 2020). Ancak *Vitis vinifera* L. türüne ait çeşitlerin genel eğilimi bu şekilde tanımlanabilir. Nitekim bu ifadeyi destekler nitelikteki bulgulara eriştiğimiz çalışmamızda, üzüm çeşitleri göz ardı edilerek farklı göz düzeylerinden alınıp köklendirilen tek gözlü çeliklerin ortalama randıman değerleri bakımından en iyi performansı sergileyen gözlerin yıllık dalların orta boğumlarında yer aldığı belirlenmiştir (Şekil 2.). Kontrollü koşullar altında yetiştirilen tek gözlü çeliklerin, alınmış oldukları boğum düzeylerine göre randımanları incelendiğinde 4., 5., ve 6. boğumlarda yer alan gözleri taşıyan çeliklerin tamamında %100 randıman sağlandığı saptanmıştır. Bununla birlikte tek gözlü çeliklerde ortalama randıman değerinin, yıllık dalların bazalında yer alan boğumlardaki gözlerden (1., 2. ve 3.) hazırlanan çeliklerden başlayarak orta boğumlarda yer alan gözlere doğru giderek artış gösterdiği, aksine orta boğumlarda yer alan gözlerden apikalde yer alan gözlere (7., 8. ve 9.) doğru ise giderek azaldığı görülmektedir (Şekil 2.). Dolayısıyla çalışmamızdan elde ettiğimiz bulgular, bu yönüyle literatür bildirişleri ile uyumludur.



Şekil 2. Farklı göz düzeylerinden alınan çeliklerin ortalama randımanı (%)

Çalışmamızda incelenen üzüm çeşitlerinin yıllık dallarının farklı boğum (göz) düzeylerinden alınarak hazırlanmış tek gözlü çeliklerinden elde edilen bitkilerin, bazı vejetatif gelişim parametrelerine ilişkin bulgular Çizelge 1.'de sunulmuştur. Elde edilen bulgulara göre, çelik yaş ağırlığı bakımından hem üzüm çeşitleri arasında hem de üzüm çeşidi x göz düzeyi interaksiyonunda yer alan gruplar arasında istatistiksel olarak anlamlı bir farklılık bulunmamıştır. Buna karşın vejetatif gelişim özelliklerini yansıtan diğer parametrelerde (sürgün çapı, sürgün uzunluğu, sürgün yaş ağırlığı, yaprak sayısı ve yaprak yaş ağırlığı) üzüm çeşitleri arasında ve üzüm çeşidi x göz düzeyi interaksiyonunda yer alan gruplar arasında istatistiksel olarak anlamlı ($p<0.01$) farklılıklar saptanmıştır.

Çilorut çeşidinin 2. boğumundan (2.80 mm) ve Yediveren çeşidinin 9. boğumundan (2.70 mm) alınan gözlerin çoğaltılmasıyla elde edilen bitkilerin sürgün çapı değerleri birbirine benzer ve üzüm çeşidi x göz düzey interaksiyonunda yer alan diğer gruplara ait bitkilerin sürgün çapı değerlerinden daha yüksek bulunmuştur. İncelenen çeşitlerin sürgün çapı değerleri göz düzeylerinden bağımsız olarak değerlendirildiğinde ise en kalın sürgünlere sahip çeşidin Kabarcık olduğu ve bunu sırasıyla Çilorut, Hönüsü, ve Yediveren çeşitlerinin takip ettiği saptanmıştır. Öte yandan bu çeşitler istatistiksel olarak aynı grupta yer almışlardır. Sürgün çapı bakımından Çiloreş üzüm çeşidi en düşük değere sahip bulunmuş ve incelenen diğer çeşitlerden bu özellik bakımından istatistiksel olarak ayrışmıştır. En uzun sürgünlere sahip bitkilerin, Kabarcık çeşidinin 1. göz düzeyinden (28.00 cm) alınan çeliklerin çoğaltımıyla elde edildiği saptanmıştır. Buna karşın Yediveren çeşidinin 1., Çiloreş çeşidinin 2. ve Çilorut çeşidinin 9. göz düzeyinden alınıp hazırlanan tek gözlü çeliklerde sürgün oluşumu gerçekleşmemiştir. Üzüm çeşitleri ortalama sürgün uzunluğu değerleri bakımından göz düzeylerinden bağımsız olarak karşılaştırıldığında, en uzun sürgünlere Kabarcık (15.93 cm) çeşidinin, en kısa sürgünlere ise Çiloreş (6.93 cm) çeşidinin sahip olduğu belirlenmiştir. Sürgün uzunluğu ile benzer şekilde sürgün yaş ağırlığı bakımından da en yüksek değere sahip çeşit x göz düzeyi gurubunun, Kabarcık çeşidinin 1. göz düzeyinden alınan çeliklerin çoğaltımıyla elde edilen bitkilerin yer aldığı grup olduğu saptanmıştır. Buna ek olarak incelenen üzüm çeşitleri ortalama sürgün yaş ağırlığı değerleri bakımından farklı istatistiksel gruplarda yer almıştır. Nitekim ortalama sürgün yaş ağırlığı değerleri bakımından üzüm çeşitleri sıralandığında ilk sırada Kabarcık çeşidi yer almış ve bu çeşidi sırasıyla Hönüsü, Çilorut, Yediveren ve Çiloreş çeşitleri takip etmiştir.

Çalışmamız kapsamında, farklı üzüm çeşitlerinin değişik göz düzeylerini içeren tek gözlü çeliklerinin çoğaltılmasıyla elde edilen bitkilerin oluşturdukları yaprak sayıları ve yaprak yaş ağırlıkları bakımından birbirlerinden istatistiksel olarak anlamlı ($p<0.01$) farklılıklar gösterdikleri ve farklı Tukey gruplarında yer aldıkları saptanmıştır. En fazla sayıda yaprak oluşturan bitkilerin (15.0 adet/bitki), Kabarcık çeşidinin 2. göz düzeyini içeren tek gözlü çeliklerinin çoğaltılmasıyla elde edildiği belirlenmiştir. Yaprak yaş ağırlığı bakımından en yüksek değere (525.7 mg) sahip olan bitkilerin ise Kabarcık çeşidinin 1. göz düzeyini içeren

tek gözlü çeliklerin çoğaltılmasıyla elde edilen bitkiler olduğu tespit edilmiştir. Öte yandan çalışma kapsamında incelenen sürgün özelliklerine ilişkin parametrelerle paralel bir şekilde, üzüm çeşitleri ortalama yaprak sayıları ve yaprak yaş ağırlıkları bakımından göz düzeylerinden bağımsız olarak incelendiğinde de çeşitler arasında istatistiksel olarak anlamlı ($p<0.01$) farklılıkların olduğu saptanmıştır. Tek gözlü çeliklerinden elde edilmiş bitkilerinde ortalama en fazla sayıda yaprağa (12.3 adet/bitki) ve en yüksek yaprak ağırlığı değerine (311.6 mg) sahip üzüm çeşidi Kabarcık, en az sayıda yaprağa (5.0 adet/bitki) ve en düşük yaprak ağırlığı değerine (127.7 mg) sahip üzüm çeşidi ise Çiloreş olmuştur.

Farklı üzüm üzüm çeşitlerinin değişik göz düzeylerini içeren tek gözlü çeliklerinden elde edilen bitkilerin, bazı kök özelliklerinin değişimine ilişkin elde edilen bulgular Çizelge 2.'de sunulmuştur. Buna göre kök uzunluğu ve kök sayısı bakımından, üzüm çeşidi x göz düzeyi interaksiyonunda yer alan gruplar arasında istatistiksel olarak anlamlı ($p<0.01$) farklılıklar saptanmıştır. Elde edilen bulgulara göre en uzun köklerin, Kabarcık çeşidinin 6. göz düzeyinden alınan gözlerin çoğaltılmasıyla elde dilen bitkilerde oluştuğu saptanmıştır. Bununla birlikte en fazla sayıda kök oluşturan bitkilerin, Kabarcık çeşidinin 3. (23.3 adet/bitki), 6. (22.7 adet/bitki), ve 7. (23.0 adet/bitki) göz düzeylerini içeren tek gözlü çeliklerin çoğaltılmasıyla elde edildiği belirlenmiştir. Her ne kadar kök yaş ağırlığı bakımından incelenen üzüm çeşidi x göz düzeyi interaksiyon grupları arasında istatistiksel olarak anlamlı farklılıklar saptanmamışsa da bu özellik bakımından en yüksek değere (377.3 mg) sahip grup Kabarcık çeşidinin 6. göz düzeyinden alınan tek gözlü çeliklerden elde edilmiş bitkilerin yer aldığı grup olmuştur. Çalışma kapsamında incelenen çeşitler, göz düzeylerinden bağımsız olarak değerlendirildiklerinde ise kök uzunluğu, kök sayısı ve kök yaş ağırlığı bakımından üzüm çeşitleri arasında istatistiksel olarak anlamlı ($p<0.01$) farklılıkların olduğu belirlenmiştir. Buna göre üzüm çeşitlerine ilişkin elde edilen ortalama değerlere göre; en uzun ve fazla sayıda kökün Kabarcık üzüm çeşidinden, en kısa ve az sayıda kökün ise Çiloreş üzüm çeşidinden elde edilen bitkilerde oluştuğu saptanmıştır. Kök yaş ağırlığı bakımından ise Kabarcık ve Yediveren üzüm çeşitleri aynı istatistiksel grupta yer almışlar ve incelenen diğer çeşitlerden bu özellik bakımından daha yüksek değerlere sahip bulunmuşlardır.

Çizelge 3.'te tek gözlü çeliklerden elde edilen bitkilerin vejetatif gelişim parametrelerinin ve kök özelliklerinin üzüm çeşitlerinden bağımsız olarak göz düzeylerine göre değişimine ilişkin bulgular sunulmuştur. Tek gözlü çeliklerden elde edilen bitkilerin çelik yaş ağırlığı, sürgün uzunluğu, yaprak sayısı ve yaprak yaş ağırlığı değerleri bakımından, çalışmada incelenen göz düzeyleri arasında istatiksel olarak anlamlı farklılıkların olmadığı belirlenmiştir. Buna karşın göz düzeyleri arasında, tek gözlü çeliklerden elde edilen bitkilerin sürgün çapı ve sürgün yaş ağırlığı bakımından %5, kök özellikleri bakımından (kök uzunluğu, kök yaş ağırlığı ve kök sayısı) ise %1 önem düzeyinde farklılıklar olduğu saptanmıştır. Elde edilen bulgulara göre 4., (2.09 mm) ve 6. (2.03 mm) göz düzeylerinden alınan tek gözlü çeliklerden elde edilen bitkiler sürgün çapı bakımından en yüksek değerlere, 1. göz (1.29 mm) düzeyinden alınan çeliklerden elde edilen bitkiler ise en düşük değerlere sahip bitkiler olarak belirlenmiştir. Sürgün yaş ağırlığı değerleri incelendiğinde ise en yüksek değerin 6. göz düzeyinden (255.9 mg), en düşük değerin ise 9. göz düzeyinden (139.4 mg) alınıp çoğaltılan tek gözlü çeliklerden elde edilen bitkilerde olduğu görülmüştür. Kök uzunluğu bakımından 2., 3., 4., 6., 7. ve 8. göz düzeylerinden alınan tek gözlü çeliklerden elde edilen bitkiler aynı istatistiki grupta yer almış ve diğer göz düzeylerinden alınıp çoğaltılanlara göre daha yüksek değerlere sahip bulunmuştur. Buna karşın kök sayısı bakımından 4., kök yaş ağırlığı bakımından ise 6. ve 7. göz düzeylerinden alınan tek gözlü çeliklerden elde edilmiş bitkilerin daha yüksek değerlere sahip olduğu saptanmıştır.

Bu çalışma, Güneydoğu Anadolu Bölgesi'nde yetiştirilen sofralık ve şıralık olarak değerlendirilebilen yerel üzüm çeşitlerinin tek gözlü çeliklerle çoğaltılabilme potansiyellerine ilişkin literatürde yer alan sınırlı sayıdaki çalışmaya bir yenisinin eklenmesi ve alanyazına katkı sunması yönüyle önem arz etmektedir. Genel olarak asma tür ve çeşitlerinin çoğaltımı ile alakalı

daha önce yapılan araştırmalara ilişkin literatür incelendiğinde; tek gözlü dal çelikleriyle, birden çok göz ihtiva eden dal çelikleriyle, aşılama ile ve *in vitro* mikro çoğaltım ve benzeri farklı çoğaltma yöntemlerinin sıklıkla ele alındığı görülmektedir. Bu nedenle mevcut çalışmamızdan elde ettiğimiz bulgular, literatürde yer alan ve benzer koşullarda yahut aynı üzüm çeşitleri üzerinde yürütülen farklı çoğaltma yöntemlerine ilişkin çalışmaların bulguları ile karşılaştırılarak tartışılmıştır. Çelik ve ark. (2023), tek gözlü dal çelikleri kullanılarak üzüm çeşitlerinin çoğaltılması üzerine yaptıkları çalışmada, Red Globe üzüm çeşidinin tek gözlü çeliklerle çoğaltım performansını inceledikleri diğer üzüm çeşitlerine (Horoz Karası, Hatun Parmağı, Barış) göre daha iyi bulmuşlar ve genel olarak üzüm çeşitlerinden çoğaltım amacıyla alınacak çeliklerin yıllık dalların 7. ile 12. boğumları arasından alınmasını önermişlerdir. Bizim çalışmamızda ise Kabarcık çeşidi incelenen üzüm çeşitleri arasında bu yönüyle ön plana çıkmıştır. Buna ek olarak çalışmamızda, üzüm çeşitlerinden bağımsız olarak yıllık dalların 4. ile 8. boğumları ve arasındaki boğumlarda yer alan kışlık gözleri içerecek şekilde alınan tek gözlü dal çeliklerinin oluşturduğu bitkilerin daha iyi vejetatif gelişim performansı gösterdiği de belirlenmiştir. Genel olarak bakıldığında, Çelik ve ark. (2023)'den farklı olarak bizim çalışmamızda 4., 5. ve 6. gözlerin yer aldığı tek gözlü çeliklerden elde edilen bitkiler de sağlıklı ve iyi bir vejetatif gelişim göstermiştir. Bu yönüyle çalışmalar arasında görülen farklılık, farklı bağlardan alınan ve üretim materyallerinin hazırlanmasında kullanılan yıllık dalların alındığı omcaların beslenme, sulanma, ilaçlanma vb. bakım koşullarının değişkenlik göstermesinden, bağlarda kullanılan anaçların veya incelenen üzüm çeşitlerinin genotipik özelliklerinin farklılığından kaynaklanmış olabilir. Nitekim bu faktörlerin her biri hem bağlardan elde edilen yaş üzüm miktarını hem üzümlerin fiziksel ve fitokimyasal özelliklerini hem de omcaların vejetatif gelişimini etkileyebilmektedir (Main ve ark., 2002; Heuvel ve ark., 2004; Kara ve ark., 2023). Diğer taraftan her iki çalışmada da 7. ve 8. gözlerin yer aldığı tek gözlü çeliklerden elde edilen bitkilerin iyi vejetatif gelişim gösterdikleri bulgusu, birbiriyle örtüşmektedir.

Bekişli ve ark. (2015), aşılı asma fidanı üretiminde bazı anaç-çeşit kombinasyonlarının katlama odası performansları ile bazı büyüme-gelişme parametrelerini incelemişler ve genel olarak Çiloreş çeşidini, inceledikleri diğer (Hönüsü ve Hatun Parmağı) üzüm çeşitlerine göre daha iyi bulmuşlardır. Yanmaz (2002) ise bazı aşılı fidanlarda büyüme, gelişme ve randımana ilişkin ölçümler yapmış ve performans ölçütleri açısından en iyi sonuçları Çiloreş, Azezi ve Hönüsü çeşitlerinde saptamıştır. Benzer bir araştırma Odabaşıoğlu (2022) tarafından da yürütülmüş ve Güneydoğu Anadolu'da yetiştiriciliği yapılan iki yerel üzüm çeşidi olan Çiloreş ve Azazi'nin farklı anaçlar üzerindeki çoğaltılma performansları incelenmiştir. Araştırmacı, Çiloreş çeşidinin yer aldığı aşı kombinasyonlarının Azazi çeşidinin yer aldığı aşı kombinasyonlarına göre daha iyi performans gösterdiği kanısına varmıştır. Ekinci ve ark. (2024) ise Şanlıurfa ilinde yetiştirilen yerel üzüm çeşitleri olan Şire, Simore, Çiloreş, Küllahi, Hasani, Elma, Serpene Kıran, Kızılbanki ve Heştur'un *in vitro* koşullarda ve farklı yetiştirme şartlarında bazı büyüme parametrelerini incelemişler ve elde ettikleri bulgulara dayanarak Çiloreş çeşidinin çoğaltılma performansının kayda değer nitelikte olduğunu bildirmiştir. Bizim çalışmamızda elde edilen bulgular ve bu alandaki literatür birlikte değerlendirildiğinde, Çiloreş üzüm çeşidinin masabaşı aşılama ve *in vitro* yöntemleri ile çoğaltıma uygun olduğu kanaati oluşmaktadır. Buna karşın elde ettiğimiz bulgular incelendiğinde, bu çeşidin tek gözlü dal çelikleri ile çoğaltılma performansı diğer üzüm çeşitlerine nazaran oldukça düşük olduğu görülmektedir. Öte yandan elde ettiğimiz bulgular Gündeşli (2018)'nin bulguları ile uyum içerisindedir. Gündeşli (2018), bazı Amerikan anaçlarının Kabarcık ve Hönüsü (Mahrabaşı) üzüm çeşitlerinde aşı başarısı ve fidan kalitesi üzerine etkilerini incelemiş ve fidan randımanı açısından en iyi sonucu Kabarcık/1103 Paulsen aşı kombinasyonundan elde etmiştir. Nitekim bizim çalışmamızda da tek gözlü dal çelikleri ile çoğaltımda en yüksek randıman değeri Kabarcık çeşidinden elde edilmiştir. Dolayısıyla genel olarak bir değerlendirme yapıldığında, Kabarcık üzüm çeşidi hem aşı ile çoğaltıma hem de tek gözlü dal çelikleriyle çoğaltıma uygun bir üzüm çeşidi olarak görülmektedir.

Aslan ve ark. (2015) farklı standart (Alphonse Lavallée, Amasya Beyazı, Boğazkere, Bozcaada Çavuşu, Cardinal, Flame Seedless, Hamburg Misketi, Kıbrıs Üzümü, Kişniş, Michele Paliere, Öküzgözü, Razakı, Red Globe, Royal, Victoria) ve yerel (Azezi, Banazı Karası, Bennitati, Gazzana, İran Çekirdeksiz, Kara, Mazrune, Tahannebi) üzüm çeşitlerinin aşı ile çoğaltılma performanslarını ve farklı asma anaçlarıyla uyumlarını incelemişler ve ekseriyetle standart çeşitlerin yerel çeşitlere göre aşı ile çoğaltılma performanslarını daha yüksek bulmuşlardır. Bu çalışma, yöntem ve kapsamı açısından bizim çalışmamızdan oldukça farklı olsa da bulguları itibariyle önem arz etmektedir. Nitekim gerek söz konusu çalışmadan gerek literatürde yer alan diğer araştırmalardan gerekse de bizim çalışmamızdan elde edilen bulgulardan hareketle, üzüm çeşitlerinin farklı çoğaltma yöntemlerinde gösterdikleri performansların değişkenlik gösterebileceği değerlendirmesi yapılabilir. Bununla birlikte, bitkilerde çoğaltma, sürme, büyüme ve gelişme konularının büyük oranda genetik ve çevresel faktörler tarafından etkilendiği aşikârdır.

Çizelge 1. Üzüm çeşitlerinin farklı göz düzeylerini içeren tek gözlü çeliklerinden elde edilen bitkilerin vejetatif gelişim özelliklerinin değişimi

	Çeşit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Ort.**
Çelik Yaş Ağ. (mg)	Çiloreş	1800.0 Öd	1706.7	2590.0	2353.3	2803.3	2456.7	1523.3	2380.0	2603.3	2246.3 ÖD
	Çilorut	1380.0	1215.0	1317.0	2233.3	1560.0	1753.3	1900.3	2576.7	2026.7	1773.6
	Kabarcık	1526.7	1749.3	2600.3	2506.3	2294.0	2494.3	2546.0	1934.0	2488.0	2237.7
	Hönüsü	1478.0	1301.0	825.3	2539.3	2536.0	2057.3	2831.0	2706.7	1396.0	1963.4
	Yedieren	1816.7	2279.7	1408.3	2421.0	1639.7	2077.3	6488.7	1805.3	1729.0	2407.3
Sürgün Çapı (mm)	Çiloreş	0.57 b-e**	0.00 e	0.57 b-e	2.07 a-d	1.60 a-e	1.83 a-e	0.47 de	0.53 cde	1.63 a-e	1.03 B**
	Çilorut	2.00 a-d	2.80 a	2.13 a-d	1.87 a-e	2.07 a-d	2.07 a-d	2.17 a-d	2.50 ab	0.00 e	1.96 A
	Kabarcık	2.03 a-d	1.57 a-e	2.33 a-d	2.10 a-d	1.63 a-e	2.20 a-d	2.30 a-d	1.93 a-e	2.00 a-d	2.01 A
	Hönüsü	1.83 a-e	1.93 a-e	2.03 a-d	2.20 a-d	1.67 a-e	2.43 abc	1.67 a-e	2.13 a-d	1.37 a-e	1.92 A
	Yedieren	0.00 e	2.27a-d	1.90 a-e	2.20 a-d	2.03 a-d	1.63 a-e	2.30 a-d	2.23 a-d	2.70 a	1.92 A
Sürgün Uzunluğu (cm)	Çiloreş	3.33 cd**	0.00 d	4.00 cd	12.67 a-d	12.00 a-d	11.33 a-d	2.67 cd	4.67 cd	11.67 a-d	6.93 C**
	Çilorut	13.33 a-d	8.67 bcd	24.00 ab	10.00 bcd	14.00 a-d	9.00 bcd	9.00 bcd	14.00 a-d	0.00 d	11.33 B
	Kabarcık	28.00 a	18.00 abc	16.00 a-d	13.67 a-d	10.67 bcd	11.33 a-d	12.67 a-d	17.67 abc	15.33 a-d	15.93 A
	Hönüsü	16.00 a-d	15.00 a-d	15.67 a-d	14.67 a-d	11.00 bcd	8.33 bcd	12.00 a-d	14.00 a-d	6.67 cd	12.59 AB
	Yedieren	0.00 d	14.33 a-d	9.33 bcd	14.33 a-d	13.67 a-d	10.33 bcd	11.67 a-d	9.33 bcd	18.00 abc	11.22 B
Sürgün Yaş Ağ. (mg)	Çiloreş	80.0 cd**	0.0 d	76.7 cd	131.3 bcd	157.7 a-d	351.3 abc	46.7 cd	70.0 cd	177.0 a-d	121.2 C**
	Çilorut	141.0 a-d	240.0 a-d	220.0 a-d	190.0 a-d	236.7 a-d	227.0 a-d	221.0 a-d	145.7 a-d	0.0 d	180.2 BC
	Kabarcık	453.3 a	235.3 a-d	195.0 a-d	340.3 abc	196.7 a-d	264.3 a-d	398.7 ab	251.3 a-d	261.3 a-d	288.5 A
	Hönüsü	321.7 abc	300.7 a-d	229.0 a-d	151.0 a-d	273.3 a-d	216.3 a-d	199.3 a-d	174.0 a-d	87.7 bcd	217.0 AB
	Yedieren	0.0 d	189.0 a-d	150.0 a-d	158.7 a-d	230.0 a-d	220.7 a-d	271.7 a-d	124.3 bcd	171.0 a-d	168.4 BC

Yaprak Sayısı (adet/bitki)	Çiloreş	2.0 bc**	0.0 c	3.0 abc	9.0 abc	8.3 abc	8.7 abc	2.0 bc	2.0 bc	10.3 abc	5.0 C**
	Çilorut	4.7 abc	6.0 abc	9.0 abc	8.3 abc	9.0 abc	8.3 abc	11.0 abc	4.3 abc	0.00 c	6.7 BC
	Kabarcık	14.3 ab	15.0 a	12.3 abc	10.7 abc	10.7 abc	13.7 ab	13.7 ab	14.0 ab	6.7 abc	12.3 A
	Hönüsü	8.3 abc	12.0 abc	8.3 abc	12.7 abc	9.3 abc	7.0 abc	9.7 abc	10.0 abc	7.7 abc	9.4 AB
	Yediveren	0.00 c	11.3 abc	9.7 abc	10.0 abc	13.3 ab	8.0 abc	7.3 abc	7.7 abc	14.0 ab	9.0 B
Yaprak Yaş Ağ. (mg)	Çiloreş	40.0 bc**	0.00 c	43.3 bc	330.0 abc	217.0 abc	158.7 bc	116.7 bc	33.3 bc	210.0 abc	127.7 C**
	Çilorut	230.7 abc	365.0 ab	282.7 abc	219.3 abc	201.7 abc	226.0 abc	133.3 bc	170.0 abc	0.00 c	203.2 BC
	Kabarcık	525.7 a	306.0 abc	238.3 abc	206.7 abc	330.7 abc	337.3 abc	330.3 abc	335.0 abc	194.0 abc	311.6 A
	Hönüsü	227.3 abc	287.0 abc	198.3 abc	306.0 abc	219.0 abc	148.3 bc	222.3 abc	201.0 abc	107.3 bc	212.9 B
	Yediveren	0.00 c	218.3 abc	196.0 abc	220.0 abc	300.0 abc	202.3 abc	191.0 abc	168.7 abc	249.0 abc	193.9 BC

Üzüm çeşitlerine ait ortalama değerlerden farklı harflerle (A, B, C) belirtilmiş olanlar arasında istatistiksel olarak anlamlı (**: $p<0.01$) farklılık vardır. ÖD: Önemli değil.

Üzüm çeşidi x Göz düzeyi interaksiyonunda yer alan grupların farklı harflerle (a, b, c, d, e) belirtilmiş olan ortalama değerleri arasında istatistiksel olarak anlamlı (**: $p<0.01$) farklılık vardır. Öd: Önemli değil.

Çizelge 2. Üzüm çeşitlerinin farklı göz düzeylerini içeren tek gözlü çeliklerinden elde edilen bitkilerin bazı kök özelliklerinin değişimi

	Çeşit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Ort.**
Kök Uzunluğu (cm)	Çiloreş	4.67 a-d**	0.00 d	2.00 bcd	5.33 a-d	1.67 cd	2.33 bcd	3.33 a-d	3.67 a-d	5.67 a-d	3.19 C**
	Çilorut	0.00 d	13.00 a-d	9.67 a-d	11.33 a-d	17.33 abc	12.33 a-d	15.67 a-d	12.33 a-d	6.67 a-d	10.93 AB
	Kabarcık	14.00 a-d	16.00 abc	17.67 ab	16.67 abc	12.00 a-d	18.67 a	14.67 a-d	8.67 a-d	3.33 a-d	13.52 A
	Hönüsü	0.00 d	10.67 a-d	9.67 a-d	11.33 a-d	0.00 d	15.33 a-d	15.67 a-d	14.33 a-d	8.33 a-d	9.48 B
	Yediveren	0.00 d	14.00 a-d	11.00 a-d	13.33 a-d	13.00 a-d	13.67 a-d	11.00 a-d	11.00 a-d	12.00 a-d	11.00 AB
Kök Sayısı (adet/bitki)	Çiloreş	6.7 a-d**	0.0 d	5.3 a-d	12.0 a-d	4.7 a-d	2.3 bcd	6.7 a-d	5.0 a-d	12.3 a-d	6.1 C**
	Çilorut	0.0 d	8.7 a-d	10.0 a-d	20.7 ab	9.7 a-d	17.7 a-d	11.7 a-d	14.0 a-d	3.3 bcd	10.6 B
	Kabarcık	20.3 abc	14.3 a-d	23.3 a	13.0 a-d	17.3 a-d	22.7 a	23.0 a	14.0 a-d	3.3 bcd	16.8 A
	Hönüsü	0.0 d	9.7 a-d	16.3 a-d	13.7 a-d	0.0 d	11.7 a-d	14.3 a-d	20.0 abc	8.7 a-d	10.5 B
	Yediveren	0.0 d	2.0 bcd	1.6 cd	2.3 bcd	2.1 bcd	1.6 cd	2.2 bcd	2.3 bcd	1.5 cd	1.7 D
Kök Yaş Ağ. (mg)	Çiloreş	46.7Öd	0.0	30.0	82.0	16.7	266.7	166.7	116.7	163.3	98.7 B**
	Çilorut	0.0	117.3	151.7	223.3	248.0	164.7	153.3	155.3	40.3	139.3 AB
	Kabarcık	328.7	198.7	270.0	167.7	183.7	377.3	267.3	208.0	35.7	226.3 A
	Hönüsü	0.0	179.0	216.7	187.7	0.0	134.3	223.3	196.0	113.7	138.9 AB
	Yediveren	0.0	221.3	108.0	254.3	184.7	293.3	343.7	216.3	186.3	200.9 A

Üzüm çeşitlerine ait ortalama değerlerden farklı harflerle (A, B, C, D) belirtilmiş olanlar arasında istatistiksel olarak anlamlı (**: $p<0.01$) farklılık vardır.

Üzüm çeşidi x Göz düzeyi interaksiyonunda yer alan grupların farklı harflerle (a, b, c, d) belirtilmiş olan ortalama değerleri istatistiksel olarak anlamlı (**: $p<0.01$) farklılık vardır. Öd: Önemli değil.

Çizelge 3. Tek gözlü çeliklerden elde edilen bitkilerin vejetatif gelişim parametrelerinin ve kök özelliklerinin göz düzeyine bağlı olarak değişimi

Göz Düzeyi	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Çelik Yaş Ağ. (mg)	1600.3Öd	1650.3	1748.2	2410.7	2166.6	2167.8	3057.9	2280.5	2048.6
Sürgün Çapı (mm)	1.29 b*	1.71 ab	1.79 ab	2.09 a	1.80 ab	2.03 a	1.78 ab	1.87 ab	1.54 ab
Sürgün Uz. (cm)	12.13Öd	11.20	13.80	13.07	12.27	10.07	9.60	11.93	10.33
Sürgün Yaş Ağ. (mg)	199.2 ab*	193.0 ab	174.1 ab	194.3 ab	218.9 ab	255.9 a	227.5 ab	153.1 ab	139.4 b
Yaprak Sayısı (adet/bitki)	5.9Öd	8.9	8.5	10.1	10.1	9.1	8.7	7.6	7.7

Yaprak Yaş Ağ. (mg)	204.7^{Öd}	235.3	191.7	256.4	253.7	214.5	198.7	181.6	152.1
Kök Uzunluğu (cm)	3.73 b**	10.73 a	10.00 a	11.60 a	8.80 ab	12.47 a	12.07 a	10.00 a	7.20 ab
Kök Sayısı (adet/bitki)	5.4 b**	6.9 ab	11.3 ab	12.3 a	6.7 ab	11.2 ab	11.6 ab	11.1 ab	5.8 ab
Kök Yaş Ağ. (mg)	75.1 b**	143.3 ab	155.3 ab	183.0 ab	126.6 ab	247.3 a	230.9 a	178.5 ab	107.9 ab

Aynı satırda farklı harflerle (a, b, c) belirtilmiş olan ortalama değerler arasında istatistiksel olarak anlamlı (*: $p<0.05$, **: $p<0.01$) farklılık vardır. Öd: Önemli değil

SONUÇ

Araştırma kapsamında incelenen çeşitler arasında Kabarcık üzüm çeşidinin yıllık dallarından hazırlanan tek gözlü dal çeliklerinin gerek randımanlarının yüksek olması gerekse de bunlardan elde edilen bitkilerin vejetatif gelişim parametrelerine ilişkin bulguların incelenen diğer çeşitlerinkine nazaran daha iyi bulunması nedeniyle, Kabarcık üzüm çeşidinin tek gözlü dal çelikleri ile çoğaltılmaya elverişli olduğunu söylemek mümkündür. Öte yandan Çiloreş üzüm çeşidi hem çelik randımanının düşük olması hem de tek gözlü çeliklerinden elde edilen bitkilerin büyüme ve gelişme yönünden düşük performans sergilemesinden dolayı, tek gözlü dal çelikleri ile çoğaltılmaya elverişli bulunmamıştır. Hönüsü, Yediveren ve Çilorut üzüm çeşitlerinin ise iyi pişkinleşmiş ve karbonhidrat rezervleri açısından zengin olan gözlerinin yer aldığı boğumlarından hazırlanan tek gözlü çeliklerle çoğaltılması gerekmektedir. Ayrıca incelediğimiz bu üzüm çeşitleri tek gözlü çeliklerle çoğaltılırken çeliklerin bazalının oksin grubu bir hormonla uygun doz ve süre ile muamele edilmesi, daha fazla kök teşekkülünün sağlanması ve elde edilen bitkilerin vejetatif gelişimlerinin iyileştirilmesi açısından tarafımızca önerilmektedir. Bununla birlikte üzüm çeşitlerinde tek gözlü çelikler ile çoğaltım için en uygun fitohormon ve bunun dozunun belirlenmesine yönelik araştırmaların yürütülmesi bu alandaki bilgi birikiminin arttırılması ve pratikte ekonomik kayıpların minimize edilmesi için gereklidir.

Farklı üzüm çeşitlerinin incelendiği araştırmalarda hem aşılamada hem çelikle çoğaltımda hem de tek gözlü çeliklerle çoğaltımda kullanılması önerilen materyalin, yıllık dalların hangi boğum (göz) düzeyinden alınmasının daha uygun olacağına dair farklı yaklaşımlar öne sürülmüştür. Buna karşın bizim çalışmamızda da önceki çalışmalarla paralel bir şekilde, her üzüm çeşidinin farklı göz düzeylerinin bu amaçla kullanıma uygun nitelikte olduğu görülmüştür. Genel bir değerlendirme yapıldığında ise incelediğimiz üzüm çeşitleri için 4., 5., 6., 7. ve 8. göz düzeylerinden en az birinin yer aldığı çoğaltma materyallerinin, çelikle çoğaltma için kullanılabileceği görüşü oluşmuştur.

Sonuç olarak, üzüm çeşitlerini tek gözlü dal çelikleri ile çoğaltma yöntemi hızlı, pratik, kolay ve maliyet bakımından uygun bir çoğaltma yöntemi olarak önemini korumaktadır. Nitekim bu yöntem az sayıdaki bitki materyalinden çok sayıda bitki elde etmeye olanak sağlamaktadır. Bu anlamda giderek artan kaliteli dikim materyali ihtiyacına cevap verebilecek niteliktedir. Ancak tüm bu artılarına karşın bu yöntemle çoğaltılacak asma fidanlarının, filoksera ile bulaşık olan alanlarda bağ tesisinde kullanımının mümkün olmadığı gerçeği de unutulmamalıdır. Daha önce tarım veya bağcılık yapılmamış ve filokseradan ari alanlarda, deneysel araştırmalarda, topraksız bağcılık yapılan örtü altı üretim alanlarında ve benzerinde, üzüm çeşitlerinin çoğaltım için en uygun olan göz düzeylerinden alınarak tek gözlü çeliklerle çoğaltılmak suretiyle üretilmiş asma fidanları kullanılabilir.

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OPTIMIZING SPEECH KEYWORD SPOTTING TASKS UNDER NARROWBAND ENVIRONMENTS USING CONVOLUTIONAL NEURAL NETWORKS

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ABSTRACT

Introduction and Purpose: Narrowing speech frequency spectrum is essential in some application areas such as cellphones and TV broadcasts for effective usage and implementation. Speech keyword spotting under narrowband conditions is a daunting challenge. It is a well-known fact that when a speech signal is hipass filtered with a threshold of up to 700 Hz, it is still able to preserve its intelligibility and speaker related characteristics including speaker gender, emotional state and even fundamental frequency. This study focuses on the keyword spotting task in speech recognition under narrowband environments using convolutional neural networks.

Materials and Methods: Speech Command Dataset (SCD) version 2 (Warden, 2018) is used including more than 100,000 samples and 35 keywords. The data is bandpass filtered between 300-7000 Hertz in the first experiment and between 500-7000 Hertz in the second experiment. MFCC (Mel Frequency Cepstral Coefficients) (Bridle & Brown, 1974) were extracted including first order delta coefficients. Experiments were run under Colab A100 GPUs using a convolutional neural network with Adam optimizer (Kingma & Ba, 2017).

Results: In the first experiment, data is bandpass filtered between 300 Hertz-7000 Hertz and 88.96% accuracy is obtained. In the second experiment, data is bandpass filtered between 500 Hertz-7000 Hertz and 86.84% accuracy is obtained.

Discussion and Conclusion: The frequency 500 Hertz is selected to investigate the effects in the recognition performances because 500 Hertz is the borderline for the first formants of the vowels and some consonants. By removing it, the first formant from all vowels and even some consonants have been erased. The accuracies are nearly 10% lower compared to the wideband experiments and it can be concluded that there is still too much works to overcome the difficulties in narrowband keyword spotting.

Key Words: Keyword Spotting, Speech Recognition, MFCC, Convolutional Neural Networks

BIBLIOMETRIC ANALYSIS OF THESIS INVESTIGATION OF THE EFFECTS OF OMEGA 3 SUPPLEMENTATION ON BLOOD LIPID LEVELS IN THE FIELD OF NUTRITION AND DIETETICS

BESLENME VE DİYETETİK ALANINDA OMEGA 3 DESTEĞİNİN KAN LİPİD DÜZEEYLERİNE ETKİLERİNİN İNCELENDİĞİ TEZLERİN BİBLİYOMETRİK ANALİZİ

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ÖZET

Giriş: Omega 3 yağ asiti vücudumuzun sentezleyemediği elzem çoklu doymamış bir yağ asitidir. EPA ve DHA açısından zengin omega 3'ün kan lipid değerleri, kardiyovasküler, Tip 2 diyabet ve metabolik sendrom üzerine iyileşme sürecinde faydalı olabileceği düşünülmektedir. Bu çalışmanın amacı Türkiye'de omega 3 desteğinin kan lipid düzeyleri üzerine etkilerinin incelendiği lisansüstü tezleri bibliyometrik analiz şeklinde incelemektir.

Materyal ve Yöntem: Veriler Yükseköğretim Kurulu Ulusal Tez Merkezi Arşivi'nde veri tabanında "omega 3" anahtar kelimesi ile yapılan tarama sonucunda Beslenme ve Diyetetik alanında yapılan 33 teze ulaşılmıştır. Tarama sırasında çıkan tezlerin içerikleri incelenerek omega 3 alımının kan lipid parametreleri üzerine etkilerinin incelendiği 12 tez; tezin yılı, yapıldığı üniversite, tez türü, örneklem grubu ve tezden elde edilen bulgular açısından incelenmiştir.

Bulgular: Tezler yıllara göre incelendiğinde 2005'te 1, 2008'de 3, 2011'de 2, 2020'de 1, 2022'de 4 ve 2023'te 1 adet tez bulunmuştur. Tezlerin 6'sı yüksek lisans, 6'sı doktora tezi şeklindedir. Tezlerin 3tanesi hayvanlar üzerine yapılmış çalışmalar iken 9 tanesi insanlar üzerinde yapılmıştı. Tezlerin 5'i vakıf, 7'si devlet üniversitelerinde yapılmıştı. Çalışmalar arasında bazı farklılıklar bulunmakla birlikte omega 3 desteğinin genel olarak kan lipid profili (ALT, AST, HDL, LDL, TG vb.) üzerine olumlu etkileri olabileceği düşünülmektedir.

Sonuç: Bu analizde Türkiye'de Beslenme ve Diyetetik alanında omega 3 desteğinin kan lipit düzeyleri ile ilgili alanında yapılan tezlerin sınırlı sayıda olduğu görüldü. Omega 3 desteğinin kan lipid düzeyleri üzerine etkisi ile ilgili daha net sonuçlara ulaşabilmek için bu konuda çalışma sayısının arttırılmasına ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Bibliyometrik analiz, Omega 3 desteği, Kan lipid düzeyi, Lisansüstü eğitim

ABSTRACT

Introduction: Omega 3 fatty acid is an essential polyunsaturated fatty acid that our body cannot synthesize. It is thought that omega 3, rich in EPA and DHA, may be beneficial in the recovery process on blood lipid values, cardiovascular, Type 2 diabetes and metabolic syndrome. The aim of this study is to examine the postgraduate theses in Turkey examining the effects of omega 3 supplementation on blood lipid levels in a bibliometric analysis.

Material and Method: Data As a result of the search conducted with the keyword "omega 3" in the database of the Council of Higher Education National Thesis Center Archive, 33 theses in the field of Nutrition and Dietetics were reached. The contents of the theses found during the search were examined and 12 theses examining the effects of omega 3 intake on blood lipid parameters were examined in terms of the year of the thesis, university where it was conducted, thesis type, sample group and the findings obtained from the thesis.

Findings: When the theses were examined by year, 1 theses were found in 2005, 3 in 2008, 2 in 2011, 1 in 2020, 4 in 2022 and 1 in 2023. 6 of the theses were master's and 6 were doctoral theses. While 3 of the theses were studies on animals, 9 of them were on humans. 5 of the theses were conducted in foundation universities and 7 in state universities. Although there are some differences between the studies, it is thought that omega 3 supplementation may have positive effects on blood lipid profile (ALT, AST, HDL, LDL, TG etc.).

Conclusion: In this analysis, it was seen that there are a limited number of theses in the field of Nutrition and Dietetics in Turkey regarding omega 3 supplementation on blood lipid levels. In order to reach clearer results regarding the effect of omega 3 supplementation on blood lipid levels, the number of studies on this subject needs to be increased.

Keywords: Bibliometric analysis, Omega 3 supplementation, Blood lipid level, Postgraduate education

Giriş

Bilgi, çağlar boyunca insanların önem verdiği bir olgudur. Bu yüzden insanlık bilgi kaynaklı çalışmaları sayesinde teknoloji, sağlık vs. gibi alanlarda birçok gelişme göstermiştir. Günümüzde bilgiye ulaşım, bilgi miktarı artmış durumdadır. Bununla birlikte veri kalabalıklığı ile dolu literatürün içinde doğru bilgiyi ayıklama, güvenli kaynak ve güncellik oldukça önemlidir. Bunun için kullanılabilecek ideal bir yöntem de bibliyometrik analizdir (Berkman, 2009).

Kavram olarak bibliyometriden ilk bahseden kişi 1969 yılında Alan Pritchard'tır. Kendisi bibliyometriyi; yazılı iletişimin istatistik ve matematiksel yöntemlerle değerlendirerek iletişim süreçleri ve bir bilim alanının gelişiminin, gerçekliğinin ortaya konulması şeklinde tanımlamıştır (LAWANI, 1981). Bibliyometrik çalışmalar bu isim ile yapılmasa da aynı uygulama yöntemi ile çok daha eski 1900'lü yılların başında da kullanılmaktaydı. Örneğin 1917'de Cole ve Eales tarafından yapılmış anatomi üzerine 1550 - 1860 yılları arasındaki çalışmaların karşılaştırmalı analizi bu alanda ilklerdendir (Okubo, 1997). Bibliyometrik analiz, herhangi bir alanda yapılmış çalışmaların istatiksel ve matematiksel yöntemlerle incelenmesi olarak tanımlanmaktadır (Pritchard, 1969). Bibliyometrik analiz ile çalışmalar; yazar, konu, üniversite, bilim dalı vb, açılardan istatiksel olarak incelenir. Aynı zamanda çalışma konusu; sonuçları ve sosyal yapısı açısından da ortaya konulmaktadır (Çetinkaya Bozkurt & Çetin, 2016).

Diyetimizde aldığımız yağ asitlerinin türü ve oranı organizmamızı önemli ölçüde etkilemektedir. Trans ve doymuş yağ asitleri yerine tekli doymamış yağ asitleri ve çoklu doymamış yağ asitleri tercih edilmelidir (Albracht-Schulte et al., 2018). Omega 3 gibi EPA ve

DHA açısından zengin çoklu doymamış yağ asitlerinin beslenmemizde çok bulunması vücudumuzda hipotrigliseridemik, kardiyoprotektif ve antiinflamatuar olumlu etkilere sebep olabildiği rapor edilmiştir (Albracht-Schulte et al., 2018; Sala-Vila et al., 2016).

Vücudumuzda birçok yağ asidi sentezlenebilirken α-linolenik asit sentez için gerekli desatüraz enzimini üretememektedir. Bu yüzden omega 3 yağ asidi dışarıdan alınması gerekli esansiyel bir yağ asitidir. Omega 3 yağ asidi; yağlı balıklar, planktonlar, ceviz ve keten tohumunda bol bulunur. Bitkisel kaynaklı bir omega 3 yağ asidi olan α-linolenik asitin kaynakları ise ceviz, chia tohumu, keten tohumu, kanola yağı, soya fasulyesidir. Somon balığı, sardalya ve ringa balığı gibi yağlı soğuk iklim balıklarında da EPA ve DHA bulunmaktadır. Bunlar en elzem yağ asitleridir (Saini & Keum, 2018).

Omega 3'ün beyin, böbrek ve karaciğer dokularında iyileşme yaptığı Tip2 DM, hipertansiyon, KVH, romatoid artrit ve çeşitli merkezi sinir sistemi hastalıklarının önlenmesi ve tedavisinde pozitif etkisi olduğu bilinmektedir (Ruxton et al., 2004). Özellikle diyetle alınan sağlıklı yağ tüketiminin kan lipid değerlerini olumlu etkileyerek kalp-damar sağlığı için önemi üzerine durulmaktadır.

Son zamanlarda yapılmış çalışmalar omega 3 alımının Tip2DM, obezite ve Gestasyonel DM hastalarının metabolik profilleri üzerine olumlu etkilerini göstermektedir. Birçok çalışma dolaşımdaki omega 3 seviyesinin Tip2DM riski ile negatif ilişki halinde olduğunu söylemektedir. Omega 3 alımının diyette önerilen miktardan az olması kardiyometabolik hastalıklar ve ölümle ilişkili bir diyet bileşeni olduğu belirtilmiştir. Gözleme dayalı çalışmaların çoğu omega 3 alımının artması ile kardiyometabolik riskte azalma ve omega 3'ün kan lipid seviyelerini, inflamasyon ve endotel fonksiyon üzerine etkileri olduğunun bildirmektedir (O'Mahoney et al., 2018).

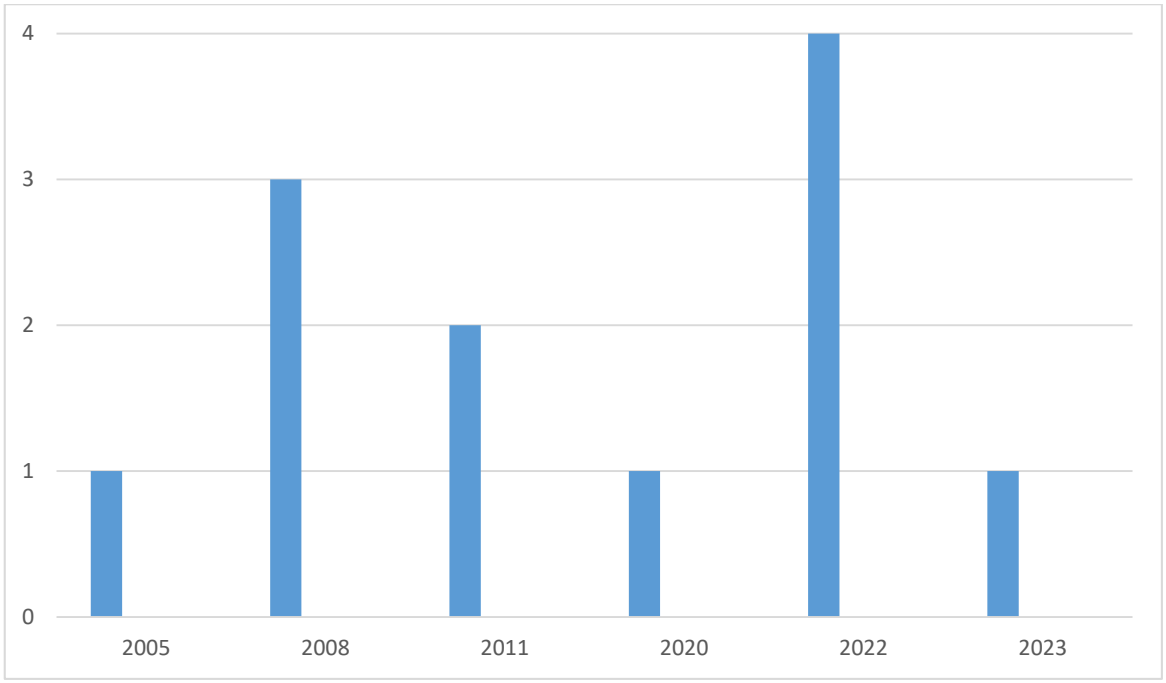
Gereç ve Yöntem

Yükseköğretim Kurulu Ulusal Tez Merkezi (YÖKTEZ)'nin dijital arşivinden "Omega 3" konulu tezler tarandı. Beslenme ve Diyetetik alanında yapılmış YÖKTEZ tarafından açık erişim ile ulaşılabilen tezler değerlendirmeye alındı. Bu kapsamda ulaşılan 33 tezden 12'sinde "Omega 3 ve kan lipid profili üzerine etkileri ile ilgili içeriğe sahip olduğu sonucuna ulaşıldı.

Tezler; tezin yapıldığı yıl, tezin yürütüldüğü üniversite (devlet veya vakıf), tezin kimler üzerine yapıldığı ve tezlerin türlerine (yüksek lisans ve doktora) göre incelendi.

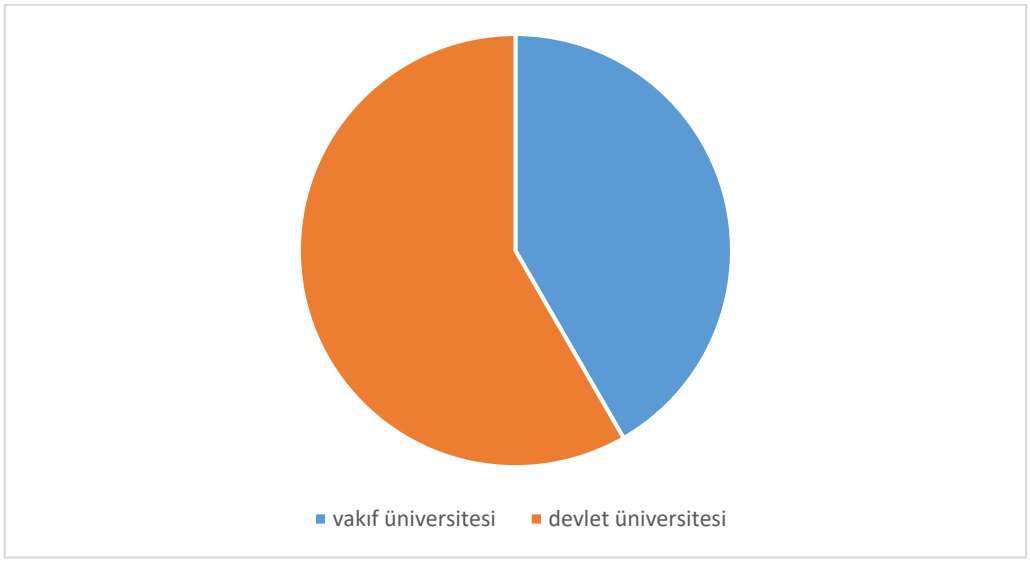
Bulgular

YÖKTEZ'de yapılan literatür taraması sonucunda 12 teze ulaşıldı. Bu tezlerin 1'inin 2005 yılında, 3'ünün 2008 yılında, 2'sinin 2011 yılında, 1'inin 2020 yılında, 4'ünün 2022 yılında ve 1'inin 2023 yılında yapıldığı belirlendi (Şekil 1).



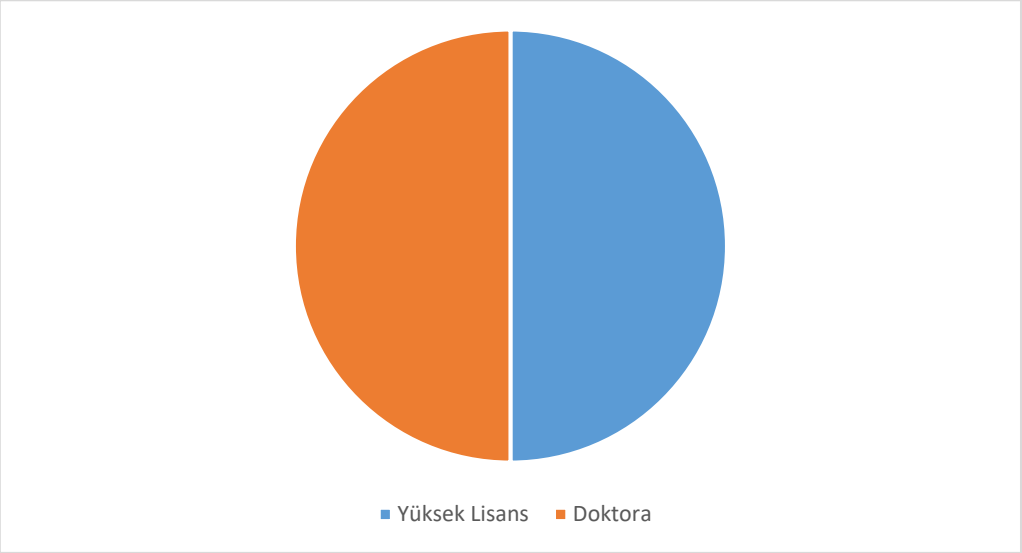
Şekil 1. Tezlerin yıllara göre dağılımı

Ulaşılan tezlerin yapıldığı üniversitelere bakıldığında; 5'i vakıf, 7'si devlet üniversitesi olduğu görülmüştür.



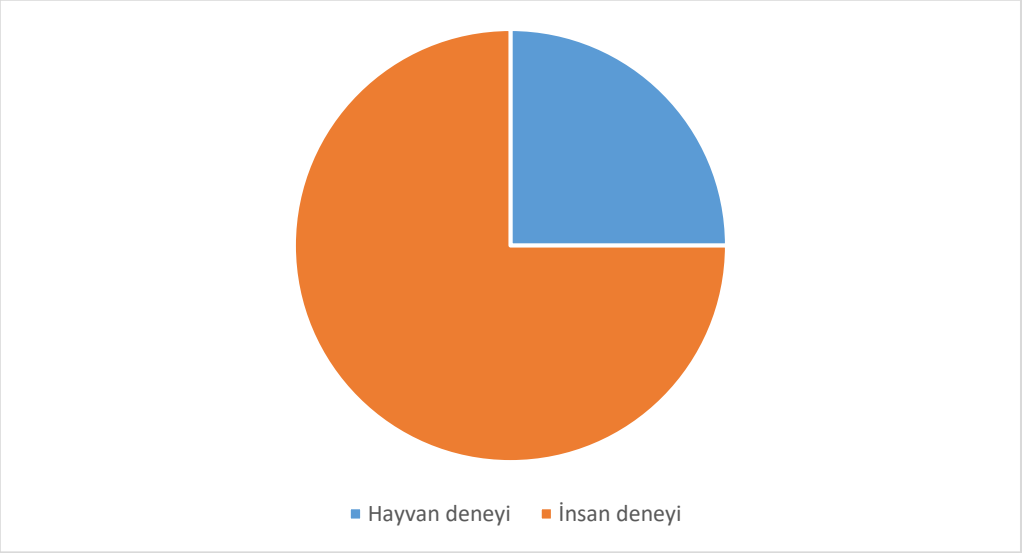
Şekil 2. Tezlerin üniversitelere göre dağılımları

Tezlerin %50'si (n=6) yüksek lisan tezi iken %50'sinin de doktora tezi (n=6) olduğu sonucuna ulaşılmıştır.



Şekil 3. Tezlerin türüne göre dağılımları

Tezlerin kimler üzerine yapıldığı incelendiğinde %25'i (n=3) hayvanlar üzerine iken, %75'i (n=9) insan kaynaklı çalışmalardır.



Şekil 4. Tezlerin denek gruba göre dağılımı

Tartışma

Tezler incelendiğinde çalışmalarda genelde; omega 3 takviyesi alımının karaciğer yağlanması, serum lipid değerleri ve kardiyovasküler hastalıklar riski üzerine etkilerine bakılmıştır. Omega 3 desteğinin beyin, böbrek ve karaciğer dokularında düzeltme yaptığı görülmüştür. Sıçanlar üzerine yapılan çalışmalarda verilen omega 3 takviyesinin genelde 200-300 mg/kg/gün olduğu ve deneyler 8 haftalık yapılmaktadır.

Çalışmalar kan glukoz ve lipid seviyeleri (ALT, AST, TG, HDL, LDL, TOTAL KOLESTEROL) üzerine odaklanmıştır. Çalışmalar arasında farklılıklar görünmekle birlikte genel olarak omega 3 desteğinin kandaki lipid seviyesi için olumlu etki gösterdiği HDl'yi yükselttiği, LDL'yi düşürdüğü, TG'yi düşürdüğü, ALT ve AST değerleri üzerine olumlu etki ettiği sonucuna ulaşılmıştır. Buna karşılık bazı çalışmalarda ise omega 3 takviyesi alanlarda bu değerler üzerine herhangi bir anlamlı farklılık tespit edilemediği bazı parametreler düzelirken

bazılarının değişmediği belirtilmiştir. Çalışmalardaki tüm bu farklılıklar, bize çalışmaların hazırlanma aşaması, yürütülme kısmının daha iyi yapılması gerektiği ve bu konuda kapsamlı daha çok çalışma yapılması gerektiğini düşündürtmüştür.

Sonuç

Omega 3 bilindiği gibi günümüzde çok kullanılan bir besin destek ürünüdür. Beraberinde kandaki lipid değerlerinin bozulması ile ilişkili kardiyovasküler hastalıklar, karaciğer yağlanması, hipertansiyon vb. hastalıklar çağımızın sorunlarındandır. Bu analizde Türkiye'de Beslenme ve Diyetetik alanında omega 3 desteğinin kan lipit düzeyleri ile ilgili alanında yapılan tezlerin sınırlı sayıda olduğu görüldü. İlgili tez çalışmaları çoğunlukla omega 3 desteğinin kanda lipid profilini iyileştirdiği fakat bazı çalışmalarda ise bazı lipid değerlerini iyileştirirken bazı değerler ise herhangi bir fark göstermediği sonucuna varılmıştır. Omega 3 desteğinin kan lipid düzeyleri üzerine etkisi ile ilgili daha net sonuçlara ulaşabilmek için bu konuda çalışma sayısının arttırılmasına ihtiyaç duyulmaktadır.

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THE DEFICIENCY IN THE PRINCIPLE OF FAIR TRIAL AND LEGAL SECURITY DUE TO THE COURTS' DIFFERENT DECISIONS ON LEGAL DISPUTES OF THE SAME NATURE

AYNI NİTELİKTEKİ HUKUKİ İHTİLAFLARA MAHKEMELERCE FARKLI KARARLAR VERİLMİŞ OLMASIYLA ADİL YARGILAMA VE HUKUKİ GÜVENLİK İLKESİNİN ZEDELENMESİ

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ABSTRACT

The right to a fair trial is the most important guarantee of fundamental rights and freedoms and of people themselves as a natural result of the fact that all people are human beings. The realization of the ideal of the rule of law, which is one of the main goals of a democratic administration, depends only on the effectiveness of a fair trial. It is possible with the internalization of this as a mandatory duty of the state and a fundamental right for individuals. The right to a fair trial is included in Article 6 of the European Convention on Human Rights. There is no clear regulation in the Convention regarding different decisions being given for the same incident.

European Court of Human Rights (ECHR) accepts that the resolution of complaints regarding this matter is a problem of the domestic law of the contracting states, and that an examination of whether the decisions made by national courts are similar to each other cannot be conducted, as the Convention does not empower the European Court of Human Rights (ECHR) in this regard. The Strasbourg court does not consider whether the national judicial authorities have come up with a result suitable for the purpose intended to be reached by the agreement on resolving the entanglements by interpreting their own domestic legal rules.

It is understood from here that if the court does not make an arbitrary interpretation, the issue of how the domestic law rules are interpreted is not considered within the scope of the right to a fair trial. This situation, which is clearly contrary to the principle of legal security, makes court decisions controversial and undermines trust in the judiciary. The European Court of Human Rights has remedied the deficiency in the regulation in Article 6 of the convention, which includes the right to a fair trial, through interpretation, since no regulation has been made in the article. Accordingly, the principle of legal security, which is an essential element of the rule of law principle contained in the preamble, has been evaluated together with the right to a fair trial, providing the basis for the binding nature of final provisions and acceptance by society.

The fact that courts at the same level give different decisions on similar incidents in the same judicial system is a situation that damages the principle of legal certainty, violates the right to a fair trial and requires correction.

With this review, it is aimed to identify issues arising in domestic law and examined in the ECHR’s decisions and to bring solution suggestions.

Keywords: Right to a Fair Trial, Legal Security, European Court of Human Rights (ECHR)

GİRİŞ

Devlet hukukun kurallarını koyarken karmaşık bir sistemin inşasının farkında olmalıdır. Devletin bir hukuk devleti olmasını sağlayacak tüm kurumların eksiksiz olarak fonksiyonlarını yerine getirecek tarzda oluşturulmalıdır. Hukuk kurallarının normlar hiyerarşisine uygun olarak hayata geçirilmesi sağlanmalıdır. Zira normlar hiyerarşisi temel hak ve özgürlüklerin koruyuculuğu fonksiyonunu ifade eder. Kurallara tabi olan sınırlı bir iktidarın ortaya çıkmasına yol açan hukuk devleti, yöneticilerinin yasaların üzerinde yer almamasını sağlayan hukuk tarafından çerçevelenen ve düzenlenen bir işleve sahip olmalarını belirtir. Günümüzde bütün iktidarların meşruluklarının görünüşteki güvencesi haline gelmiştir ama bu kimi ülkelerde "anayasacılıksız anayasa" kavramını da beraberinde getirmiştir. Hukuk devletinin en önemli vasfı, devlet iktidarının sınırlandırılmasını sağlamak ile temel hak ve özgürlükleri güvence altına almış olmasıdır. Bu aşamada iki husus öne çıkar. Bunlardan birincisi hukuk devleti kavramının enstrümanlarının neler olduğu, ikincisi ise iktidarın sınırlandırılması ile sağlanacak olanın ne olduğudur. Burada önemli enstrüman katı, şekli bir anayasadır. Anayasaya aykırı olmayan normlarda hukuk devletinin sürdürülebilir olmasının şartıdır. Bunun gerçekleşmesi ise anayasa yargısının etkin denetimi ile olur.

HUKUK DEVLETİ

Hukuk devleti ilkesi, devletin üç kurucu unsurunun hukuka bağlı olmasıyla gerçekleşebilir. Yasama organının Anayasayla kendisine verilmiş görev ve yetkilerinde hukuka bağlı olarak hareket etme zorunluluğu vardır. Yasama fonksiyonunun yerine getirirken Anayasaya aykırı kanun yapmamalıdır. Yaparsa Anayasa Mahkemesi tarafından iptal edilir. Hukuk devletinin gerçekleştirilmesinde yürütmenin tüm faaliyetlerinin hukukun hakimiyeti altında olması gerekir. Yürütmenin yasaya karşı gelmemek, yasanın üstünlüğünü kabul etmek ve yasal bir yetkiye dayanarak hareket edebileceğinin bilincinde olması gerekir. Yürütme ve idarenin her türlü eylem ve işlemlerinin yargı denetimine tabi olacağını bilmeleri ve buna göre hareket etmeleri gerekir. Yargı organı da yargılama faaliyetlerini yerine getirirken hukuk kurallarıyla bağlı olmak zorundadır. Anayasa 138'ci maddesinde, hâkim anayasaya, kanuna, hukuka ve vicdani kanaatine göre karar verir derken, yapılabilecek olası müdahaleleri de yasaklayarak mahkemelerin hukuktan ayrılmamasını sağlamayı hedefler. 1982 Anayasasının 11'inci maddesinde, anayasanın yasama, yürütme ve yargı organlarını bağlayan temel hukuk kuralları olduğu ifade edilmiştir.

Hukuk devleti ilkesi devletin hukuku yapısına güveni oluşturur. Hak sahibinin haklarının korunmasını talebi adil bir hukuki süreci başlatmalıdır. Bu sürecin ilk aşaması hukuki korunma hakkıdır. Bu hak devletin cevap vereceği bir haktır, muhatap devlettir. Devlet bu korumayı mahkemeler vasıtasıyla yapacaktır. Devletin görevi, hak arayan hak sahibinin mahkemeye erişim hakkını sağlamaktır. Yargı örgütü ülkenin adalet hizmetlerinin ideal düzeyde yerine getirecek şekilde oluşturulmalıdır.

Hukuk devleti ilkesinin varlığı pek çok ilkenin hak ve hürriyetin yeri geldikçe birlikte fonksiyon ifa etmesiyle mümkündür. Ancak hukuk devleti için olmazsa olmaz iki temel anlayışın incelenmesi gerekir. Bunlar yargı yetkisinin kullanımında hep var olan Hukuk Güvenliği İlkesi ve Hukuki Belirlilik ilkesidir.

Hukuk Güvenliği ve Hukuki Belirlilik

Hukuk güvenliği ilkesi hukuk devletinden de önce ortaya çıkmış bir ilkedir. Devletteki hukuk kurallarının herkes tarafından bilinebilir olmasını ve bununla beraber bu normların uygulamasının kişiler açısından ne gibi hak mahrumiyetlerine uğrayabileceklerinin öngörülebilir hale getirilmesidir. Anayasa mahkemesine göre: hukuki belirlilik ilkesi yasal

düzenlemelerin hem kişiler hem de idare yönünden herhangi bir duraksamaya ve kuşkuya yer vermeyecek şekilde açık net anlaşılır ve uygulanabilir olmasını, ayrıca kamu otoritesinin keyfi uygulamalarına karşı koruyucu önlem içermesini ifade etmektedir. Alman Anayasa Mahkemesi de hukuki metinlerin yurttaşların normun içeriklerini ve eylemlerinin sonuçlarını takip edebilmelerini sağlayacak kesinlikte açıklıkta ve netlikte yazılmalıdır demektedir. Hukuk güvenliği ilkesi, hukukun kalitesinin geliştirilmesine de katkı sağlar. Fransız anayasa konseyi de yasaların kalitesinin iyileştirilmesinin sağlanmasını, son dönemlerdeki vermiş olduğu kararlarında sıklıkla işaret etmektedir. Konsey yasa koyucudan hukuk öznelerin anayasaya aykırı bir yoruma ya da keyfilik riskine karşı korunmalarını sağlayacak kadar net hükümler ve muğlak olmayan formüller benimsenmesini istemektedir.

Hukuki belirlilik ile hukuk güvenliği iç içe geçmiş birbirinin tamamlayıcısı iki ilkedir. Kişinin devlet karşısındaki konumunu, devletin vatandaşa yönelik davranışlarının sınırlarını, bu ilişkideki kuralların neler olduğunun bilinmesi gerekir. Bu kuralların nasıl uygulanacağı, vatandaşlar üzerindeki tesirlerinin ne olacağının öngörülebilmesi, toplumsal düzenin sağlanması açısından gereklidir. Devlet birey ile ilişkisini, güven temeli üzerinde tesis etmelidir. Hukuk devleti şeffaf, inandırıcı, güven veren bir yapıda olmalıdır. Mahkemelerde verilen kararlarının güven sarsıcı olarak, aynı nitelikteki olaylara farklı kararlar verilerek kararlardaki ortaya çıkan tutarsızlıklar, hukuki güvenliği ve hukuki belirlilik ilkelerinin gerçek hayatta olmadığına dair işaretler olarak anlaşılır.

Gerçekten mahkemelerin benzer olaylarda aynı maddeyi karara dayanak yaparak farklı sonuçlar ortaya çıkarması ve birbirinden farklı kararlar vermesi hukuk adına kabul edilebilir değildir. Hukuk güvenliği ve hukuki belirlilik ilkelerini yok eden bir anlayışla verilmiş kararlar toplum düzeni içerisinde adalete olan inancın zedelenmesi demektir. Hukuk güvenliğini ortadan kaldıran, hukuki belirlilik ilkesini yok sayan mahkeme kararları, tüm yargı dalları için söz konusu olabilmektedir. Daha çok özel hukuk ve ceza hukuku alanındaki uyuşmazlıkların giderilmesine yönelik başvurularda olacağı beklenilirken gerek AİHM gerekse Anayasa Mahkemesi bireysel başvurularında İdari Yargı görev alanına giren davalarda da aynı şikayetlerin gündeme geldiği görülmektedir.

Aynı maddi vakalardan kaynaklanan davalarda farklı karar verilmesini hakkaniyete uygun yargılama hakkı kapsamında incelemek gerekecektir Anayasa Mahkemesi de maddi olayların yorumunun mahkemeye ait olduğunu, maddi vakaların farklı değerlendirilmesinin farklı kriterlere ulaşılmasına ve birbiriyle çelişik kararlar verilmesini de mümkün hale getirmekte olduğunu ifade etmektedir.

O zaman da aynı vakanın farklı değerlendirilmesi ve yorumlanmasına bağlı olarak adil yargılama hakkı ihlal edilmiş olacaktır. Adil yargılanma hakkının ihlali, hukuk devleti kapsamındaki hukuki güvenlik ve hukuki belirlilik ilkelerinin yok sayılmasına neden olacağından, Hukuk Devleti ve Adil Yargılanma hakkı ilişkisinin bir bütünlük içerisinde olduklarını gösterir. Parçalardan herhangi birindeki bozulma, diğerine de sirayet eder.

ADİL YARGILANMA HAKKI

İnsan Hakları Avrupa Sözleşmesi sisteminin temeli "Adil Yargılanma Hakkı'na" dayalıdır. Adil yargılama hakkının koşulları, Avrupa insan hakları sözleşmesinin altıncı maddesinde yer almaktadır. Herkesin dava açma ve davalara katılma hakkına sahip olduğunu, medeni hak ve yükümlülüklerine ilişkin uyuşmazlıklar ya da cezai alanda kendisine yöneltilen suçlamaların esası konusunda karar verecek olan yasayla kurulmuş, bağımsız ve tarafsız bir mahkeme tarafından, kamuya açık olarak ve makul bir süre içerisinde görülmesini isteme hakkına sahiptir. Bu kural Türkiye tarafından da uluslararası sözleşmelerin bir kanunla uygun bulunmasıyla bir iç hukuk kuralı haline gelmiştir. AİHS'nin 6'ncı maddesinde adil yargılama hakkının tam bir tanımı yoktur. 1982 Anayasasının 36'ncı maddesinde hak arama hürriyeti içerisinde yer alan

Adil Yargılanma Hakkında da bir tanım yoktur. Herkesin adil yargılama hakkına sahip olduğu belirtilmekle yetinilmiştir.

Bu temel ilke tatbiki tek başına adil yargılanma hakkının içeriğini izaha yeterli değildir. Bu ilkenin içeriği AİHM yargı sürecindeki içtihatlarla gelişmiştir. Yargılama sürecinde uygulanacak hukuk kuralları çok önemlidir. Ulusal Hukuk, Uluslararası Hukuk, AİHS ve Sözleşmenin eki protokoller içerikleri ve AİHM İçtihatları, uygulanan kurallar olmuştur Özellikle AİHM içtihatları davalarda uygulanacak, adeta öncü bir norm haline gelmiştir. Bu kurallar bütünü adil yargılanma hakkının gerçekleşmesinde en önemli kilometre taşlarıdır. Aslında çok geniş bir yelpaze olan adil yargılanma hakkı içerisinde; yargılanma öncesi, yargılanma safhası ve yargılanma sonrasını birlikte değerlendirmek gerekir. Bütün yargılama safhalarını kapsar. Adil yargılanma hakkı sonucunun, adil karar verme, hakkaniyetli karar verme ve verilen kararların kamu vicdanında bir tatmin duygusunun gerçekleştirilmesini sağlama mecburiyeti de vardır. Sorun bunun nasıl sağlanacağında toplanmaktadır. AİHS'nin hukuki bir metin olarak çerçeve oluşturma amaçlı olduğu anlaşılmaktadır. Bu bağlamda adil yargılama hakkı tüm ayrıntılarıyla düzenlenmemiştir. Sözleşmenin altıncı maddesini oluşturan adil yargılama hakkının gerçekleştirilmesinin, bağımsız tarafsız bir mahkeme önünde yargılanmanın yapılmasının, bu mahkemenin kanunla kurulmuş olmasının, yargılamanın makul bir süre içinde gerçekleşmesinin, yargılamaların aleni olmasının ve hakkaniyete uygun olarak yapılmasının yönelik bir çerçeve oluşturduğu gözden uzak tutulmamalıdır.

Mahkeme hak sahibinin yargılama sürecindeki tüm iddia ve savunmalarını dinlemeli, ilgili yerlerden delillerin getirilmesini sağlamalı, delillerini incelemeli, tarafların tahkikat aşamasındaki davaya ilişkin tüm beyanlarını dinlemeli ve taraflar kendilerinin dinlenilmediği endişesine düşürülmemelidirler. Hak sahibinin hakkı ile ilgili iddialarının ve karşı taraf savunmalarını adil eşitlikçi bir yargı süreci içerisinde incelenerek yargı organınca karara varılmasını istemesi, her iki taraf için de adil yargılanma hakkının yerine getirildiğinin ve bir hukuk devletinin varlığının ifadesidir.

Taraflar devletin yargı fonksiyonunu yerine getirirken hakkaniyetli bir yargılanma ve bunun sonunda adil bir kararın verilmesini, beklerler. Mahkemelerin benzer olaylarda aynı nitelikte kararlar vermesi ve hukuki belirlilik hem de tarafların fiilleri neticesinde kendisine uygulanacak yasa kurallarını ve bunların sonuçlarını ön görülebilmesinin de gerçekleşmesi, devletin adil yargılama hakkının gereklerini yerine getirmesidir.

AYNI KONUDAKİ DAVALARDA FARKLI KARARLARIN VERİLMESİ

Adil yargılama hakkı kapsamında, Adil yargılanma hakkının ihlaline ilişkin şikayetler, Aynı konuda yargılama makamları tarafından farklı kararların verildiği iddiasına dayanmaktadır. Başvuruculaların şikayetleri kendileri açısından somut bir gerçekliğe dayanmaktadır. Taraf oldukları bir davada umdukları bir neticeyle karşılaşmamış olmaları Buna karşılık aynı nitelikte görülmekte olan bir davanın sonundaki verilmiş olan kararların kendileri açısından da verilmesi gerektiğini bu sebeple hukuki güvenliğin ihlal edildiği keza hukuki öngörü ve hukuki belirlilik ilkelerinin ihlaliyle, hukuk devleti ilkelerinin ve adil yargılanma hakkının ihlal edilmiş olduğunu, adil ve hakkaniyetli bir karar çıkmadığı inancıyla şikâyet hakkını kullanmaktadırlar.

Bireysel başvuru yoluyla yapılan Anayasa Mahkemesi şikayetleri ile Avrupa insan Hakları Mahkemesi bu yöndeki şikayetleri inceleme hususunda kurallara uygun olma şartı getirmişlerdir.

1982 Anayasasının 148/4 maddesinde ve 6216 sayılı Anayasa Mahkemesinin Kuruluşu ve Yargılama Usulleri Hakkında Kanunun 49/6 maddesinde, kanun yolunda gözetilmesi gereken hususlarda inceleme yapılamaz hükmünü getirilmiştir. Bu durumda yeniden temyiz incelemesi yapılması anlamına gelecek olan başvuruların reddi gerekecektir.

AİHM, adil yargılama hakkının ulusal mahkemelerin kararlarının doğru veya yanlış olup olmamasını değil, başvurucuya iddialarını dile getirmesine, delillerini ibraza, delillerin toplanması, değerlendirilmesi gerekirse bilirkişi incelemesinin yapılması ve özellikle gösterilen tanıkların hangi konuda dinleneceğinin beyanının alınmasıyla tanık dinlenmesinin mutlaka sağlanması ve karşı delilleri yürütebilmesi noktasında yeterli fırsatların tanınarak silahların eşitliği ilkesi çerçevesinde yargılamaya esas olan usul hükümlerinin eksiksiz uygulanması aramaktadır.. Mahkeme usulü adaleti sağlayan bir yargılamanın, sonucuyla ilgilenmeyeceğini söylemektedir. Gerçekten AİHM'si istikrarlı bir şekilde kendisinden temyiz mahkemesi gibi inceleme yapmasının beklenilmemesi gerektiğini, kendisinin ulusal mahkemelerce verilen kararları son aşama olarak tüm dosya kapsamının yeniden incelenmesi taleplerini asla kabul etmemektedir.

AİHM Sözleşmenin 6'ncı maddesinde belirtilen adil yargılanma hakkının unsurları olarak anlaşılan yasayla kurulmuş bağımsız ve tarafsız bir mahkemeye erişim hakkının engellenmesini, makul bir sürede aleni olarak hakkaniyete uygun olarak yani silahların eşitliği ilkesine göre davanın görülmesi hakkını, güvence altına almaktadır. Bu hakların ihlali halindeki şikayetlerde, mahkeme dosyayı incelemektedir.

AİHM ve Anayasa Mahkemesinin sözleşmenin 6'cı maddesine ilişkin inceleme alanının yargılamadaki usul hukuku işlemlerinin eksiksiz yerine getirilip getirilmediği hususuyla ilgili ve sınırlı olduğu, içtihatlarından anlaşılmaktadır. Ancak yargılamanın sonucuyla ilgilenmeyen mahkemenin önüne gelebilecek ve şimdilerde de çokça gelmekte olan aynı olaya farklı kararların verilmesi adil yargılama hakkının ihlali sayılmayacak mı?

Konunun bu yönüyle incelenmesinde bazı hukuki sorunlar öne çıkmaktadır. Bireysel başvuru aşamasında, derece mahkemeleri inceleme aşamalarından geçmiş olduğu belli olan dava dosyasının derece hukuk yollarının tüketildiğini, hükmün kesinleştiğini ve bireysel başvuru noktasına geldiğini göstermektedir. Mahkeme kararının kesin hüküm haline gelmiş olması, o'na toplum içerisinde ve hukuk dünyasında bir statü kazandırır. Kesin hükmün ile hukuk güvenliği ilkesi içerisinde sahip olduğu statü ile o artık herkes için geçerli bir mahkeme kararıdır. Ancak karar yanlış bir yasanın uygulanması suretiyle verilmişse ne olacaktır? Kesin hüküm olarak saygı görmeye devam mı edecektir? Şayet aynı hukuki olaya aynı mahkeme veya farklı mahkemeler farklı kararlar verirse, bu kararlar saygı gösterilecek kesin kararlar mı olacaktır? Bir ceza davasında topluca işlenen ve suçun faillerinin eylemlerinin aynı olduğu durumda sanıkların bir kısmının yakalanması bir kısmının kaçmış olması halinde, yakalananlara verilen cezalar ile sonradan yapılan yargılamalardaki cezaların benzer olmaması halinde verilen kararlara saygı duyulacak mı? Hakkaniyetle adil olarak verilmiş kararlar olarak mı kabul görecek? Aynı dosyada sanık olarak yargılanan aynı derecede sorumlu olan bir suça verilecek ceza, sanıkların ikrarı, tanık beyanları, bilirkişi incelemesi, adli tıp kurumu raporunda sabit olan eşit sorumluluk haline rağmen, faillere farklı cezalar verilebilmesi adil bir yargı sürecinin işlediğini mi gösterecektir.? Dosya içeriklerine göre bu soruları çoğaltmak mümkündür.

Ulusal zeminde ortaya çıkan aynı olaya farklı karar verilmesi konusunda, şikâyetin incelemesinde AİHM, kendisinin sorumluluk alanının sadece yargılama sürecindeki eksikliklerle ilgili olduğunu, mahkemelerin kararları yanlış uygulamalarının veya sanıklara farklı cezaların verilmesinin bir iç hukuk sorunu olduğunu kabul etmektedir. Mahkemelerin kanunları ne şekilde yorumlayarak karar verdiğinin, kendisinin sorunu görmemektedir. Açık hukuksuzluğu görmemekte, kulak tıkamaktadır. AİHM ancak aşikâr olarak hukuka aykırı olarak yapılmış yoruma dayalı bir mahkeme kararını, inceleme konusu yapmaktadır.

AİHM de gerçekleşmiş olan içtihat değişikliği ile açık hukuk ihlallerinin hukuki güven ilkesini zedeleyeceğini, hukuk güvenliğinin hukuk devletinin önemli göstergesi olduğunu, adil yargılanma hakkının ise hukuk devletinin bir unsuru olması nedeniyle adil yargılanma hakkı içerisindeki kıstaslar arasına farklı mahkemelerden aynı olay için verilmiş kararlar veya benzer

olaya farklı kararlar verilmesine ilişkin şikayetlerin kabulüne karar verdikleri görülmektedir. Ancak AİHM kararlarındaki bu içtihat değişikliğinin tümüyle kendilerini davaların sonuçlarını inceleyen bir temyiz mahkemesine dönüştürdükleri sonucu çıkmaz. Çünkü kendisini temyiz mahkemesi gibi görmeme kararlılığı devam etmekte olup, bu husus verdikleri kararlardan anlaşılabilmektedir.

Anayasa Mahkemesi de aynı yargı kolundaki mahkeme kararlarında bariz takdir hatası ve açık bir keyfilik olmadığı müddetçe kararların adil olmadığına ilişkin şikayetlerin geçerli hukuki dayanaktan yoksun olduğuna karar vermektedir. Ancak bu görüşünü kimi kararlarında bu tür kararların verilmiş olmasının hukuk güvenliğini zedelediğini, hukuki belirsizlik oluşturması nedeniyle şikayetlerin başvurularını kabul kararları vermektedir ve Adil yargılanma hakkının ihlalini kabul etmektedir.

SONUÇ

Devlet iktidarının sürdürülebilir olması devletin hukuk devleti ideallerine ulaşmış veya daha doğru bir ifadeyle ulaşma konusunda iyi niyetli bir gayretin içerisinde olmasına bağlıdır. Burada ifade edilen iyi niyet romantik bir iyi niyet değil; hukuki anlamda hakların kullanılmasında devletin inşasında sarf edilecek iradeyi ifade etmektedir. İktidarların gücü insanlara ait olan hakların sosyal sözleşmelerle devlete intikal ettirilmiş olması ortaya çıkmıştır. Hak sahipliği el değiştirmiş artık üzerinde hak iddia etmedikleri, edemedikleri haklar devlet tarafından kullanılmaktadır. Kendisine yönelik düzenlemelerinin hukuk kuralları olarak dönüşümünü umulmuş, bu çerçeve içerisinde oluşan hukuk kuralları devletlerin hayatlarında o kurallara uygun hareket edebildikleri müddetçe yaşamalarına imkân sağlanmıştır.

Milletin devlet düzeni içerisinde devlete inanarak güvenerek ve sorumluluklarını yerine getirerek yaşayabilmesinin en belirgin sebebi, devletin kuruluş felsefesindeki insanlara vadettiği ve insanların da bunu her daim görmek istedikleri güven ilkesinin varlığıdır. Devletin zaman içerisinde gelişimine uygun olarak, güven ilkesi hukuki güvenliği ilkesine dönüşmüştür. Bu dönüşüm devletin de hukuk devleti haline gelmesinde etkili olmuştur. Dolayısıyla hukuk güvenliği hukuk devletinin en önemli unsurlarından biridir. Kişilerin ve iktidarların normlar hiyerarşisindeki ilişkiyi iyi özümsemiş olmaları ve anayasanın üstünlüğünü kabul etmeleri gerekir. Hukukun üstünlüğünün kabul edilmesiyle devletin bir hukuk devleti haline gelmesi tüm kurumlarıyla temel insan hak ve özgürlüklerini güvence altına alabilmeleri ancak mümkün olacaktır. Bunun için gerek ulusal gerekse uluslararası düzeyde hukuk zemininde kişilerin temel hak ve özgürlüklerinin sağlanmasına çalışılacaktır.

Başarılı olunmasının en önemli göstergelerinden birisi adil yargılama hakkı kapsamı içerisinde insanlarda herhangi bir şüphe oluşturmadan, kanunların uygulanmasında, onların yorumlamasında yanlışlıklara düşülmemesidir. Ulusal düzeyde yapılan yargılamalarda aynı olaylarda farklı kararların verilmesi bir hukuk devletinde, hukuk güvenliği, hukuki bilinirlik ve adil yargılanma hakkı ilkelerinin varlığında kabul edilebilir bir şey değildir. İkinci bir gösterge ise, daha özenli ve dikkatli yargılama yapma sürecinin oluşturulmasını gerekli kılar. Üçüncü olarak yasaların hazırlanması sürecinde kanun metinlerinin net, kesin ve anlaşılır olma sorunu olmayan, yapılacak yorumun anlam değiştirmesine neden olacak şekilde bir dil kullanılmaması gerekliliği sonucu ortaya çıkar.

Gerek kanun yapımı aşamasında gerekse yargılamalar sürecinde yapılan hatalardan arınılmadığı sürece, Türkiye'nin insan hakkı ihlallerinin en ziyadesiyle yaşandığı bir ülke imajından ve AİHM, de en çok ihlal davaları olan ülkelerden biri kabulünden kurtulunamayacağını belirtmek gerekir.

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SHOULD THE TURKISH CONSTITUTIONAL COURT HAVE THE AUTHORITY TO SUSPEND THE ENFORCEMENT?

TÜRK ANAYASA MAHKEMESİNİN YÜRÜRLÜĞÜ DURDURMA YETKİSİ OLMALI MIDIR?

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ABSTRACT

The 'suspension of laws' is an important issue in terms of constitutional judiciary. This is because a law that has been accepted by the legislative body and put into force with the approval of the President is theoretically argued to reflect the will of the majority and therefore should not be impeded. On the other hand, it is considered reasonable for the Constitutional Court to give “suspension of execution” decisions, since they prevented irreparable consequences, even if unauthorized. It is suggested as the opposite view that they are inevitable in terms of social benefit. Which one is correct?

When focusing on the constitutional judiciary practices in Continental Europe, it becomes clear that there are different preferences and that the practices have developed within a legal framework, staying away from political considerations. In court decisions, while requests for the suspension of the law are generally rejected in Germany, in Belgium, if strong evidence emerges and it is understood that the entry into force of the law would lead to difficult-to-reverse consequences, the court can issue a suspension order. In Spain and Portugal, it is observed that after examining the reasons justifying the suspension of the law in question, if there is a valid justification, they have issued suspension orders.

The situation is quite complicated in terms of Turkish constitutional judiciary. Although the 'Suspension of Enforcement Authority' is not found in the 1982 Constitution and the founding law of the Constitutional Court, on October 21, 1993, the Constitutional Court issued a decision to suspend the enforcement of the statutory decree regarding the establishment of Türk Telekomünikasyon A.Ş. Although there had been requests for suspension of enforcement before this date, these requests were rejected because the Court did not have the authority. These rejection decisions were also experienced during the 1961 Constitution period for the same reason.

While the concept of lack of authority was prominent from its establishment until 1993, the Constitutional Court repositioned itself in the Telekom decision. It has been foreseen that applying the law whose annulment is requested during the period until the annulment decision may cause irreparable damages. In this case, it is seen that the social benefits provided by an unlawfully given suspension of enforcement outweigh the defensible aspects that the 'authority issue' would bring about, along with the discussions surrounding it.

With this study, we aim to contribute to the discussion on whether the Turkish Constitutional Court can give “suspension of execution” decisions without any dispute.

Keywords: Constitutional Court, suspension of enforcement, Decree-Law

GİRİŞ

1924 Anayasası döneminde Türkiye Büyük Millet Meclisinde 1946 yılına kadar sistem gereği Cumhuriyet Halk Partisinin tek parti olarak bulunduğu, 1950 sonrasında ise listeli çoğunluk seçim sisteminin bir sonucu olarak TBMM çoğunluğunu alan Demokrat Parti ile yine bir tek parti anlayışına imkân veren yapı oluşmuştu. Her iki dönemde de çoğunlukçu demokrasi anlayışına uygun olarak ister istemez gerek meclis dışındaki gerekse meclis içindeki muhalefetin görüşlerine itibar edilmeyerek yapılmış olan yasalarda anti demokratik özellikler olduğu anlaşılmaktadır. Yürürlüğe girmesine engel olabilecek herhangi bir hukuki düzenleme bulunmaması nedeniyle de demokratik tartışma ortamında yapılmayan yasaların uygulamada pek çok soruna sebep olduğu, objektif, kişilik dışı olma özelliğini taşımadığı görülmektedir. Bu yasaların hukuk tekniğine uygun olup olmaması bir tarafa, uygulanmalarıyla kamu vicdanında ortaya çıkan tahribat, uzun yıllarca unutulmak istenilen dönemlerin yaşanmasına neden olmuştur. Milletten alınan yetkinin kötüye kullanılmasının tipik örnekleri olarak ülkede yaşayan insanların siyasi, sosyal ve ekonomik hayatı olumsuz etkilemiştir. Partilerin isimleriyle anılan dönemler millet hafızasından silinmemiştir. Parlamento çoğunluğuna dayana otoriter bir yönetim anlayışının ve bunu sağlamaya zemin oluşturacak kanunların keza aynı şekildeki düşüncelerle oluşturulmasının sıkıntıları yaşanmıştır. Kanunların bir murakabeye ihtiyacı olduğu hususu ortaya çıkmıştır. Kanun yapmadaki keyfilik, diğer sebeplerle birlikte devlet düzeninin devamına engel olmuş, bir darbeyle kurulmakta olan çok partili demokratik hayat sekteye uğramıştır.

1961 Anayasası'nın hazırlanması aşamasında Anayasa Mahkemesinin kuruluşuna ilişkin Temsilciler Meclisinde yaşanan tartışmalardan birinde, üye Sadettin Tokbey "Türkiye'nin realitesi şudur ki teşrii organın yapmış olduğu tasarruflardan bu millet çok eziyet çekmiştir. Bundan dolayıdır ki bu müessese ihdas edilmiş bulunmaktadır. Bu Mahkemede görev alacak kişilerin, yasama meclislerince belirlenmemesi zorunludur" demiştir (Özbudun, 2012: 9). Mecliste yaşanan tartışmalardaki gerilime sebep olan hususun, yasaların geçmişte olduğu gibi millete eziyet çektirmemesi bunun önlenmesi için de gereken tedbirlerin alınmasının dile getirilerek geçmişi çağrıştıran hiçbir düzenlemenin yeni Anayasa'da yer almaması hedeflenmiştir.

1924 Anayasası bilindiği gibi 103. Maddesinde "Anayasanın hiçbir maddesi hiçbir sebep ve bahane ile savsanamaz ve işlerlikten alıkonulamaz. Hiçbir kanun Anayasaya aykırı olamaz" hükmünü taşıyor olmasına rağmen Anayasaya aykırı kanun yapmamak hususunda çok da özenli davranılmamıştır. Bu konuda tipik bir örnek Konya Akşehir'de yaşanan bir olay nedeniyle, Akşehir Asliye Hukuk Mahkemesinin Kanunların Anayasanın 103'cü maddesi gereğince Anayasaya aykırı olamayacağına dayanarak verdiği karar üzere ortaya çıkmıştır.

19 Temmuz 1943 tarih ve 4486 sayılı Teknik Ziraat ve Teknik Bahçıvanlık Okulları Kanununun 1924 Teşkilat-Esasiye Kanununa aykırılığı sorunu uygulamada nasıl çözümlenmiştir? TBMM, 15 Temmuz 1953 tarih ve 6151 sayılı Kanunla, 19 Temmuz 1943 tarih ve 4486 sayılı Teknik Ziraat ve Teknik Bahçıvanlık Okulları Kanununun 3'üncü maddesinden bazı köylü çocuklarının teknik ziraat okullarına velilerinin isteği hilafına zorunlu kaydına ilişkin hükmü çıkarmış ve ceza yaptırımı öngören 15'inci madde ile ve 20 yıl mecburi hizmet yükümlülüğü getiren 16'ıncı maddeyi ise tümden yürürlükten kaldırmıştır. Böylece Anayasaya aykırılık sorunu, yasama organı tarafından çözümlenmiştir.

Yukarıda örnek olarak verdiğimiz 1924 Anayasasının yürürlükte olduğu dönemde gerçekleşen olaydaki öğrencinin ne kendisinin ne de velisinin rızası olmadan kanun gereği okula zorunlu olarak kaydedilmesi ve öğrencinin okuldan atılması ile tazminat alacağı için tüm yoksulluğuna rağmen velisi olan annesine icra takibi yapılması, bir müdahalenin yapılarak haksız sonuçlara yol açan yasanın yürürlükten kaldırılması, küçüğün rıza hilafına okula kayıt nedeniyle okuldaki zarar ziyan ve tazminatın istenmesindeki haksızlığın giderilmesi gerektiği ortadadır. Kanunların Anayasaya aykırı olsa dahi bunu incelemekle görevli bir organının bulunmaması,

mahkemelerin kuruluş, görev ve yetkilerinin Anayasanın 53'üncü maddesine uygun çıkarılan kanunlarda da mahkemelere bu hususta bir yetki verilmediği Yargıtay Hukuk Genel Kurulu Kararıyla, yargı yoluyla bu hukuksuzluğa müdahale edilemeyeceği noktalanmıştır.

Bu karar göstermektedir ki kanunlar yasama organları tarafından pekâlâ Anayasalara aykırı, içerik yönünden zayıf, sosyal realitelere aykırı, ihtilafların çözümünde de vatandaşın yargıya güvenini yok eden niteliklerde de yapılabilmektedir. Bunun çözümü ise kanunların ihtiyaçlara ve yargı kararlarında ortaya çıkan adaletsizliklere göre yeniden göz geçirilerek düzeltmelerin yapılmasıdır. Diğer bir çözüm ise anayasa yargısı yoluyla, yasama organının yaptığı kanunların ve diğer düzenleyici işlemlerin Anayasal denetiminin sağlanarak, aykırılıkların varlığı halinde bunları iptal etmek olmalıdır. Bu durumda Anayasa Mahkemesinin ve anayasa yargısının bir ülke Anayasası içinde yer alması zorunludur.

Kıta Avrupa'sında Avusturya, Almanya ve İtalya'dan sonra Anayasa mahkemesi kurulmuş olan ülke 1961 Anayasası ile Türkiye'dir. O halde hem TBMM hem de Anayasa Mahkemesi yukarıda izah edilen örnekte olduğu gibi Anayasaya aykırılıklar ile kanunlarda değişiklik yapılması, kaldırılması veya yeniden kanun yapılmasını gerçekleştirerek Hukuk Devleti ilke ve idealine ulaşmada etkin rol oynayacaklardır.

Türk Anayasalarında ilk kez Anayasa Mahkemesi'nin müessese olarak yer alması 1961 Anayasası ile mümkün olmuştur. Anayasanın 148'inci maddesinin ilk şekline göre "Anayasa Mahkemesi'nin kuruluşu ve yargılama usulleri kanunla; Mahkemenin çalışma tarzı ve üyeleri arasında iş bölümü kendi yapacağı iş tüzükle düzenlenir" hükmü yer almaktadır. Buna göre Anayasa Mahkemesi 22.4.1962 tarihli 44 sayılı yasayla kurulmuştur. 1961 Anayasasının 147/1 maddesinin ilk şekline göre Anayasa Mahkemesinin görev ve yetkileri de "Anayasa mahkemesi, Kanunların ve TBMM İçtüzüklerinin Anayasaya, Anayasa değişikliklerinin de Anayasada gösterilen şekil şartlarına uygunluğunu denetler" şeklindedir.

1961 ANAYASASI DÖNEMİNDEKİ ANAYASA MAHKEMESİ UYGULAMALARI

Anayasa Mahkemesi, Anayasada ve 44 sayılı Anayasa Mahkemesi'nin Kuruluş Kanununda yer alan görev ve yetkilerini yapmak suretiyle Anayasanın 2'nci maddesinde yer alan Cumhuriyetin niteliklerini uygun olarak, Türkiye'yi hukuk devleti ideallerine yaklaştıran görev üstlenmiştir. Tabii olarak bu görevi üstlenirken kanunların kendisine verdiği görev ve yetki içinde kalmak zorunluluğunda olmuştur. Ancak her yasal düzenlemede görülebilme ihtimali olan, yasal düzenlemelerin yapılırken sınırlı yetki ve sınırlı görev verme tercihi, 1961 Anayasasını yapan Asli Kurucu İktidar ve Tali Kurucu İktidar tarafından da Anayasa Mahkemesinin görev ve yetkilerinin düzenlenmesinde görülmüştür. Anayasa Mahkemesinin önüne gelen dosyalarda karar verilmesi istenilen hususlarda kimi kez görevsizlik ve yetkisizlik sorunu ortaya çıkmıştır.

Kanunların Anayasaya aykırılığı sebebiyle iptali istemindeki davalarda iptal kararı kadar, davanın açılması anıyla beraber iptale ilişkin ciddi sebeplerin varlığına rağmen dava süresince kanunun yürürlükte kalmasının ileride giderilemeyecek zararlara yol açma ihtimalinin varlığı iptal davası ile karar verilmesi istenilen hususların başında gelmektedir. Teorik olarak hep olabilecek bu ihtimal; Anayasa mahkemesinin önüne ölüm cezalarının infazına dair kanunun iptali istemiyle açılan davada "kanunun uygulanmasının durdurulması" talepli olarak gelmiştir.

İptali istenen kanun: Dava konusu edilen «Deniz Gezmiş, Yusuf Aslan ve Hüseyin İnan'ın Askeri Yargıtay 2. Dairesinin 10/1/1972 tarih ve 1971/4- 1972/1 Esas, 1972/1 karar sayılı ilam ile kesinleşen, 25/3/1972 günlü, 14139 sayılı Resmî Gazetedeki metinde yer alan Ölüm cezalarının Yerine Getirilmesine Dair 17/3/1972 günlü, 1576 Sayılı kanun "nün iptali istemi ve "kanunun uygulanmasının durdurulması "talep edilmiştir.

Davayı açan Cumhuriyet Halk Partisi, kanunun uygulanmasının durdurulması hususunda öznel kanun işlemlerinin uygulanmasının Anayasa Mahkemesince durdurulabileceği inancını

taşıdıklarını ifade etmişlerdir. Anayasa mahkemesi ise ilk defa önüne gelmiş ölüm cezasının infazına dair kanunun iptali ve infazın yürürlüğünün durdurulması talebi karşısında farklı gerekçelerle kabul ve karşı oylarla olaya yaklaşmışlar ve 6 üyenin karşı oyuna karşılık oy çokluğuyla talep ret olunmuştur.

Kanunun Yürürlüğünün Durdurulmasına ilişkin talep Anayasa Mahkemesince ret olurken, üyeler şu görüşlerin tesirinde karar vermişlerdir. Anayasaya uygunluk denetimi yapılan bir kanunun, yürürlüğünün durdurulması gibi ağır sonuçları olabilecek bir yetkinin Anayasa Mahkemesi'ne ancak Anayasa ile verilmesi gerekir. Soruna bir yargılama usulü konusu gibi bakılırsa o zaman da yetkinin mahkemenin kuruluşunu ve yargılama usullerini düzenleyen 44 sayılı kanunda yer alması sonucuna varılacaktır. Anayasa Mahkemesine ne Anayasa ile ne de 44 sayılı Kanunla böyle bir yetkinin tanınmamış olduğu ortadadır.

Anayasa Mahkemesi'nin uygunluk denetimini yaptığı kanunun nasıl bir özelliği olursa olsun, kendisini yorum ve kıyaslamaya giderek yasaca verilmemiş böyle bir yetkiyle donanmasına olanak yoktur. (Anayasa Mahkemesi Kararlar Dergisi, Sayı 10; 273- 317).

Anayasa mahkemesinin genel yaklaşımı pozitif hukuk kurallarıyla belirlenmiş yetki ve görev tanımlamasına uygun olarak hareket etmekten ibarettir. Nitekim bu anlayışlarını önlerine gelen 24.5.1977 tarihli 1977/60-E, 1977/81 karar sayılı dosyada verdikleri kararında da göstermişlerdir.

1980 ANAYASASI DÖNEMİNDEKİ ANAYASA MAHKEMESİ UYGULAMALARI

2709 nolu kanunun 7.11.982 tarihinde halk oylamasıyla kabul edilmesi suretiyle 9 11.1982 tarihinde resmi gazetede yayınlanarak yürürlüğe giren 1982 Anayasası, Anayasa Mahkemesi'nin görev ve yetkilerini düzenlediği 148'inci maddesi ile 1961 anayasasının 147/1 maddesinde bulunmayan Kanun Hükmünde Kararnamelerin Anayasaya şekil ve esas bakımından uygunluğunu denetler hükmü getirilmiş, aynı şekilde kanunların ve TBMM İçtüzüğünün de anayasaya şekil bakımından uygunluğunun denetlenmesi görev ve yetkiler arasında sayılmıştır.

10 Kasım 1983 tarihinde Anayasa Mahkemesi'nin Kuruluşu ve Yargılama Usulleri Hakkındaki 2949 sayılı Kanun kabul edilerek 13 Kasım 1983 tarihinde Resmî Gazetede ilan edilmek suretiyle yürürlüğe girmiştir.

Ne Anayasa'da ne de yargılama usullerini belirten 2949 sayılı Kanunda Anayasa Mahkemesinin görev ve yetkileri ile Kanunların Yürürlüğünün Durdurulmasına ilişkin bir düzenleme yapılmamıştır. Bu nedenle mahkeme 1961 Anayasası dönemindeki durumundan daha farklı değildir.

21.10.1993 tarihi Anayasa Mahkemesi için bir dönüm noktası olmuş ve tarihindeki ilk Yürürlüğün Durdurulması Kararını vermiştir. Karar 20 Ağustos1993 tarih ve 509 sayılı Türk Telekomünikasyon Anonim Şirketi Kurulması Hakkında Kanun Hükmünde Kararnamenin" yürürlüğünün durdurulmasına" karar vermiştir. "3 Ekim 1993 tarihinde Resmî Gazetede gerekçesiz olarak yayınlanan Mahkemenin bu kararının gerekçesi 1993/40-2 sayılı karar olarak 6 Kasım 1993 tarihli Resmî Gazetede yayınlanmıştır.

Anayasada ve 2949 sayılı Kanunda bir değişiklik olmamasına rağmen bu kararın verilmiş olması çok tartışılmıştır.

Tartışmanın önemli bir ekseni Anayasa Mahkemesinin görev ve yetkilerine ilişkin bir düzenlemenin olmamasına rağmen yorum yoluyla bu yetkinin kendisinde var olduğunun kabulü ile karar vermiş olmasının kanuna aykırı olduğu şeklindedir.

Bir başka görüş ise, Anayasanın ve Anayasa Mahkemesi kuruluş kanununda verilmemiş yetki Anayasa Mahkemesi'nin bu normları yorumlamak suretiyle bu davada yürürlüğün

durdurulması kararının verilmesi, kamu yararı açısından uygun bir sonuçtur; zira Mahkemeyi kanunun yürürlüğünün durdurulması kararının verilmesine sevk eden hem Kanun Hükmünde Kararnamenin Anayasaya aykırılığı hem de bu aykırı nitelik taşıyan normun uygulanması hâlinde telafisi imkansız zararların doğmasına neden olacağının kuvvetle muhtemel olması yürürlüğü durdurma kararının verilmesini haklı görenlerin dayandıkları görüşlerdir.

Bir diğer görüş ise bizzat mahkemenin kendi görüşüdür. Mahkeme kararında: Kendisine Anayasa ve Kuruluş Kanunuyla verilmeyen yetkinin aslında yargı yetkisi içerisinde bulunduğunu, yönetimde hukuka uygunluğu sağlamanın en etkin yolunun yargısal denetim olduğunu; yargının etkinliğini özgürce ve etkisiz kullanabilmesi için "yürütmenin durdurma" yetkisini içermesi gerektiği belirtmiştir. Mahkeme devamla "Bir yasanın Anayasaya aykırılığı nedeniyle iptal edilmesi gibi çok geniş bir yetkiyi Anayasa Mahkemesine tanıyan Anayasa ve Yasa koyucunun daha hafif sonuçlar doğuracak olan uygulamayı durdurma yetkisini öncelikle tanımış olduğunun kabulü gerekir demektedir. Mahkeme devamla "HUMK ve İYUK' nun yargılamanın amacına ulaşabilmesi için farklı adlar altında çeşitli koruma önlemleri getirdiğini, İhtiyati tedbir, İhtiyati haciz, yürütmenin durdurulması kararları bunlara örnek olarak gösterilebileceğini" belirtmiştir. Bir başka sebep olarak da "Hukuk Boşluğunun Hâkim Tarafından Doldurulmasının bu davada kullanılacak bir yöntem olduğunu, Medeni Kanun'un 1. Maddesinde yer alan bu yetkininin kıyasen Anayasa yargısında da kullanabileceği sonucunu çıkarmıştır. Mahkeme son olarak kendisinin yetkilendirilmiş olmasının gerekli olmadığını, yasaklanmamış olmasının yeterli olduğunu belirtmek suretiyle bu sebeplere dayanarak gerekçe oluşturduğu sonucu çıkmaktadır.

Anayasa Mahkemesinin Yürürlüğü Durdurma Kararı vermesi doktrinde de tartışılmış, çok farklı görüşler ortaya çıkmıştır. Konuyu Avrupa ülkelerindeki uygulamalar açısından inceleyen İbrahim Ö Kabaoğlu, Almanya'da askıya alınması talep edilen işlem bireysel başvuru kapsamına giren işlemlerdir, yerel mahkeme geçici koruma istemlerini genellikle reddetmektedir. Belçika'da güçlü kanıtların ortaya konması halinde ve başvuru konusu olan hükmün derhal uygulanması giderilmesi güç ve ciddi sakıncalar yaratma tehlikesini beraberinde taşıyorsa Hakem Divanı normu askıya alabilir, her iki koşul birlikte mevcut olmalıdır. İspanya ve Portekiz için de durum yine haklılık halinin varlığı ve telafisi imkânsız zararların doğma ihtimali halinde bir güvence oluşturması açısından kanunların uygulanması askıya alınmaktadır demektedir. (Kabaoğlu, 2007;161). Türkiye açısından ise Avrupa uygulamalarındaki sebeplere göre şartların oluşması halinde Mahkemenin kendisini zorlayarak içtihat oluşturduğunu ifade etmektedir.

Erdoğan Teziç ve Ergun Özbudun Anayasa Ders kitaplarının eski baskılarında Anayasa Mahkemesinin Yürürlüğü Durdurmasına ilişkin karar verip veremeyeceği hususlarında zamanla değişen görüşlerinin olduğu, kitapların ilk baskı dönemleriyle daha sonraki baskılarında bu ifadelerini metinlerden çıkardıkları görülmektedir. Erdoğan Teziç bu değişimin varlığını bizzat kendisi kitabında açıklamaktadır. Teziç, Anayasa Hukuku, 2009, 13. Baskısında "Bu kitabın 1986 yılı baskısında "Anayasa Mahkemesi Müteferrik kararında bu yönde bir yetkinin anayasada ve kuruluş kanununda kendisine tanınmadığı gerekçesiyle istemi reddetmişti. Konuyla ilgili olarak kitabımın 1986 yılı ilk baskısında şu görüşü ileri sürmüştüm. "Kanunların Anayasaya uygunluğunun denetimini yapan Anayasa Mahkemesi yargısal bir çalışma yapmaktadır. Onun için her yargılama makamı gibi onun da yargılama kapsamı içinde gerekli önlemleri alma yetkisi vardır. Aslında Anayasa Mahkemesi'nin gerekli önlemler alma konusunda Anayasa ve kanunlarda açıkça bir hüküm bulunmasa da bu yönde karar alma yükümlülüğünün bulunduğu varsayılır; zira bu yolda bir karar almadığı takdirde kişileri olduğu kadar kamu düzenini de Anayasaya himayesinden yoksun bırakmış sayılır" seklinde devam eden radikal görüşlerle Anayasa Mahkemesi'nin önüne gelen meseleye ilişkin karar vermesinde yetkilendirilmemiş olsa dahi kanunun uygulanmasını durdurmayı engelleyecek bir kuralın bulunup bulunmadığını araştırmalıdır ve bu itibarla yürürlüğünü durdurma kararı verebilmelidir demiştir" sonraki görüşler ise daha ılımlı olarak sınırlı bir şekilde Mahkemenin karar

vermesinden sonra gerekçeli kararı yazıp, Resmi Gazetede yayımlandığı evrede, koruyucu bir önlem olarak kanunun uygulanmasının durdurulması kararı verebilir demektedir.

Ergun Özbudun 1993 yılı üçüncü baskı Türk Anayasa Hukuku isimli ders kitabında "Eğer ölüm cezasına ilişkin kanunlarda olduğu gibi kanunu uygulanması telafisi mümkün olmayan sonuçlar doğurabiliyor ve anayasaya uygunluk denetiminin anlamını tamamen ortadan kaldırıyorsa Anayasa Mahkemesinin bu istisnai durumlarda yürütmenin durdurulması kararı verebilmesi gerekir. Dolayısıyla anılan durumlarda yürütmeyi durdurma yetkisinin varlığı "yargı denetimi kavramının içerik ve kapsamının yorumu yoluyla" kabul edilebilir demiştir. 2017 baskı yılı 17. basım Türk Anayasa Hukuku ders kitabında ise "Anayasanın ve Kanunların vermediği bir yetki yorum yoluyla ihdas edilemez. Özel hukukun aksine, kamu hukukunda bir kanun boşluğu olduğu ve bunun içtihat yoluyla doldurabileceği iddiası kabul edilemez. Çünkü kamu makamları ancak Anayasanın ve kanunların kendilerine tanıdığı yetkileri kullanabilirler" demektedir. Anayasa Mahkemesi en radikal görüş değiştiren olayın öznesi olmuştur.

SONUÇ

Anayasa Mahkemesi 1961 ve 1982 anayasalarında Kendisine verilmiş olan görev ve yetkiler arasında bulunan kanunların, kanun hükmünde kararnamelerin Anayasaya uygunluğunu denetleme görevini, Anayasanın yetkili kıldıklarının açacağı iptal davalarında yerine getirir. Bu davada Anayasa Mahkemesinin görevi Anayasaya aykırılığı tespit etmek ve dava konusu normun iptaline karar vermekten ibarettir. Ancak verilen kararın gerekçesinin yazılmadan açıklanmaması, kararların resmî gazetede yayınlanmasıyla ancak yürürlüğe girebileceği bazı kararlarda ise İptal edilen hükmün yasama organı tarafından doldurulmasının sağlanması açısından yayından itibaren en fazla bir yıl geçinceye kadar yürürlüğe girebileceğini kararlaştıra bilmesi ve bu süre içerisinde İptal edilen kanunun yürürlükte kalması cevap bulmakta zorlanan hususlardır. Kanun İptal edilmiştir ancak yürürlüktedir yürürlükte olması nedeniyle de görülmekte olan bir davada bu kanun uygulanabilecek olan bir kanundur o zaman da şöyle bir netice ortaya çıkar anayasa Mahkemesi'nin ertelediği tarih itibariyle yürürlükten kalkacak olan bu kanunun görülmekte olan davada uygulanacak olması tarafların adalet duygusunu ne oranda etkileyeceği düşünülmemiş midir.?

Anayasa mahkemesince verilen iptale yönelik kararın açıklanmasıyla norm yürürlükten kalkar. Yukarıda ifade edildiği gibi bir normun iptal edilmiş olmasına rağmen hâlâ yürürlükte kalıyor ve o normun uygulamada yer buluyor olması hukuk devleti ilkesiyle bağdaşmaz. Hukuk devleti ilkesinde, hukuk kurallarının ilga edilmemiş, iptal kararı verilmemiş, yürürlükte olan, kurallardır. Burada hukuk kuralının artık kural olma niteliği ortadan kalkmıştır. Peki niçin hâlâ yürürlükte olmaya devam edecektir?

Hakkında İptal davası açılmış bir normun Anayasa Mahkemesi tarafından yürürlükte olmasının telafisi güç, imkânsız zararların ortaya çıkmasına neden olacağı ve bu sebeple bu normun artık Türk hukuk sistemi içerisinden derhal çıkartılmasına ilişkin mekanizmanın çalışması gerekecektir. Zira bu normun Anayasaya aykırı olduğu için iptali istenmiştir. Anayasa Mahkemesi de bu durumu davayı açanlar gibi ilk bakışta görebilmiştir. Bir kısım yabancılara toprak satışını gerçekleştirmek için çıkartılan yasada mütekabiliyet şartı aranmaksızın satışların gerçekleştirilmesini sağlayan normun, anayasaya aykırı olduğu ve dolayısıyla iptali gerektiğine ilişkin açılan davada beklenildiği gibi iptal kararı verilmiştir. Ancak kararın verilmesi anına kadar kanun yürürlükte kalmıştır. İptal kararının yürürlüğe girebilmesi mahkemenin kararının gerekçeli olarak yazılıp Resmî Gazetede yayınlanmasıyla mümkün olması, Anayasa hükmü olduğundan bu kez yürürlükte kalmaya devam eden kanun nedeniyle hukuka aykırı şekilde toprak satışları devam ettirilmiştir.

İşte bu gibi durumları ortadan kaldırmak ve 1972 yılından bu yana hâlâ tartışılan Anayasa Mahkemesi'nin İptal istenilen bir norm nedeniyle, normun yürürlükte kalmasının sakıncalarını

açık seçik görülüyor olması ve doğuracağı zararların telafisinin imkânsız olduğu hallerde yukarıda ifade edilen süreçlerin tamamlanmasına kadar bu kanun yürürlükte kalarak hükmünü icra edecek mi?

Burada bizce Anayasa Mahkemesine yürürlüğü durdurma kararı verme yetkisi verilmeli midir verilmemeli midir tartışmalarının sona erdirilmesi gerekir. Çünkü Anayasa Mahkemesi ilk kez kendisinin önüne gelen yürürlüğün durdurulması talebinin 1972 yılında Anayasayla ve anayasa Mahkemesi'nin kuruluş kanunuyla bize verilmemiş olan yetkileri biz ihdas edemeyiz demiştir. Bunu söylerken haklıdır. Bunu söylemeyip yürürlüğün durdurulması kararını verilmesini isteyen görüşler de yine kendi açılarından hukuku zorlamakla da olsa haklılık payı zayıf da olsa vardır. Zira orada da telafisi güç zararların ortaya çıkabileceği endişesiyle bunun durdurulması amaçlanan düşünce ürünleridir.

Olayı daha basite indirgeyerek çözmek pekâlâ mümkündür. Çünkü buradaki tartışmalar kanunların yürürlüğünün durdurulması hususunda mahkemenin verdiği kararın hukuki olup olmadığına ilişkin tartışmadır. Bunun temelinde de mahkemelerin bu kararı verirlerken açıkça pozitif hukuk kurallarına dayanmamış oldukları, yorum yoluyla kendilerinin böyle bir karar verebileceğini düşünmüş olmalarıdır.

Bilimsel tartışmalara bakıldığında Anayasa Mahkemesinin, norm iptaline ilişkin davalarda yürürlüğü durdurma kararını vermesini ilke olarak reddetmiş değildir. Tartışmalar dayanak noktasından doğmaktadır. O halde yapılacak şey Anayasaya ve Anayasa Mahkemesinin Kuruluşu ve Yargılama Usulleri Hakkında Kanun'da açık bir düzenleme yapmak suretiyle Anayasa Mahkemesi'nin İptal davalarında yürürlüğün durdurulması kararını verebileceğini kabul etmektir. Bu yetki sınırsızca tüketilecek bir yetki değildir. Nihayetinde şartların uygunluğu hâlinde Mahkemenin iptale ilişkin kararı verme yetkisi varken yine kanuna dayalı olarak o normun yürürlüğünün durdurulmasına karar vermesini sağlayacak düzenlemenin yapılması bütün tartışmaları bitirecektir.

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AN EVALUATION OF THE CONTENTS OF VAKİT NEWSPAPER REGARDING THE LANGUAGE REVOLUTION

VAKİT GAZETESİNİN DİL İNKILABINA YÖNELİK İÇERİKLERİ ÜZERİNE BİR DEĞERLENDİRME

Bu çalışma, Ankara Hacı Bayram Veli Üniversitesi Lisansüstü Eğitim Enstitüsü'nde Gazetecilik Anabilim Dalında Prof. Dr. Ersin ÖZARSLAN danışmanlığında hazırlanarak 2022 yılında kabul edilen "Türk Matbuatında Vakit Gazetesi" başlıklı doktora tezinden üretilmiştir.

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ÖZET

Mehmet Asım Us ve Ahmet Emin Yalman ortaklığında 1917 yılında yayın hayatına başlayan *Vakit* gazetesi, Cumhuriyet devri Türk matbuatında iz bırakmış önemli yayınlardan biridir. Türk basınında "Us kardeşler" olarak bilinen Mehmet Asım Us, Hakkı Tarık Us ve Hasan Rasim Us idaresinde neşredilen gazete, Millî Mücadele Dönemi'nden itibaren Cumhuriyet'in kurucu kadrolarını ve iradesini destekleyen bir genel yayın politikasına sahip olmuştur. Bu çerçevede Batıcılık ve Milliyetçilik fikirlerini temsil eden gazete, Cumhuriyet'in ilanından sonra da Batılılaşma merkezli inkılapları sahiplenmiştir. Gazetede Türk edebiyatında ve aydın çevrelerinde sürekli tartışılan lisan meselesine dair de önemli oranda içerik üretilmiştir. Dil İnkılabı ve Harf İnkılabı ile ilgili görüş, düşünce ve çözüm önerisi üreten *Vakit* gazetesi, lisana dair konularda öncü bir rol oynamış ve dille ilgili yapılması planlanan değişiklikleri ve gelişmeleri yakından takip etmiştir. Bu çalışmada *Vakit* gazetesinin lisanla ilgili gerçekleştirilmeye çalışılan inkılaplara ilişkin içerikleri, gazetenin ilgili sayılarına arşiv taraması yoluyla ulaşılarak tespit edilmiş ve tespit edilen haber ve yazılar, içerik analizi yöntemi kullanılarak analiz edilmiştir. Çalışmada dil İnkılabı ve harf İnkılabı gibi dili yakından ilgilendiren konularla ilgili olarak gazetenin bakış açısının ve tutumunun ne olduğunun ortaya konulması amaçlanmıştır. Türk matbuatında önemli bir yere sahip olan *Vakit* gazetesinin erken Cumhuriyet devrindeki önemli inkılaplardan biri olan ve o devrede de basın dünyasında tartışılan dil konusuna ilişkin görüşleri, Türk basın tarihinde gazetenin rolünü tanımlamak bakımından önem arz etmektedir. Bu süreç *Vakit* gazetesinin inkılaplara ilişkin tutumunu göstermesi bakımından da ayrıca önemlidir.

Anahtar Kelimeler: gazetecilik, batılılaşma, Vakit gazetesi, dil

ABSTRACT

Vakit newspaper, which started its publication life in 1917 under the partnership of Mehmet Asım Us and Ahmet Emin Yalman, is one of the important publications that left its mark on the Turkish press of the Republican era. The newspaper, published under the management of Mehmet Asım Us, Hakkı Tarık Us and Hasan Rasim Us, known as "the Us brothers" in the Turkish press, had a general publication policy supporting the founding teams and will of the Republic since the War of Independence. In this context, the newspaper represented the ideas of Westernism and Nationalism and embraced the revolutions centered on Westernization after

the declaration of the Republic. The newspaper also produced a significant amount of content on the language issue, which is constantly debated in Turkish literature and intellectual ambients. *Vakit* newspaper, which produced opinions, ideas and solution proposals regarding the Language Revolution and the Alphabet Revolution, played a leading role in language-related issues and closely followed the planned changes and developments regarding the language. In this study, the contents of the Vakit newspaper regarding the reforms that were attempted to be carried out regarding language were determined by accessing the relevant issues of the newspaper through archive scanning and the news and articles determined were analyzed using the content analysis method. The aim of the study is to reveal the newspaper's perspective and attitude on issues closely related to language, such as the Language Revolution and the Alphabet Revolution. The views of the Vakit newspaper, which has an important place in the Turkish press, on the issue of language, which was one of the important revolutions in the early Republican period and was also discussed in the press world at that time, are important in terms of defining the role of the newspaper in the history of the Turkish press. This process is also important in terms of showing the Vakit newspaper's attitude towards the revolutions.

Key Words: journalism, westernism, Vakit newspaper, language

ASSESSING COASTAL VULNERABILITY OF THE YEŞİLIRMAK AND KIZILIRMAK DELTAS USING PRINCIPAL COMPONENT ANALYSIS

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ABSTRACT

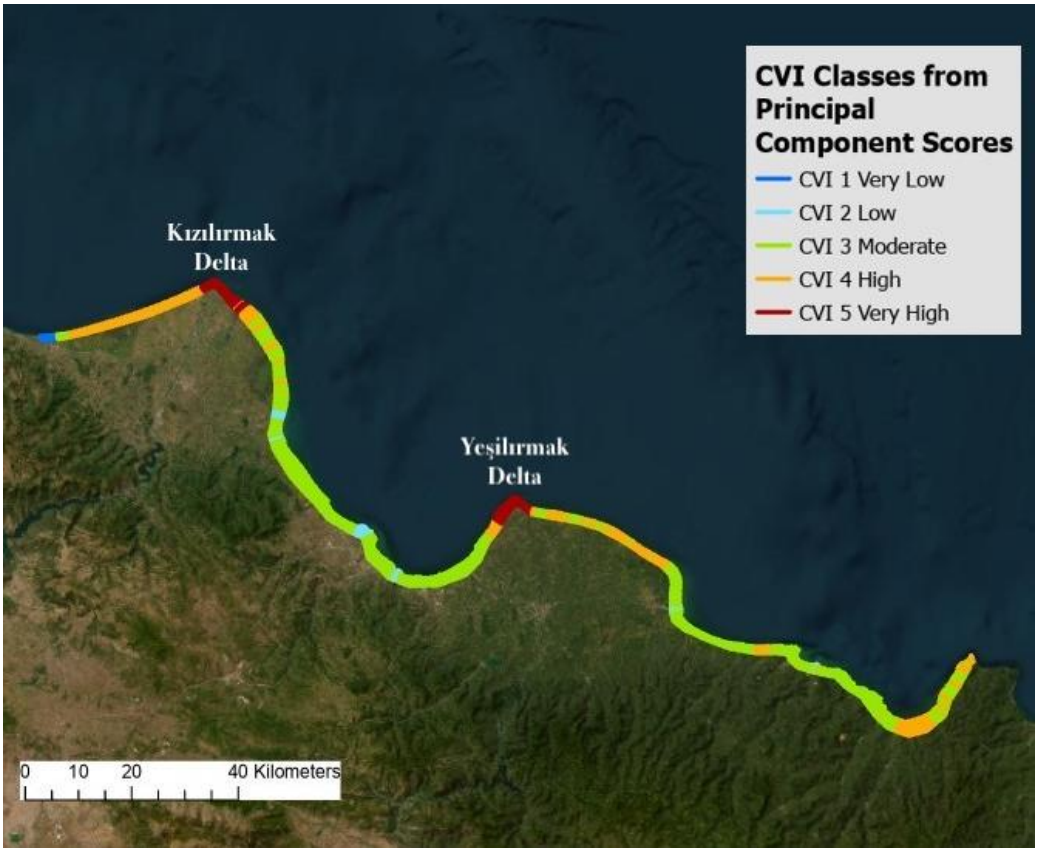
Introduction and Purpose: The assessment of coastal vulnerability is crucial for the effective management and protection of dynamic coastal environments. Understanding the factors influencing coastal vulnerability is essential for developing sustainable planning strategies and risk mitigation measures. This study aims to contribute to sustainable coastal management by employing Principal Component Analysis (PCA) to identify and evaluate the key factors affecting the vulnerability of the Yeşilırmak and Kızılırmak Deltas along the Black Sea coast of Turkey.

Materials and Methods: This study integrates multiple datasets, including sea level rise, wave dynamics, land characteristics (land use/land cover (LULC) and coastal slope) sediment input, and shoreline variations, to assess coastal vulnerability. With the increasing demand for large-scale data processing and high-dimensional data analysis, PCA has become a widely used statistical method for examining multivariate datasets by identifying dominant features and uncovering underlying patterns. This study applies PCA to examine relationships among coastal factors such as terrain, shoreline changes, sea level rise, wave dynamics, and sediment input. Using data from satellite imagery, field surveys, and reports, PCA reduces dimensionality by transforming variables into principal components. Instead of the traditional Coastal Vulnerability Index (CVI), vulnerability is assessed based on the principal component with the highest variance.

Results: Between 1990 and 2025, satellite imagery analysis revealed erosion rates of -7.28 m/yr in the Kızılırmak Delta and -8.66 m/yr in the Yeşilırmak Delta. Along a 250 km coastline, maximum accretion/erosion rates were 20.65 m/yr and -28.79 m/yr, respectively. PCA identified three principal components explaining 69.4% of variance, highlighting strong correlations between shoreline change, sediment input, and significant wave height.

Discussion and Conclusion: This study highlights PCA as an effective tool for coastal management, and provide a more objective vulnerability assessment. Future research should expand this method to larger regions and include more parameters to enhance prediction accuracy.

Key Words: Coastal Vulnerability; Principal Component Analysis; Shoreline Change; Yeşilırmak Delta; Kızılırmak Delta.



CVI Classes from Principal Component Scores on the Black Sea Coastline

DESIGN AND PERFORMANCE ANALYSIS OF VIBRATION TESTER FOR AUTOMOBILE HEADLIGHTS

OTOMOBİL FARLARI İÇİN TİTREŞİM TEST CİHAZININ TASARIMI VE PERFORMANS ANALİZİ

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ABSTRACT

Introduction and Purpose: Car headlights are crucial for traffic safety. However, vibrations on uneven roads can lead to misalignment, loosening, and component deformation, causing performance degradation. This study focuses on the design and performance analysis of a vibration simulation device developed to test the durability of headlight systems under controlled vibration conditions.

Materials and Methods: Car headlights are crucial for traffic safety. However, vibrations on uneven roads can lead to misalignment, loosening, and component deformation, causing performance degradation. This study focuses on the design and performance analysis of a vibration simulation device developed to test the durability of headlight systems under controlled vibration conditions.

Results: The device successfully generates stable vibrations across the specified frequency and amplitude ranges. No significant changes in current fluctuations or light stability are observed in the tested lamps, indicating their resilience to short-term vibrations. However, noise levels exceed 85 dB at frequencies above 36 Hz, posing potential risks for prolonged operator exposure. Histopathological evaluations confirm the device's ability to simulate mechanical stress, with tissue necrosis and inflammation scores providing quantitative insights into vibration-induced damage.

Discussion and Conclusion: The vibration test device demonstrates high industrial applicability, enabling rapid fault detection and energy-efficient testing. While the system effectively simulates real-road conditions, noise reduction measures, such as sound insulation or the use of viscoelastic materials, are recommended for long-term use. Future studies should incorporate extended-duration tests and hybrid protocols combining vibration and thermal stress to further validate the device's capabilities. This study highlights the importance of robust

testing methodologies in improving the durability and reliability of automotive lighting systems.

Key Words: Vibration simulation; Car headlights; Durability testing; Industrial applicability; Noise control

ÖZET

Giriş ve Amaç: Araç farları, trafik güvenliği açısından kritik bir rol oynar. Ancak engebeli yollarda maruz kalınan titreşimler, açı kaybı ve bileşen deformasyonuna neden olarak performans kaybına yol açabilir. Bu çalışma, far sistemlerinin titreşim dayanıklılığını laboratuvar ortamında test etmek üzere özel olarak tasarlanmış bir titreşim simülasyon cihazının tasarımını ve performans analizini incelemektedir.

Gereç ve Yöntemler: Titreşim test cihazı, 1.10 kW AC motor, eksantrik kam mekanizması, yaylı tabla sistemi ve gerçek zamanlı ayarlamalar için kontrol panelinden oluşmaktadır. Cihaz, 10–100 Hz frekans ve 0.1–5 mm genlik aralığında kontrollü titreşim üretebilmektedir. CLL (şehir ışığı), DLL (gündüz farı), HI (uzun far) ve LOW (kısa far) lambaları üzerinde 5 saniyelik titreşim testleri gerçekleştirilmiştir. Testler sırasında akım dalgalanmaları (±0.2 A) ve ışık stabilitesi izlenmiş, gürültü seviyeleri ISO standartlarına uygun şekilde ölçülmüştür.

Bulgular: Cihaz, belirtilen frekans ve genlik aralıklarında kararlı titreşim üretmektedir. Test edilen lambalarda akım dalgalanmaları veya ışık stabilitesinde anlamlı bir değişiklik gözlemlenmemektedir. Bununla birlikte, 36 Hz üzerindeki frekanslarda gürültü seviyesi 85 dB'i aşarak, uzun süreli kullanımda operatör sağlığı için risk oluşturabileceğini göstermiştir. Histomorfolojik değerlendirmeler, cihazın mekanik stresi simüle etme yeteneğini doğrulamıştır.

Tartışma ve Sonuç: Titreşim test cihazı, endüstriyel uygulanabilirliği yüksek, hızlı arıza tespiti sağlayan ve enerji verimli bir çözüm sunmaktadır. Ancak, uzun süreli kullanım için gürültü seviyesinin düşürülmesi amacıyla ses yalıtımı veya viskoelastik malzemelerin kullanılması önerilmektedir. Gelecek çalışmalarda, uzun süreli titreşim ve termal stres testlerinin dahil edilmesi, cihazın yeteneklerini daha kapsamlı bir şekilde değerlendirmeye olanak sağlayacaktır. Bu çalışma, otomotiv aydınlatma sistemlerinin dayanıklılığını ve güvenilirliğini artırmada sağlam test metodolojilerinin önemini vurgulamaktadır.

Anahtar Kelimeler: Titreşim simülasyonu; Araç farları; Dayanıklılık testi; Endüstriyel uygulanabilirlik; Gürültü kontrolü

COMPARISON OF DIGITAL GAME ADDICTION LEVELS OF STUDENTS STUDYING AT THE FACULTY OF SPORTS SCIENCES

SPOR BİLİMLERİ FAKÜLTESİNDE OKUYAN ÖĞRENCİLERİN DİJİTAL OYUN BAĞIMLILIĞI DÜZEYLERİNİN KARŞILAŞTIRILMASI

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ÖZET

Çalışmanın Amacı: Yapılan bu çalışmanın amacı, Iğdır Üniversitesi Spor Bilimleri Fakültesinde okuyan öğrencilerin dijital oyun bağımlılığı düzeylerini çeşitli değişkenler acısından karşılaştırmaktır. Çalışmanın evreninin Spor Bilimleri Fakültesinde okuyan tüm öğrenciler oluştururken, örneklemini ise çalışmaya gönüllü olarak katılmayı kabul eden 119 öğrenci oluşturmaktadır.

Materyal Metod: Çalışmada veri toplama aracı olarak, Hazar ve Hazar (2019) tarafından geliştirilen 21 soru 3 alt boyuttan oluşan "Üniversite Öğrencileri İçin Dijital Oyun Bağımlılığı Ölçeği" kullanılmıştır. Elde edilen verilerin analizinde SPSS 20 programı kullanılmıştır. Verilerin analizinde tanımlayıcı istatistik, Bağımsız örneklem t testi ve tek yönlü varyans analizi uygulanmıştır.

Sonuç: Çalışmanın sonunda, aşırı odaklanma ve erteleme boyutunda erkeklerin; çatışma, yoksunluk ve arayış alt boyutunda kadınların; duygu değişimi ve dalma alt boyutunda kadınların daha yüksek puan aldığı belirlenmiştir. Ancak cinsiyet değişkenine bağlı alınan puanların karşılaştırılmasında ise, istatistiki olarak anlamlı bir farklılık tespit edilmemiştir.

Anahtar Kelime: Dijital Oyun, Bağımlılık, Üniversite Öğrenci, Spor Bilimleri.

ABSTRACT

Introduction and Purpose: The purpose of this study is to compare the digital game addiction levels of students studying at the Faculty of Sports Sciences at Iğdır University in terms of various variables. While the universe of the study consists of all students studying at the Faculty of Sports Sciences, the sample consists of 119 students who agreed to participate in the study voluntarily.

Materials and Methods: The "Digital Game Addiction Scale for University Students", consisting of 21 questions and 3 sub-dimensions developed by Hazar and Hazar (2019), was used as the data collection tool in the study. SPSS 20 program was used in the analysis of the obtained data. Descriptive statistics, Independent sample t-test and one-way analysis of variance were applied in the analysis of the data.

Results: At the end of the study, it was determined that men scored higher in the over-focus and procrastination dimension; women scored higher in the conflict, deprivation and search sub-dimension; and women scored higher in the mood swing and absorption sub-dimension. However, no statistically significant difference was found in the comparison of the scores obtained based on the gender variable.

Key Words: Digital Game, Addiction, University Student, Sports Sciences.

GİRİŞ

Teknolojik gelişmelerin hız kazanması hayatımızın farklı yerlerinde (eğitim, ulaşım, sağlık, iletişim, eğlence v.b) kendisini göstermektedir. Dolayısıyla bu gelişmeler hayatımızında farklılaşmasını kaçınılmaz hale getirmiştir. Örneğin fazla uzağa gitmeden yakın zamanda haytımızın çoğu halka açık alanlarda, parklarda, piknik alanlarında, bahçelerde ve özellikle sokaklarda hep birlikte oynanırdı (Irmak ve Erdoğan, 2016). Dijital oyunların çıkması geleneksel oyunların yerine almış yani oyun algısı tamamen değişmiş ve bireyleri kendi iç dünyasıyla yaşanır hale getirmiştir (Ülker ve diğ.). Teknolojik bağımlılık denen kavram ortaya çıkmış olup (oyun, telefon, sosyal medya, internet v.b) çok zamanlarını dijital ortamlarda geçirerek insanları bağımlı hale getirmiştir (Özdemir, 2023). Dünyada dijital oyunun tarihçesine bakacak olursak ilk 1971 yılında Computer Spacepiyasaya sürülmesi ile başlayan şuan hali hazırda 24,75 milyarda seviyelerinde bütçesi olan ve bir milyara yakın kullanıcısı olan çok büyük bir endüstri haline gelmiştir (Entertainment Software Association 2013). Dijital oyunlar 90 lı yıllardan itibaren hızla artan ve tüketilen, sürekli yeni versiyonları çıkan bir sektör haline gelmesi ve çok çabuk tüketilen bir endüstri ve çok farklı türlerde (versiyonlar) ortaya çıkmaktadır. Bu dijital oyunlar örnek vermek gerekirse; simülasyon, yap boz, macera, taktik spor, rol yapma ve aksiyon gibi yedi kategoride göstermek mümkündür (Adams ve Rollings 2006). Her geçen gün teknolojini ileriye doğru hızlı bir şekilde gitmesi, şehirleşmenin artması ve çocuklar için ve gençler içim oyun alanların yetersiz olması eskiye göre yani geleneksel oyunlar dediğimiz oyunların yerine bilgisayar ve internet üzerinden oynanan dijital oyunlar yerini almıştır. Her yaş gurubuna hitab eden bu dijital oyunlar giderek artış göstermektedir (Gentile 2009, Rideout ve ark. 2010). İnsanların sağlık problemlerini artırmadığı sürece bireylerin dijital oyunlara zaman ayırması ve bireyleri mutlu etmesi duygusal olarak rahatlaması açısından katkı sağladığı düşünüle bilir. (Green ve Bavelier 2003, Prot ve ark. 2014). Tabi bunun olumsuz tarafıda bireyler oynadığı oyuna dur diyemiyorsa zaman olarak control sağlayamıyorsa, oyununa kendine tamamen kaptırıp duygularına hislerine etki ediyorsa ozaman problem var demektir (Griffith's ve Davies 2005, Ögel 2012, Young 2009).

Yapılan bazı çalışmalarda özellikle 10-19 yaşlarında erkeklerin ergen kızlara göre dijital oyun oynama da daha yüksek oldukları ortaya çıkmıştır (Chiu ve ark. 2004). Dijital oyun bağımlılığı henüz hastalık olarak litaratüre girmesede bu olay otuz yıldır aslında makalelerde dile getirilmektedir (Soper ve Miller1983). Dijital oyunları tercih etme cinsiyete göre farklılıklar gösterdiği ortaya çıkmaktadır. Kadınların genelde fantazi içerikli, tek kişilik olan, şiddet içerikli olmayan oyunları tercih ederken, erkekler daha farklı stratejik planlama özellikli, heyecan verici aksiyon olan spor ağırlıklı ve özellikle çok kişi ile oynan oyunları tercih etmektedirler (Homer ve ark. 2012, Quaiser-Pohl ve ark. 2006). Dijital oyunların bireylerde olulmu ve olumsuz etkileri üzerine yapılan çalışmalara bakıldığında sipesifik olarak bakmak gerekirse; Olumlu yönleri dijital oyunların bireylerin boş zamalarını değerlendirdiği, bireylerin yaşamış oldukları kentsel yaşamda kendilerini stresden uzaklaşma, yorgunluk hallerinde rahatlatladığı, öz güvenin artması, görsel ve dikkat odaklanma, becerilerinin gelişmesi gibi özelliklerin artış görülmesi gibi bir çok etkenler söylenebilir (Green ve Bavelier 2003, Griffiths 2005). Bununla birlikte bireylerin ders başarılarını artırmasında dijital eğitici oyunların etkisi olduğu söylenmektedir. (Green ve Bavelier 2003, Prot ve ark. 2014).

Tabi ailelerin çocuklarımızın dijital oyunları kullanması ile ilgili yapması ve katkı sağlaması gereken durumlar söz konusudur.

- Ebeveyn olarak Çocuğun gerçek ve sanal dünya arasındaki farkı anlayıp anlamadığına emin olun.
- Çocugunuza sınırlamalar koymak 'ne zaman, ne kadar v.b gibi sınırlamaları en baştan itibaren oluşturun.
- Yönlendirmeler yaparak şiddet içren oyunlardan eğitici oyunları tercih etmesini konuşarak anlamasını sağlayın.
- Çocuklarınızın Kendi sorumluluklarını bitiminden sonar oyun oynamasını sağlayın.
- Okul ve eğitimini aksatmamasına özen göstererek, kendi üzerine düşen işerde başarılı olması dahilinde oyun oynması gibi daha bir çok etkenlerden söz edilebilir. (Griffiths (2003).

Dijital oyunların olumsuz etkileri; şiddet içeren dijital oyunlarda bireyler davranışsal problemler ortaya çıkarabiliyor. Yapılan çalışmalara bakıldığında dijital oyunlardaki bağımlılık ile okul başarısı arasında ki yapılan çalışmalarda, ilk başda normal oyuncu iken bağımlı oyuncu durumuna geldikten sonar sosyal fobi, anksiyete, depresyon gibi durumlar okuldaki başarısını etkilemiştir. Bağımlı olan oyunculara özellikle şiddet içeren oyunlarda bağımlı olanlarda kendi haytalarında da şiddete meyilli, saldırganlık ve fizyolojik uyarıları artırdığı ortaya çıkmıştır (Anderson ve arkadaşlarının (2010). Bu çalışmamızda spor bilimlerinde okuyan öğrencilerin dijital oyun bağımlılk düzeyleri üzerine bir çalışma yapılmıştır.

YÖNTEM

Araştırmada nicel araştırma yöntemi içerisinde yer alan nedensel karşılaştırma modeli kullanılmıştır.

Örneklem

Çalışmanın evreninin Spor Bilimleri Fakültesinde okuyan tüm öğrenciler oluştururken, örneklemini ise çalışmaya gönüllü olarak katılmayı kabul eden 119 öğrenci oluşturmaktadır.

VERİ TOPLAMA ARAÇLARI

Çalışma veri toplama aracı olarak Hazar ve Hazar (2019) tarafından geliştirilen 21 soru 3 alt boyuttan oluşan "Üniversite Öğrencileri İçin Dijital Oyun Bağımlılığı Ölçeği" kullanılmıştır. Ölçeğin bu çalışma için yapılan Cronbach Alpha iç tutarlılık değerleri; aşırı odaklanma ve erteleme alt boyutu için α=0.90, çatışma, yoksunluk ve arayış alt boyutu için α=0.90, duygu değişimi ve dalma alt boyutu için α=0.79 olarak belirlenmiştir. Toplam ölçeğin Cronbach Alpha iç tutarlılık değerleri ise α=0.94 olarak bulunmuştur. Aşırı odaklanma ve erteleme alt boyutu (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11); çatışma, yoksunluk ve arayış alt boyutu (12, 13, 14, 15, 16, 17); duygu değişimi ve dalma alt boyutu (18, 19, 20, 21) maddelerden oluşmaktadır. Ölçek "Hiç Katılmıyorum (1)", "Katılmıyorum (2)", "Kararsızım (3)", "Katılıyorum (4)", "Tamamen Katılıyorum (5)" olacak şekilde planlanmıştır. Ölçekten alınabilecek en düşük puan "21" iken; en yüksek puan "105" tir. Ölçek puanlamasının derecelendirmesinde ise; "1-21 puanlar arasında yer alanlar normal grup, 22-42 puanlar arasında yer alanlar az riskli grup, 43-63 puanlar arasında yer alanlar riskli grup, 64-84 puanlar arasında yer alanlar bağımlı grup ve son olarak 85-105 puanlar arasında yer alanlar yüksek düzeyde bağımlı grup" olarak değerlendirilmektedir (Hazar ve Hazar, 2019).

VERİLERİN ÇÖZÜMLENMESİ

Verilerin çözümlenmesinde SPSS 20 paket programı kullanılmıştır. Verilerin analizinde, tanımlayıcı istatistik, bağımsız örneklem t testi ve tek yönlü varyans analizi kullanılmıştır.

BULGULAR

Tablo 1. Cinsiyet Değişkenine Bağlı Tanımlayıcı İstatistik Bulgusu

		Mean	**Std. Deviation**
Aşırı odaklanma ve erteleme	Kadın	44,9333	4,28740
	Erkek	46,0930	3,87798
Çatışma yoksunluk ve arayış	Kadın	26,4889	1,89043
	Erkek	26,3721	2,11596
Duygu değişimi ve dalma	Kadın	16,7111	1,54658
	Erkek	16,5116	1,56406
Toplam	Kadın	88,1333	5,70327
	Erkek	88,9767	5,27116

Yapılan tanımlayıcı istatistik analizi sonunda, aşırı odaklanma ve erteleme boyutunda erkeklerin; çatışma, yoksunluk ve arayış alt boyutunda kadınların; duygu değişimi ve dalma alt boyutunda kadınların daha yüksek puan aldığı belirlenmiştir.

Tablo 2. Cinsiyet Değişkenine Bağlı Bağımsız Örneklem T Testi

	F	t	p
Aşırı odaklanma ve erteleme	1,018	-1,329	,187
Çatışma yoksunluk ve arayış	1,607	,273	,785
Duygu değişimi ve dalma	,000	,601	,549
Toplam	1,019	-,720	,474

Cinsiyet değişkenine bağlı yapılan karşılaştırma sonunda, bütün boyutlar arasında istatistiksel olarak anlamlı bir farklılık bulunamamıştır.

Tablo 3. Bölüm Değişkenine Bağlı Tek Yönlü Varyans Analizi

		Mean	Std. Deviation	p
Aşırı odaklanma ve erteleme	Beden Eğitimi ve Spor Öğretmenliği	45,4242	4,46535	,844
	Antrenörlük Eğitimi	45,8571	3,38531	
	Spor Yöneticiliği	45,2222	4,45778	
Çatışma yoksunluk ve arayış	Beden Eğitimi ve Spor Öğretmenliği	26,6364	2,10384	,033
	Antrenörlük Eğitimi	26,9643	2,13406	
	Spor Yöneticiliği	25,6296	1,4451	
Duygu değişimi ve dalma	Beden Eğitimi ve Spor Öğretmenliği	16,6667	1,42887	,265
	Antrenörlük Eğitimi	16,25	1,6015	
	Spor Yöneticiliği	16,9259	1,61545	
Toplam	Beden Eğitimi ve Spor Öğretmenliği	88,7273	6,01183	0,667
	Antrenörlük Eğitimi	89,0714	4,47154	
	Spor Yöneticiliği	87,7778	5,85947	

Yapılan tek yönlü varyans analizi sonunda, çatışma yoksunluk ve arayış boyutunda istatistiksel olarak anlamlı bir farklılık belirlenmiştir.

Tablo 4. Sınıf Değişkenine Bağlı Varyans Analizi

		Mean	**Std. Deviation**	**P**
Aşırı Odaklanma Ve Erteleme	1	45,6667	4,45896	,303
	2	46,2353	4,88018	
	3	46,5882	3,65819	
	4	44,5556	3,68351	
Çatışma Yoksunluk Ve Arayış	1	26,8889	1,74521	,159
	2	25,8235	1,77607	
	3	27,1176	1,96476	
	4	26,1667	2,14476	
Duygu Değişimi Ve Dalma	1	17,0556	1,34917	,388
	2	16,7647	1,48026	
	3	16,6471	1,49755	
	4	16,3056	1,68725	
Toplam	1	89,6111	5,55337	,148
	2	88,8235	6,83955	
	3	90,3529	4,47131	
	4	87,0278	4,95976	

Yapılan tek yönlü varyans analizi sonunda, bütün boyutlara istatistiki olarak anlamlı bir farklılık belirlenmemiştir.

TARTIŞMA ve SONUÇ

Yapılan tanımlayıcı istatistik analizi sonunda, aşırı odaklanma ve erteleme boyutunda erkeklerin; çatışma, yoksunluk ve arayış alt boyutunda kadınların; duygu değişimi ve dalma alt

boyutunda kadınların daha yüksek puan aldığı belirlenmiştir. Ancak bütün boyutlar arasında istatistiksel olarak anlamlı bir farklılık bulunamamıştır. Bölüm değişkenine bağlı olarak yapılan karşılaştırma sonunda, çatışma yoksunluk ve arayış boyutunda istatistiksel olarak anlamlı bir farklılık belirlenmiştir. Sınıf değişkenine bağlı yapılan karşılaştırtma sonunda, bütün boyutlara da istatistiki olarak anlamlı bir farklılık belirlenmemiştir. Yapılan literatür taraması sonunda. Konu ile ilgili yapılan birçok çalışmanın olduğu görülmüştür. Bu çalışmalardan bazıları aşağıda verilmiştir.

Orak ve arkadaşları 2021 yılında yaptıkları çalışmalarında, Duygu, Aşırı Odak ve Yoksunluk alt boyutlarında Diğer Fakülteler lehine istatistiksel olarak anlamlı fark tespit edilmiştir. Arslan, (2020) yapmış olduğu çalışmada Üniversite öğrencilerinin dijital bağımlılık seviyelerinin orta düzeyde olduğunu ifade etmiştir.

Koçoğlu tarafından (2019) yılında yapılan bir çalışmada, üniversite öğrencilerinin çevrimiçi oyun oynama süreleri arttıkça bağımlılık düzeylerinde bir artış olduğu belirlenmiştir. Yine yapılan farklı çalışmalarda, dijital oyun oynamak için harcanan para miktarı arttıkça, dijital oyun bağımlılığı düzeyinin arttığı sonucuna ulaşılmıştır (Ayhan ve Köseliören, 2019; Çavuş vd., 2016). Yapılan bazı çalışmalarda Öğrencilerin ailelerinin sosyo-ekonomik düzeyi arttıkça öğrencilerin dijital oyun bağımlılık düzeylerinin arttığı sonucuna ulaşılmıştır (Orak ve ark.2021; Ekinci ve ark. 2017; Göldağ, 2018). Çavuş ve arkadaşları tarafından (2016) yılında yapılan bir çalışmada, üniversite öğrencilerinin ailelerinin gelir düzeyi arttıkça, bağımlılık düzeyinin de arttığı tespit edilmiştir. Bilge ve arkadaşları tarafından (2018) yılında yapılan bir araştırmada, erkek öğrencilerin kadın öğrencilere oranla daha fazla patolojik internet ve oyun bağımlılığına sahip oldukları belirlenmiştir. Arslan ve Bardakçı ise (2020) yılında yaptıkları çalışmalarında, erkek öğrencilerin, kadın öğrencilere kıyasla tüm alt boyutlarda daha bağımlı olduklarını belirlemişlerdir. Bilge ve arkadaşlarının (2018) yılındaki çalışmalarında, Spor Bilimleri Fakültesinde okuyan öğrencilerin diğer fakültelerde okuyan öğrencilerden daha fazla dijital oyun bağımlılığı oldukları belirlenmiştir.

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NUMERICAL ANALYSIS OF LOW-VELOCITY IMPACT ON GLASS FABRIC-ALUMINUM SANDWICH COMPOSITE PLATES

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ABSTRACT

This study examines the low-velocity impact (LVI) response of reinforced epoxy composite plates subjected to an impact energy of 20 J, concentrating on structures made of woven glass fiber, aluminum, and their symmetric hybrid configurations. Numerical simulations using finite element analysis (FEA) were conducted to compare the mechanical behavior and energy absorption characteristics of these materials under controlled impact conditions.

The analysis was conducted using LS-DYNA, and composite plates were modelled ACP(Pre) module. LVI test was simulated by a dropped impactor having 12.7 mm diameter at a velocity of 2.06 m/s. First, optimum fiber orientation of the glass fiber was studied by comparing the absorbed energy and peak load values of two different fiber orientations ($[60/45/-45/-60]_6$ and $[90/0/-45/45]_6$). The results were then validated against experimental data in the literature. After validating the model, different stacking configurations were modeled in the thickness of 5.1 mm.

The results reveal that symmetric hybrid configurations, combining woven glass fiber and aluminum layers, exhibit superior impact resistance compared to monolithic glass fiber or aluminum plates. Specifically, the hybrid composites demonstrated enhanced energy dissipation, and reduced peak force, highlighting the benefits of material hybridization. This research provides critical insights into the design and optimization of hybrid composite structures for applications requiring impact resilience, such as aerospace, automotive, and marine industries. The findings underscore the potential of symmetric hybrid composites to improve structural performance under dynamic loading scenarios.

Key Words: Low-velocity Impact; Glass Fiber; Epoxy; Composite; Numerical Analysis.

EFFICIENCY MEASUREMENT OF KÜTAHYA HEALTH SCIENCES UNIVERSITY: DEA METHODOLOGY

This study was produced from the project titled "Efficiency and productivity measurement of Kütahya Health Sciences University: Evidence based on non-parametric approaches" supported by Kütahya Health Sciences University Scientific Research Projects Coordination Unit within the scope of project number SBA-2024-195.

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ABSTRACT

Introduction and Purpose: An inclusive, egalitarian and efficient quality education system is at the top of the agenda of education authorities around the world. However, higher education institutions need to characterize a strong goal rationalism. At the same time, the management of higher education institutions is complex and measuring the strengths and weaknesses is very important in order to be a better educational institution. The purpose of this research is to calculate the relative efficiency of the institutes, faculties and vocational schools of Kütahya Health Sciences University in the 2021-2022, 2022-2023 and 2023-2024 academic years.

Materials and Methods: Data Envelopment Analysis (DEA) can calculate the efficiency, that is, the performance, of universities whose primary objectives are non-profit, from multiple perspectives. In this context, DEA methodology is followed in the study in question. The sample group of the study consists of the decision-making units (DMU) of the Graduate Education Institute, Faculty of Health Sciences, Faculty of Medicine, Gediz Health Services Vocational School, Tavşanlı Health Services Vocational School and Simav Health Services Vocational School. For the relative efficiency measurements of the relevant DMUs, the ratio of the number of students to the number of academic staff and the budget input variables, and the number of graduate students and scientific activities were used as output variables.

Results: The six decision-making units included in the analysis and forming the sample set correspond to 75% of the number of universe units. The performance findings of the output-oriented BCC (Banker, Charnes and Cooper) model and the variable returns to scale envelope surface type DEA provide information that three DMUs out of six are effective and efficient.

Discussion and Conclusion: After determining the effective and ineffective decision-making units with the DEA methodology, reference sets were created for ineffective DMUs. Within the scope of the reference sets, potential improvement rates were calculated for DMUs to increase their performance. Therefore, measuring the input and/or output amounts that need to be increased and/or decreased prevents resource waste and aims to increase efficiency.

Key Words: Efficiency; Performance; University; Data Envelopment Analysis

DETERMINATION OF THE QUALITY PROPERTIES OF PRODUCED RAW MILK

ÜRETİLEN ÇİĞ SÜTLERİN KALİTE ÖZELLİKLERİNİN BELİRLENMESİ

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ABSTRACT

Quality raw milk is obtained from healthy and clean animals, possessing normal appearance, taste, flavor, smell, and composition, with a low microorganism count and free from any foreign substances. Ensuring milk quality is essential for healthy human nutrition. The production of high-quality raw milk is crucial for obtaining safe and superior dairy products. In Turkey, the quality of raw milk is regulated by the Regulation on the Supply of Raw Milk (Communiqué No: 2017/20), Regulation on the Classification of Raw Cow's Milk (Communiqué No: 2019/64), and Raw Milk Support and Dairy Market Regulation Implementation Communiqués (Communiqué No: 2020/15).

The primary criteria determining raw milk quality include microbiological quality, chemical composition, physical and sensory properties, and purity. Microbiological analyses assess the presence of pathogenic microorganisms and the total bacterial load, while chemical analyses evaluate milk components and detect potential adulteration. Physical tests examine structural properties such as viscosity, density, and temperature, and sensory evaluations assess color, smell, and taste characteristics.

This review study examines the quality characteristics of raw milk produced in Turkey according to various criteria. Additionally, potential adulterants and contaminants (antibiotics, pesticides, aflatoxin M1, heavy metals, PCBs, dioxins) in raw milk are thoroughly addressed, emphasizing their potential health risks to humans. Ultimately, enhancing raw milk quality requires implementing effective quality control processes, adhering to hygiene and sanitation standards, and strengthening collaboration among all stakeholders in the sector.

Keywords: Raw Milk Quality, Raw Milk Adulteration, Raw Milk Contaminants.

ÖZET

Kaliteli çiğ süt sağlıklı ve temiz bir hayvandan elde edilen, normal görünüm, tat, lezzet, koku ve bileşime sahip, mikroorganizma sayısı düşük, dışarıdan bulaşmış herhangi bir yabancı madde içermeyen süttür. İnsanların sağlıklı beslenebilmeleri için süt kalitesinin belirlenmesi ve kontrol edilmesi zorunludur. Kaliteli çiğ süt üretimi, yüksek kaliteli ve güvenli süt ürünleri elde edilmesi açısından büyük önem taşımaktadır. Çiğ sütün kalitesi ile ilgili Çiğ Sütün Arzına Dair Tebliğ (Tebliğ No: 2017/20), Çiğ İnek Sütünün Sınıflandırılmasına İlişkin Tebliğ (Tebliğ No: 2019/64) ve Çiğ Süt Desteği ve Süt Piyasasının Düzenlenmesi Uygulama Tebliğleri (Tebliğ no: 2020/15) vardır. Çiğ süt kalitesini belirleyen temel kriterler arasında mikrobiyolojik kalite,

kimyasal bileşim, fiziksel ve duyusal özellikler ile saflık yer almaktadır. Mikrobiyolojik analizlerle patojen mikroorganizmaların varlığı ve toplam bakteri yükü belirlenirken, kimyasal analizlerle süt bileşenlerinin oranları ve olası hilelerin tespiti yapılmaktadır. Fiziksel testlerle sütün viskozite, yoğunluk ve sıcaklık gibi yapısal özellikleri değerlendirilmekte ve duyusal incelemelerle ise renk, koku ve tat gibi özellikler kontrol edilmektedir.

Bu derleme çalışmasında, Türkiye'de üretilen çiğ sütlerin kalite özellikleri çeşitli kriterler doğrultusunda incelenmiştir. Ayrıca, çiğ sütlerde görülebilecek hileler ve kontaminantlar (antibiyotik, pestisit, aflatoksin M1, ağır metaller, PCB'ler, dioksinler) detaylı olarak ele alınmış ve bunların insan sağlığı üzerindeki potansiyel riskleri vurgulanmıştır. Sonuç olarak, çiğ süt kalitesinin artırılması için etkin kalite kontrol süreçlerinin uygulanması, hijyen ve sanitasyon standartlarına uygunluk ve sektördeki tüm paydaşlar arasında iş birliğinin güçlendirilmesi gerekmektedir.

Anahtar Kelimeler: Çiğ süt kalitesi, çiğ süt hileleri, çiğ süt kontaminantları.

SYNTHESIS OF 2-PHENYLFURANS BY OXIDATIVE CYCLIZATION REACTION

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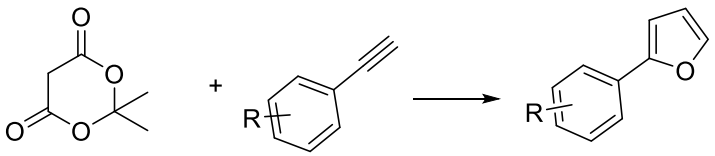
ABSTRACT

Furan is an important heterocyclic compound that forms the structures of natural products, pharmaceuticals and agricultural chemicals.[1] For example, this compound is present in the structure of important drugs such as dantrolene, ranitidine and nifurtimox. Therefore, it is of great importance to develop new methodologies for the synthesis of these compounds. There are many methods in the literature for the synthesis of these compounds.[2] The method we propose to synthesise 2-phenylfuranes in this study is a single-step synthesis and is not reported in the literature.

In this study, the synthesis of 2-phenylfurans (**3**) was carried out by reacting 2,2-dimethyl-1,3-dioxane-4,6-dione (**1**) with various acetylene compounds (**2**) in the presence of oxidative cyclization reagents. This methodology for the synthesis of 2-phenylfurans is not found in the literature.



(1) (2) (3)

Key Words: 2-Phenylfurans; acetylene; 2,2-Dimethyl-1,3-dioxane-4,6-dione; Oxidative cyclization

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