III. INTERNATIONAL APITHERAPY AND NATURE CONGRESS

IANCO25

21-23 November 2025

BAKU, AZERBAYCAN

PROCEEDING BOOK

EDITOR

SEVGİ KOLAYLI

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DEAR PARTICIPANTS

Thank you for your participation in and interest in the III. International Apitherapy and Nature Congress (IANCO25), held at the Institute of Botany, Ministry of Science and Education of the Republic of Azerbaijan, from November 21 to 23, 2025. This congress was held with the official approval of the Rectorate of Gümüşhane University (Decision No. 477, dated May 15, 2025).

Welcome to our congress. This year, we were honored to host the third edition of this congress series. The first congress was successfully held at Nakhchivan State University, and the second at Karadeniz Technical University. We are planning to organize the fourth congress in a different country. Over time, this congress has become a valuable platform for examining new studies in the natural sciences, particularly in apitherapy, sharing experiences and gaining new perspectives.

We hope that our congress has provided an opportunity for you to share your expertise in apitherapy and to establish strong professional connections. We have no doubt that your contributions, discussions, and presentations have expanded our collective knowledge in the fields of apitherapy and natural sciences. We are grateful for your contribution to the warm and constructive atmosphere that defines this congress.

The Apitherapy and Nature Research Group, which organizes and gives its name to this congress, continues its work and is pleased to announce that the Apitherapy and Nature Congress series will continue in the future. In addition, our group has been publishing the Apitherapy and Nature Journal since 2018. The journal is indexed in TR Dizin and accepts manuscripts aligned with the topics discussed at our congress.

At the 3rd Apitherapy and Nature Congress, a total of 154 papers were presented, consisting of 95 oral presentations and 49 poster presentations, by participants from 12 different countries. More than half of the oral presentation participants were from outside Türkiye. We hope that the increasing number of submissions observed compared to our previous congresses will continue in future events, as well as in the Apitherapy and Nature Journal.

We thank you for your interest, contributions, and active participation throughout the congress. We look forward to meeting again at future events and wish you continued success in your work in the fields of nature and apitherapy.

Best regards,

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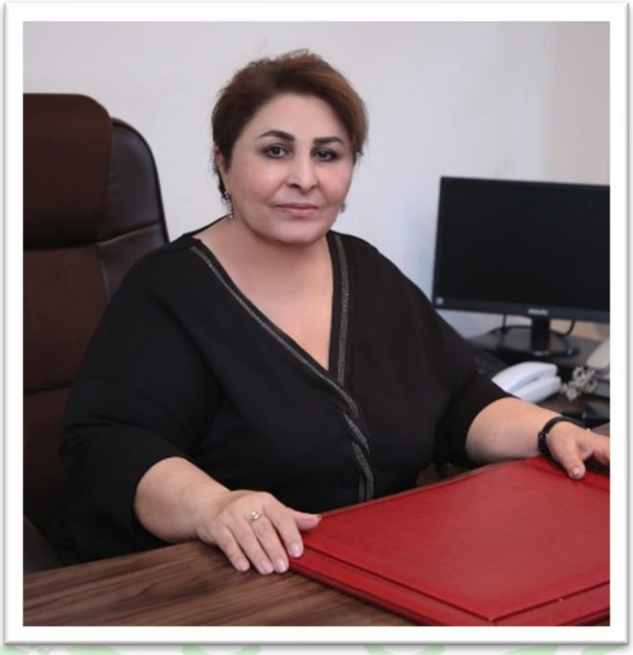

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ACCEPTED ORAL PRESENTATION PAPERS

Türkiye: 42
Other Countries: 53
Total: 95

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CONGRESS PROGRAM

3rd International Apitherapy and Nature Congress 2025
(21–23 November 2025)
Baku, Azerbaijan

22 November, Saturday - SALON A

09.00–11.00 Opening Ceremony

Time	Program
9.00-9.30	Registration
9.00-9.15	National Anthem
9.15-9.30	**Prof. Dr. Sayyara IBADULLAYEVA** Director of the Institute of Botany
9.30-9.45	**Prof. Dr. Elbrus İSAYEV** The Rector of Nakhchivan State University
9.45-10.00	**Prof. Dr. Oktay YILDIZ** The Rector of Gümüşhane University
10.00-10.15	**Prof. Dr. Sevgi KOLAYLI** Professor, Karadeniz Technical University
10.15-10.20	**Prof. Dr. M. Iqbal CHOUDHARY** Professor, University of Karachi
10.20-10.35	**Elkhan ALAKBAROV** Chairman of the Professional Beekeepers Association
10.35-11.00	Caffe Break

Zoom Link: https://us02web.zoom.us/j/9503222265?pwd=aXB4VmZWQ3QxcUIwTnVraGJoNncyQT09
Meeting ID: 950 322 2265 **Passcode**: Botanika

SESSION 1 – Bee Products and Human Health
Chairs: Prof. Dr. Bashar SAAD – Prof. Dr. Hüseyin ŞAHİN

11.00–11.15 Dimitris MOSSIALOS – Beebread Against Biofilm Formation and Biofilm Eradication...
11.15–11.30 Saida HASANOVA – Genetic Polymorphism in a New Chickpea (Cicer arietinum L.) Collection
11.30–11.45 Merve CORA – In Vitro Assessment of the Antimicrobial and Cytotoxic Effects of Bee Bread and Valya Propolis
11.45–12.00 Sinan TETİKOĞLU – Negative Anastasis in Breast Cancer After Bee Venom Exposure: An Epigenetic Insight
12.00–12.15 Muhammad ZAFAR – Advancing Bee-Based Bioactive Therapies for Global Health and Sustainable…
12.15–12.30 Bashar SAAD – Palestinian Honeys and Natural Products as Emerging Multitarget Therapeutics: Antibacterial, Antioxidant, Anticancer…

Lunch: 12.30–14.00

SESSION 2 – Natural Basic Science
Chairs: Prof. Dr. Ayhan GÖSTERİT – Assoc. Prof. Elsever ASADOV

14.00–14.15 Hüseyin ŞAHİN – Development of Eco-Friendly Propolis Extracts Using Deep Eutectic Solvents
14.15–14.30 Nevzat BATAN – New Liverwort Records from the Artabel Lakes Nature Park…
14.30–14.45 Saliha DİNÇ – Carbon Dot-Based Strategies for Vitamin Detection
14.45–15.00 Halil İbrahim GÜLER – In Silico and In Vitro Evaluation of Bis-Imidazole Derivatives as Potential HIV-1 Reverse Transcriptase Inhibitors
15.00–15.15 Ferhat DEMİR – Effect of Electromagnetic Fields on The Amount Of 10-HDA In Royal Jelly Production
15.15 –15.30 Noureddine DJEBLI – Phytochemical characterization and in vitro evaluation of the antioxidant activity of extracts from Calendula officinalis L.

Coffee Break: 15.30–16.00

SESSION 3 – Beekeeping
Chairs: Prof. Dr. Dimitris MOSSIALOS – Assoc. Prof. Dr. Saliha DİNÇ

16.00–16.15 Rahşan KOÇ AKPINAR – Honeybee Diseases: Current Status and Approches
16.15–16.30 Ömer Necati CORA – Bridging Biology to Engineering Solutions: Biomimetics
16.30–16.45 Kübra ZENGİN – First Isolation and Characterization of Bombella apis from the Digestive System of Apis mellifera caucasica …
16.45–17.00 Mevlüt TÜRK – Effects of Different Nitrogen Doses and Harvesting Times on The Forage Yield and Quality of Triticale
17.15–17.30 Ayhan GÖSTERİT – Effect of Selection on Sustainability of Mass Rearing in Bumblebees
17.30–17.45 Ayhan GÖSTERİT – Effect of Flupyradifurone (Butenoloid) on Memory and Learning Behavior of Honeybees
17.45 – 18.00 Gülsauir KURBANIYAZOVA – Geospatial Distribution and Centers of Origin of Iris hippolyti (Vved.) Kamelin Endemic Species in Uzbekistan

GALA DINNER: 19.00–23.00

22 November, Saturday – SALON B

Session 4 – Natural Products
Chairs: Prof. Dr. Zihni DEMİRBAĞ - Ass. Prof.Dr. Zeynep KALAYCIOĞLU

11.00–11.15 Zeynep KALAYCIOĞLU – Sensitive Determination of Bioactive Components in Medicinal Plants by Capillary Electrophoresis
11.15–11.30 Neslihan AKARSU – Biological Activities of Propolis and Essential Oil Combinations
11.30–11.45 Tuana KARA – Apilarnil-Loaded alginate microbeads: physicochemical properties, bioactivity, and release behaviour
11.45–12.00 Meryem N. KANTEKIN – Hazelnut Oil Oleogels Structured with Propolis Wax as a Solid Fat Alternative

12.00–12.15 Gülsüm M. BOYRACI – Fate of Tea Polyphenols in the Gastrointestinal System Stability and Bioaccessibility

12.15 – 12.30 Ramidə Zahid QULİYEVA - The Place and Position of Caryophyllaceae in the Petrofit-Floristic Complexes of Azerbaijan

Lunch: 12.30–14.00

Session 5 – Natural Products
Chairs: Prof. Dr. Ömer Necati CORA - Ass. Prof. Dr. Zulfiyya Mammadova

14.00–14.15 Muhamad SAHLAN – Indonesian Propolis: A Natural Multi Therapeutic Approach for Women's Health Challenges

14.15–14.30 Salman MAJEED – Melissopalynology and Therapeutic Potential of Melliferous Plants: Apitherapy and Bee Product Implication in the Thal desert

14.30–14.45 Gültekin ALIYEVA – The effect of royal jelly on girls' sexual development: a natural supportive and regulatory influence

14.45–15.00 Selma KAHRAMAN – The Use and Effect of Honey in Nursing Care: A Systematic Review Study

15.00–15.15 Tuğba MAZLUM ŞEN – Comparison of Antilipase Effects of Propolis, Pollen and Bee Bread Sample

15.15–15.30 Muslima AMİRİDDİNOVA – The Role of Natural Sciences in Understanding and Managing Ecotourism

Coffee Break 15.30–16.00

Session 6 – Natural Products
Chair: Ass. Prof. Dr. Tubukhanim Gasimzade

16.00–16.15 Çiğdem BOGENÇ – The Use of Artificial Intelligence and Virtual Reality in Cultural Heritage Sites: An Exploration of Nature-Based Experiences

16.15–16.30 Banu BEKÇİ – Ecosystem-Based Microlandscape Interventions in Urban Children's Playgrounds

16.30–16.45 Meltem A. MALKOÇ – Phenolic Composition and Antioxidant Capacity of Bee Pollen Collected from the Aran Region of Azerbaijan

16.45–17.00 Sevgi KOLAYLI – Phenolic Composition of Licorice (Glycyrrhiza glabra) and Propolis Mixed Extract

17.00–17.15 Merve Nur ÖZKAN – The Effects of Royal Jelly on Health and Its Reflections on Nursing Care: Review

17.15–17.30 Hilal Ebru ÇAKIR – Characterization of Physicochemical and Bioactive Properties of Butterfly Honeydew Honey Originating from Ricania simulans Secretions

17.30–17.45 Zahra MOUSAVİ – Biochemical and Histopathological Evidence for Beneficial Effects of Salvia Macrosiphon Mucilage on the Rat Model of ulcerative colitis

17.45–18.00 Gulnara BABAYEVA – Determination of antioxidant and antiviral properties of saponins obtained from Yucca aloifolia var. Tricolor

22 November, Saturday – SALON C

ONLINE Session 7
Chairs: Ass. Prof. Dr. Meltem ARIKAN MALKOÇ - Ass. Prof. Dr. Mehmet KEMAL

13.00–13.15 Sedat SEVIN – Using Technology in Royal Jelly Production: Larva Transfer System
13.15–13.30 Gülnarə ASADOVA – COP29: Azerbaijan's Major Contributions to Climate Change
13.30–13.45 Elşad İSMAYILOV – Biologically Active Components and Pharmacological Perspectives of Bee Venom
13.45–14.00 Sabina TAGHIYEVA – Determination of Anticholinesterase, Antiglaucoma and Antidiabetic Effects of Some Vitamins
14.00–14.15 Hafiz HÜSEYINOV – The Potential of Apitherapy Tourism in Nakhchivan
14.15–14.30 Fatma YAYLACI KARAHALIL – Comparative Investigation of the Effects of Geographic and Topographic Differences …
14.30–14.45 Mehmet Alaaddin YALÇINKAYA – Beekeeping and Apitherapy in the Ottoman Empire (1623–1923)
14.45–15.00 Mualla YALÇINKAYA – A Review of The Impacts of Climate Zones on Vegetation Dynamics and Driving Factors
15.00–15.15 Segueni NARİMANE – Algerian Propolis as an Effective Food Preservative: Antioxidant and Antibacterial Activities and Evaluation of Oral Toxicity
15.15–15.30 Seyfaddin JAFAROV – Study of the Dielectric Properties of Solvothermal Synthesized Cdse;0.5%Ho Nanocrystal
15.30–15.45 Badia LYOUSSI – Pharmacology of Bee Products
15.45–16.00 Esra DEMIR KANBUR – The Phenolic Composition of Licorice honey (Glycyrrhiza glabra L.)

Coffee Break 16.00-16.30

Session 8 – Natural Products
Chairs: Ass. Prof. Dr. Özlem SARAL - Ass. Prof. Dr. Saida HASANOVA

16.30–16.45 Sitara MUSTAFAYE – Investigation of the Antifungal Properties of *Inula helenium* L. (Elecampane)
16.45–17.00 Zulfiyyə MƏMMƏDOVA – Phytocoenoses Formed by Species of the Genus Trigonella L. in the Flora of Azerbaijan
17.15–17.30 Shamsiyya MAMADOVA – Determination of Biochemical and Globulin Reserve Proteins in Chickpea (Cicer arietinum Linn.) Variety Samples
17.30–17.45 Dilnoza MAMADOVA – Analysis of Biochemical and Ethnomedicinal Studies on Species of the Genus myosotis L
17.45–18.00 Mustafa AYBAR – Determination of Important Plants for Beekeeping and Their Potential Uses in the Flora of Aksu Plateau, Ardanuç District, Artvin Province

23 November, Sunday – SALON A

Session 9 – Alternative Medicine
Chairs: Prof. Dr. Noureddin DEBJİ - Ass. Prof. Dr. Aygun Mammadova

9.00–9.15 Gulshat ANARBEKOVA – Features of the Ecological Niche of Biodiversity of True Bugs (Heteroptera)
9.15–9.30 Özlem SARAL –The Truth About Microplastics in Honey
9.30–9.45 Mehmet KEMAL – Effects of Propolis on Obesity: A Review of Potential Mechanisms and Therapeutic Use
9.45–10.00 Atiye DEĞİRMENCİ – In Vitro Digestion and Colonic Fermentation: The Next Step for Phenolics Bioaccessibility
10.00–10.15 Ülkü Zeynep ÜREYEN ESERTAŞ – Recent Perspectives on the Antimicrobial Potential of Bee Products Against …
10.15–10.30 İrada MAMEDOVA – Study of bioecological properties and vegetative propagation Trachelospermum jasminoides of the species (LINDL.)LEM.

Coffee Break 10.30–11.00

Session 10 – Basic Sciences
Chairs: Dr. Muhammed ZAFAR- Ass. Prof. Dr. Nigar MURSAL

11.00–11.15 Noureddin DJEBLİ – Neuroprotective Effects of Royal Jelly on Alzheimer's Disease: In Vivo Study
11.15–11.30 Funda BİLGİLİ – Heavy Metal-Assisted Modulation of Olive Bioactivity in the Thermal Power Plant Region: Cytotoxic Effects on Cancer and Healthy Cells
11.30–11.45 Sarita QƏNBƏRLİ – Study of Spring Plants of The Genus Rosa L. Distributed in the Flora of the Nakhchivan Autonomous Republic
11.45–12.00 Afaq Amjad SAHAB – In Silico Evaluation of Calotropis Procera Phytochemicals as Potential Inhibitors of Escherichia Coli DNA Gyrase A
12.00–12.15 Ayten Yılmaz YAVUZ – Knowledge Levels of Beekeepers in Türkiye About Bee Venom Allergy and Traditional Treatment Methods They Use Against Bee Stings
12.15–12.30 Midhat JASIC – Importance Bee Products in Nutrition

23 November, Sunday – SALON B

Session 11 – Biodiversity
Chairs: Ass. Prof. Dr. Selma Kahraman - Ass. Prof. Dr. Gültekin Aliyeva

9.00–9.15 Gülşah OKUMUŞ YÜKÜNÇ – Storage-Dependent Changes in 10-HDA Content and Protein Profile of Royal Jelly
9.15–9.30 Tubukhanım QASIMZADE – Eco-geobotanical Assessment of Gakh Forest Areas
9.30–9.45 Elnara SALAHOVA – Rare and Endangered Herbaceous Plants of the Gabala Region Biodiversity

9.45–10.00 Aladdin GADIMOV – The influence of Trichoderma on Morphometric Parameters and Nitrogen Metabolism of Durum …
10.00–10.15 Mehtap ER KEMAL – Biological activity of Artemisia verlotiorum extracts
10.15–10.30 Haydeh KEYHAN – Investigating the changes of blood and tissue factors in the injection of bee venom and melittin on the knee cartilage of male rats
10.30–10.45 Saida VALIZADA – First Aid for Bee Stings: Safe and Effective First Aid Measures

Coffee Break 10.45–11.00

Session 12 – Natural Science
Chairs: Dr. Salman MAJEED - Ass. Prof. Dr. Ramidə QULIYEVA

11.00–11.15 Mirela STRANT – Bee Products for Children
11.15–11.30 Nuray GADIROVA – Vegetative Propagation Methods of Camellia japonica Adapted to Absheron Conditions
11.30–11.45 Aygun MAMADOVA – The Cosmetic Potential of Moss Species Widespread in Azerbaijan
11.45–12.00 Hilal QASIMOV – Phytocoenological Characteristics and Conservation of Rare Species Belonging to the Family Apiaceae Lindl. …
12.00–12.15 Seyidova LEYLABEYIM MIRMAMMAD – History of The Study of Free-Living İnfusoria And Amoebas İn Freshwater Basins of The Nakhchivan Autonomous Republic
12.15–12.30 Jeyran NAJAFOVA – Study of some rare tree, shrub and herb species of Khizi district

23 November, Sunday – SALON C

Session 13 – Biodiversity
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9.15–9.30 Nuri MOVSOMUVA – Ethnobotanical and Therapeutic Properties of Tree and Shrub Plants in Karabakh
9.30–9.45 Sura RAHIMOVA – The study of the Lactuca L. genus in the flora of the Nakhchivan Autonomous Republic
9.45–10.00 Zulfiyye SEYIDZADE – Pharmacological Effects And Sedical Significance of Hypericum perforatum L.
10.00–10.15 Erol TUNCA – Comparative Evaluation of Physical, Phenolic, and Antioxidant Properties of Oak, Chestnut, and Pine Honeys from Balıkesir, Türkiye
10.15–10.30 Zehra CAN – Exploring the Bioactive and Antioxidant Potential of Pollen from Distinct Regions of Türkiye
10.30–10.45 Karima EL-YAGOUBI – Protective and Anti-Anemic Effects of an Optimized Mixture of Moroccan Ziziphus lotus Honey and Bee Pollen …

Session 14 – Biodiversity
Chair: Ass. Prof. Dr. Mustafa AYBAR

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11.00–11.15 Mushtaq AHMAD – Honeybee Pollen Biodiversity and Nature Based Solutions for Health Security via Apitherapy in Asia

11.15–11.30 G. D. ANARBEKOVA – Analysis of the Antioxidant Potential of Plants Used in Traditional Medicine

11.30–11.45 Elsever ASADOV – Application of Pharmaceutical Preparations Derived from Beekeeping Products Produced in the Nakhchivan …

11.45–12.00 Elsever ASADOV – Nahçıvan Özerk Cumhuriyeti Koşullarında Arı Propolisinin Antimikrobiyal Özellikleri

12.00–12.15 Yunis RUSTAMLİ – Tropilaelaps – A New Threat to Beekeeping in Azerbaijan and Ways to Prevent it

12.15–12.30 Hasan GAMBAROV – The Impact of Helminthiasis on Livestock Productivity in the Nakhchivan Autonomous Republic

POSTER PRESENTATION

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Malik ƏLİYEV, Samirə HÜSEYNOVA

P2 **Biodegradation of NSAIDs by Stutzerimonas stutzeri Fad2: A Sustainable Biotechnological Strategy**
Sabriyə Çanakçı, Fatma Nur YILDIRIM, Elif APAYDIN

P3 **Genetıc Dıversıty Study of Lentıl (Lens Culınarıs) Accessıons Usıng Rapd Markers**
Sudaba Hasanova, Hamida Seyidova, Saida Hasanova, Fatima Babayeva

P4 **Medicinal Significance of Rosa canina L. Species in the Nakhchivan Autonomous Republic**
Anvar İBRAHİMOV, Hamida SEYİDOVA

P5 **Medicinal Significance of Satureja macrantha C.A.Mey. (Lamiaceae Lindl.) Species Distributed in the Territory of Nakhchivan Autonomous Republic**
Shafiga SULEYMANOVA

P6 **The healing properties of processed products from some indigenous grape varieties of the Nakhchivan Autonomous Republic of Azerbaijan**
Jabbar NAJAFOV, Heydar ASADOV

P7 **Protein and Amino Acid Indicators of Synthetic Wheat Genotypes under Irrigated and Rainfed Conditions**
Metanet Babayeva, Shamsiya Mammadova, Azizə Hüseynova

P8 **Mycological Monitoring of Some Medicinal Plants Distributing in the Gadabay Region**
Fidan Məmmədova

P9 **Ecogeographic Analysis of the Genus Carex L. Distributed in Azerbaijan**
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CONTENTS

ORAL PRESENTATION PAPERS

Hazelnut Oil Oleogels Structured with Propolis Wax as a Solid Fat Alternative

Katı Yağ Alternatifi Olarak Propolis Vaksı ile Yapılandırılmış Fındık Yağı Oleojelleri

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Abstract

The increasing pace of work life and the limited time individuals can devote to nutrition have led to a significant rise in the consumption of ready-to-eat foods. Solid fats are commonly used in bakery products, confectionery, processed foods, and fried products to achieve the desired texture and flavor. However, due to their high saturated and trans fatty acid content, these fats may increase the risk of health problems such as hypertension, high cholesterol, obesity, and allergies. This situation has highlighted the need for healthier alternatives, bringing to the forefront oleogels, which are obtained by structuring liquid edible oils using oleogelators. Oleogels are novel systems that provide a solid-like consistency at room temperature, are entirely based on liquid oils, and contain no trans fatty acids, making them promising substitutes for traditional solid fats. In this study, oleogels with potential as solid fat replacers were developed using **hazelnut oil**, a strategic product for Türkiye, and **propolis wax**, which contains bioactive compounds with antioxidant and preservative properties. The oleogels were formulated using **6% and 8% propolis wax**. The produced oleogels will be evaluated in terms of crystal morphology, **crystal formation time, and color values.** Hazelnut oil oleogels containing propolis wax have great potential for developing functional and healthy solid fat alternatives for the **bakery and ready-to-eat food industries**. This innovative approach presents the food industry with a new path toward utilizing local resources and developing health-oriented products.

Keywords: Solid Fat Replacer, Oleogel, Hazelnut Oil, Propolis Wax

1. INTRODUCTION

In recent years, there has been a notable increase in the consumption of ready-to-eat and packaged foods. Consumers widely prefer products such as cakes, biscuits, and wafers, which generally contain high levels of fat (Broderick et al., 2015; Millar et al., 2017). In these products, fats known as shortenings are commonly used due to the desirable taste, texture, and appearance they provide. Shortenings are produced by modifying vegetable oils, including palm, safflower, canola, and sunflower oils, through various technological processes to obtain a saturated, solid form. These fats are rich in saturated fatty acids, and partially hydrogenated shortenings may contain trans fatty acids generated during the hydrogenation process (Zbikowska et al., 2023).

The high saturated and trans fat content of shortenings has been associated with several adverse health effects. Numerous studies have reported that these lipids contribute to coronary heart disease, metabolic disorders, cancer, diabetes, and obesity. In addition, they increase low-density lipoprotein (LDL) cholesterol levels, thereby disrupting the body's cholesterol homeostasis (White et al., 2010; Morio et al., 2016).

Owing to these health concerns, both industry and academia have increasingly focused on developing alternative fat-structuring strategies that preserve the nutritional value of liquid vegetable oils while eliminating saturated and trans fats. One of the most promising approaches in this context is organogelation. Through this technique, liquid vegetable oils can be structured using organogelators to mimic the functional properties of shortenings. Oleogels produced in this manner exhibit a semi-solid consistency and contain significantly lower levels of saturated and trans fats compared with conventional shortenings. Consequently, recent research has intensified on the development of room-temperature-stable, fully liquid-oil-based, trans-fat-free emulsion–oleogel systems with desirable sensory properties. Organogelation relies on trapping an organic liquid within a three-dimensional gel network. When edible oils are used as the organic phase, the addition of small amounts of organogelators enables the formation of stable gel structures at ambient temperature (Demiralp et al., 2017; Co & Marangoni, 2018; Puscas et al., 2020; Frolova et al., 2022).

A variety of organogelators, such as rice bran, candelilla, carnauba, sunflower waxes, and beeswax, are widely used in the food industry due to their strong gelation capacity, low cost, and broad compatibility with food systems. Their low polarity, long-chain molecular structures, and high melting points promote efficient crystallization, enabling liquid oils to be immobilized within a three-dimensional network and form stable gel structures (Sarkisyan et al., 2021).

Türkiye is the world's leading hazelnut producer (60%), and hazelnuts are widely used in confectionery due to their aroma and high nutritional value, containing about 65% oil (Alasalvar et al., 2003; Ozkal et al., 2005; Brufau et al., 2006; Durmaz & Gökmen, 2019). Hazelnut oil is rich in unsaturated fatty acids (93%) and vitamin E, and antioxidants such as α-tocopherol enhance its thermal stability. It is also used in pharmaceutical and cosmetic applications (Santamaria et al., 2003; Zuniga et al., 2003; Franco et al., 2014; Mazidi et al., 2020).

Propolis is a bee-derived natural material composed of waxes, essential oils, and phenolic compounds, providing antimicrobial and antioxidant properties. Its GRAS components support its use as a natural preservative and in food packaging and also since it has a significant amount of wax components (up to 30-40%) it possesses the necessary characteristics (long-chain fatty acids/esters) to act as an effective organogelator by forming a stable network within the oil phase (Burdock, 1998; Tosi et al., 2007; Bastürk et al., 2023).

In this study, oleogels will be produced using hazelnut oil structured with 6% and 8% propolis wax. Their physicochemical, structural properties will be evaluated to determine their suitability as healthier fat alternatives for food applications.

2. MATERIALS and METHODS

Refined hazelnut oil was purchased from a local supplier and used as the continuous phase in the oleogel formulations. Propolis wax, obtained as described below, was incorporated at concentrations of 6% and 8% (w/w) to structure the oil**.**

2.1. Propolis Wax Extraction

Propolis wax (PW) was extracted by subjecting 25 g of finely ground propolis to Soxhlet extraction with hexane for 8 h. At the end of the extraction, the solvent was removed under reduced pressure using a rotary evaporator, yielding the wax-rich fraction. The purified wax was stored under refrigeration for formulation studies (Trusheva et al., 2007).

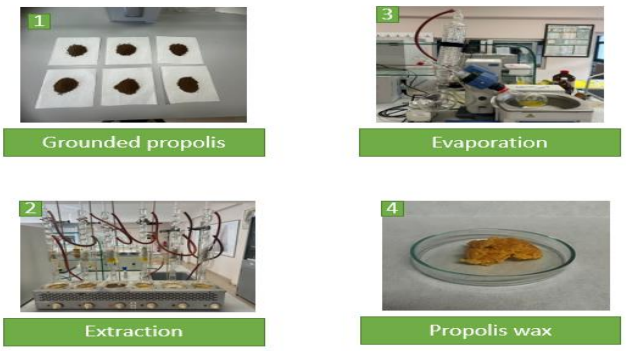

Figure 1. Schematic representation of propolis wax preparation.

2.2. Oleogel Preparation

A series of oleogels was prepared by incorporating propolis wax at two concentrations (6 and 8 w/w %) into hazelnut oil. Each mixture was heated to 90 °C and stirred for 15 min to ensure complete melting and uniform dispersion of the propolis wax. After heating, the formulations were poured into glass containers and allowed to cool to room temperature. The samples were then left overnight to enable proper gel network formation (Sislioglu et al., 2021).

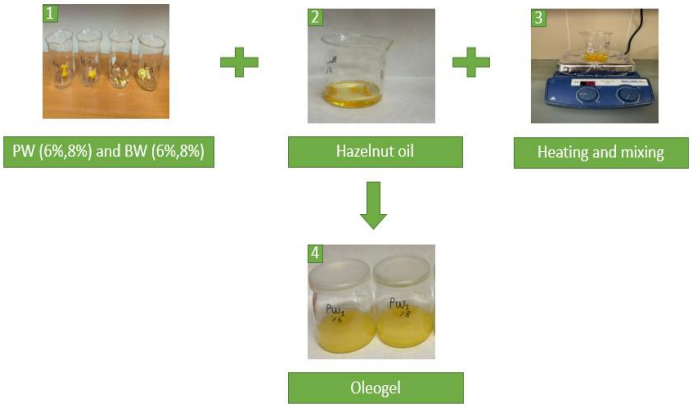

Figure 2. Preparation process of oleogels containing propolis wax.

2.3. Crystal Morphology

The crystal morphology of the oleogels was examined using a ZEISS AXIO trinocular microscope, and the images were captured with an Olympus DP28 digital camera equipped with compatible image analysis software. Microscopic evaluation was conducted to characterize the crystal shape and overall microstructural features of the oleogels.

2.4. Crystal Formation Time (CFT)

Oleogel samples were first completely melted in a water bath at 90 °C and held for 2 h to ensure isothermal equilibrium. After removal from the water bath, the samples were allowed to cool to room temperature, at which point timing was initiated. The crystal formation time (CFT) was determined as the time required for the sample to remain fixed when the tube was tilted to 90° without any observable flow (Dassanayake et al., 2009).

2.5. Color Value Determination

The color properties of the oleogel formulations were evaluated using a Linshang LS173 colorimeter. Following instrument calibration, measurements were conducted at various points on the sample surface, and the resulting L*, a*, and b* values were recorded for color characterization. The L* coordinate represents sample luminance, with lower values indicating reduced lightness and higher values denoting brighter appearances. The a* axis reflects chromatic shifts from green (−a*) to red (+a*), while the b* axis captures transitions from blue (−b*) to yellow (+b*) (Barragán-Martínez et al., 2022).

3. RESULTS and DISCUSSION

3.1. Crystal Morphology of Propolis Wax Oleogels

The microstructural features of the oleogels structured with propolis wax are presented in Figure 3. As shown, propolis wax generated a well-defined three-dimensional crystalline network within the hazelnut oil. Both the 6% and 8% formulations exhibited needle-like crystals, which are characteristic of wax-based systems rich in long-chain esters and fatty acids. This observation is consistent with the findings of Fayaz et al. (2017), who reported that propolis wax forms needle-shaped crystals across various oil matrices, indicating that this morphology is an intrinsic property of the wax rather than a phenomenon driven by oil composition.

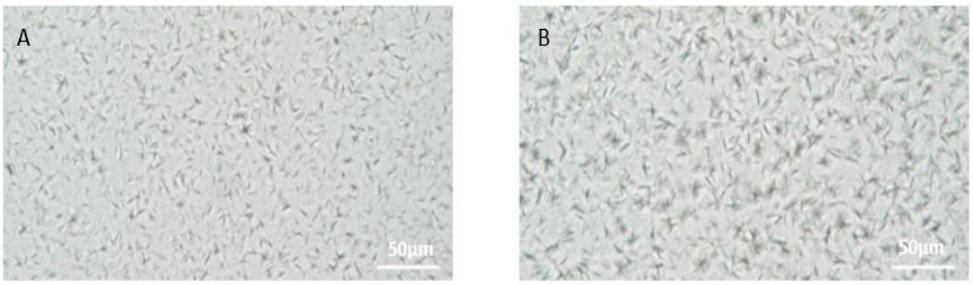

Figure 3. Crystal morphology of propolis wax oleogels: (A) PW6%, (B) PW8%.

Accordingly, the micrographs clearly demonstrate that propolis wax functions as an effective natural organogelator, with its structuring efficiency strongly dependent on concentration. The 8% formulation exhibited a denser, more continuous, and more uniformly distributed crystal network than the 6% sample. Aligning with these findings, Dassanayake et al. (2012) emphasized that elongated needle-like crystals promote the development of strong gel matrices, as their extended geometry enables the entrapment of substantial amounts of liquid oil within the three-dimensional crystalline network.

3.2. Crystal Formation Time (CFT) of Propolis Wax Oleogels

The gelling time of the oleogels structured with propolis wax is presented in Figure 4. As illustrated in the figure, the gelling behavior exhibited a clear dependence on wax concentration. Increasing the level of propolis wax from 6% to 8% resulted in a marked reduction in the time required for network formation. This concentration-dependent acceleration in gelation indicates that higher amounts of propolis wax generate a greater number of crystallization nuclei, thereby facilitating faster crystal growth and earlier establishment of a continuous network.

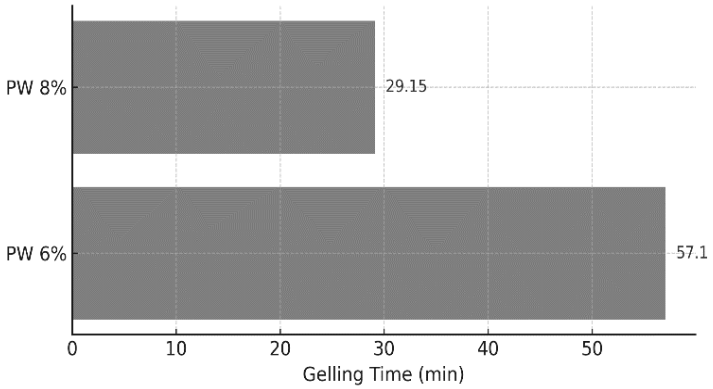

Figure 4. Gelling time of hazelnut oil oleogels structured with propolis wax (6% and 8%).

As shown in Figure 4, the 8% formulation solidified more rapidly than the 6% sample, reflecting its enhanced structural organization and improved supramolecular assembly. The faster gelling process at higher wax content aligns with the crystallization behavior of wax-based oleogels, where increased availability of long-chain esters and fatty acids promotes rapid nucleation and strengthens the developing network. The reduction in gelling time with increasing PW concentration is also consistent with earlier studies reporting that higher wax levels accelerate nucleation and crystal growth, thereby promoting faster network formation (Co & Marangoni, 2012; Toro-Vazquez et al., 2013). These findings confirm that propolis wax functions as an effective natural organogelator, and its concentration is a critical determinant of oleogel formation kinetics and final structural integrity.

3.3. Color Values of Propolis Wax Oleogels

The color parameters of the propolis wax oleogels are presented in Table 1. Increasing the propolis wax concentration from 6% to 8% resulted in a decrease in L* values, indicating that the samples became slightly darker at higher wax levels. This reduction in lightness can be attributed to the intensified presence of natural pigments and resinous compounds inherent to propolis.

Table 1. Color parameters of hazelnut oil oleogels structured with propolis wax (6% and 8%).

Sample	L^*	a^*	b^*
PW (%6)	**37.29±0.78**	**-2.11±0.16**	**10.17±0.28**
PW (%8)	**32.79±0.63**	**-3.28±0.04**	**10.40±0.04**

The a* values became more negative with increasing wax content, reflecting a shift toward greener, while b* values showed a slight rise, suggesting a mild enhancement in yellow tones. These chromatic changes are expected, given the flavonoids, phenolic compounds, and wax-derived chromophores naturally present in propolis. The observed decline in L* values, together with the subtle shifts in a* and b*, is consistent with

earlier studies reporting characteristic darkening and yellow-green tonal enhancement in propolis-based oleogels (Fayaz et al., 2017).

Overall, the color data confirm that the optical properties of the oleogels are directly influenced by propolis wax concentration, with higher levels yielding a darker, slightly greener, and marginally more yellow appearance. These changes fall within acceptable limits for food applications and are typical of formulations containing natural wax components.

4. CONCLUSION

This study demonstrated that propolis wax is an effective natural organogelator capable of structuring hazelnut oil into stable oleogels with desirable physicochemical attributes. Increasing the propolis wax concentration from 6% to 8% significantly improved gelation behavior, reducing gelling time from 57.10 min to 29.15 min, indicating a nearly two-fold acceleration in network formation. Microstructural evaluations confirmed the formation of a denser and more coherent crystalline network at higher wax levels, supporting enhanced structural integrity. Color parameters also varied in a concentration-dependent manner, reflecting the inherent pigmentation and compositional characteristics of propolis wax, while remaining acceptable for food applications. Overall, these findings highlight propolis wax as a promising clean-label alternative to conventional solid fats and widely used wax-based gelators. Its strong structuring ability, natural origin, and functional performance at relatively low concentrations position propolis wax-based oleogels as viable candidates for developing healthier fat-replacer systems in food formulations.

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Comparison of Antilipase Effects of Propolis, Pollen and Bee Bread Samples

Propolis, Polen ve Arı Ekmeği Örneklerinde Antilipaz Etkilerinin Karşılaştırılması

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Abstract

In obesity treatment, the enzyme lipase breaks down triglycerides into free fatty acids and monoglycerides in the intestines. Inhibiting this enzyme reduces fat absorption, thus reducing the amount of calories consumed. In type 2 diabetes and metabolic syndrome, limiting fat absorption may contribute to reducing insulin resistance. Glycemic control may be improved through weight loss. In the management of hyperlipidemia, it reduces lipid absorption and thus lowers postprandial (after-meal) triglyceride levels. Bee bread, pollen and propolis hold significant nutritional value among bee products. This study aimed to investigate the effects of lipase inhibitory capacity among bee bread, pollen and propolis samples.

Samples were prepared at varying concentrations and orlistat was used as a standard to determine lipase enzyme inhibition values at 405 nm and IC_{50} values were determined. These values were found to be 0.1 ± 0.002, 4.087 ± 0.451 and 363 ± 8.842 µg/mL for bee bread, propolis and bee pollen samples, respectively. In conclusion, the observation of enzyme inhibition effects in bee bread, propolis and bee pollen products supports their potential use as functional food additives. These properties may contribute to the treatment of obesity, type 2 diabetes, metabolic syndrome, and hyperlipidemia.

Keywords: Propolis, Bee Pollen, Bee Bread, Antilipase, Obesity

Özet

Obezite tedavisinde; lipaz enzimi, bağırsaklarda trigliseridlerin serbest yağ asitlerine ve monogliseritlere parçalanmasını sağlar. Bu enzimin inhibisyonu, yağ emilimini azaltır, böylece vücuda alınan kalori miktarı düşer. Tip 2 diyabet ve metabolik sendromda; yağ emiliminin sınırlanması, insülin direncinin azaltılmasına katkıda bulunabilir. Vücut ağırlığında azalma yoluyla glisemik kontrol iyileştirilebilir. Hiperlipidemi yönetiminde ise; lipid emilimini azaltarak postprandiyal (yemek sonrası) trigliserid düzeylerini düşürür. Arı ürünlerinden arı ekmeği, polen ve propolis besin değeri açısından önemli bir yere sahiptir. Bu çalışmada lipaz enziminin arı ekmeği, polen ve propolis örnekleri arasındaki inhibe edici kapasitesinin etkilerinin araştırılması amaçlanmaktadır.

Örnekler değişen konsantrasyonlarda hazırlanarak ve orlistat standardı kullanılarak lipaz enzim inhibisyon değerleri 405 nm'de ölçülmüş ve IC_{50} değerleri belirlenmiştir. Bu değerler sırasıyla arı ekmeği, propolis ve arı poleni örnekleri için 0.1 ± 0.002, 4.087 ± 0.451 and 363 ± 8.842 µg/mL bulunmuştur.

Sonuç olarak, arı ekmeği, propolis ve arı poleni ürünlerinde enzim inhibisyon etkilerinin gözlenmesi, bu ürünlerin fonksiyonel gıda katkı maddesi olarak kullanılma potansiyelini desteklemektedir. Bu özellikleri sebebiyle, obezite tedavisi, Tip 2 diyabet ve metabolik sendrom, hiperlipidemi yönetimi için katkılar sağlayacaktır.

Anahtar Kelimeler: Propolis, Arı Poleni, Arı Ekmeği, Antilipaz, Obezite

1. INTRODUCTION

Obesity is a major risk factor for the development of various metabolic and cardiovascular disorders, including atherosclerosis, hypertension and type 2 diabetes. One effective strategy for preventing obesity involves the inhibition of lipid absorption in the intestines. Pancreatic lipase plays a crucial role in this process as the primary enzyme responsible for lipid hydrolysis. Although a limited number of compounds, such as orlistat (tetrahydrolipstatin), directly interact with lipases, their clinical use is restricted due to adverse effects on the gastrointestinal tract and kidneys. Consequently, the utilization of natural products has emerged as a promising alternative approach for obesity prevention. In this context, bee-derived products are considered potential inhibitors of pancreatic lipase owing to their rich content of bioactive secondary metabolites, particularly flavonoids.

Lipases (triacylglycerol hydrolase, EC 3.1.1.3) are enzymes that catalyze the hydrolysis of ester bonds in triacylglycerols, resulting in the formation of free fatty acids, diacylglycerols, monoglycerols and glycerol. In mammals, the digestion of dietary triacylglycerols within the small intestine is predominantly mediated by pancreatic lipase. The absorbed end products of this process contribute to the development of obesity. Consequently, inhibition or reduction of triacylglycerol hydrolysis and subsequent absorption from the intestinal lumen into systemic circulation may serve as an effective strategy for obesity prevention. Therefore, digestive lipase inhibitors represent potential therapeutic agents for the management of obesity (Sharma et al. 2005).

In the treatment of obesity, lipase is responsible for hydrolyzing triglycerides into free fatty acids and monoglycerides within the intestines. Inhibition of this enzyme decreases lipid absorption, thereby reducing overall caloric intake. In individuals with type 2 diabetes and metabolic syndrome, limiting fat absorption may contribute to the alleviation of insulin resistance, while weight loss achieved through this mechanism can enhance glycemic control. Moreover, in the management of hyperlipidemia, inhibition of lipase activity

diminishes lipid absorption and consequently lowers postprandial triglyceride concentrations.

One of the strategies for reducing obesity involves pharmacological intervention with synthetic agents such as sibutramine, rimonabant, phentermine, diethylpropion, zonisamide, topiramate, and orlistat. Orlistat (N-formyl-L-leucine (1S)-1-[(2S,3S)-3-hexyl-4-oxetanyl]methyldodecyl ester), also known as tetrahydrolipstatin, is a distinctive anti-obesity drug that acts peripherally rather than centrally. Its mechanism of action occurs within the gastrointestinal tract, where it inhibits pancreatic and gastric lipases key enzymes responsible for the breakdown of long-chain triacylglycerols during fat digestion. At the recommended therapeutic dosage of 120 mg administered three times daily, orlistat reduces dietary fat absorption by approximately 30%. (Al-Suwailem et al. 2006). Sibutramine and rimonabant have been removed from the market due to their associated adverse effects. Sibutramine, in particular, has been associated with an elevated risk of myocardial infarction and stroke in individuals with preexisting cardiovascular conditions while rimonabant has been associated with severe psychiatric side effects. Consequently, there is a pressing need to identify safer and more effective anti-obesity agents derived from natural sources. While some natural compounds may still present toxic effects, these are generally less severe than those associated with purely synthetic pharmaceuticals. (Kang et al. 2012).

Beekeeping-derived products have attracted considerable scientific interest due to their potential health-promoting and bioactive properties.

Bee products including bee pollen, bee bread, and propolis are well known for their wide range of biological activities, such as antimicrobial, anti-inflammatory, antitumor, and antioxidant effects. (Margaoan et al. 2019).

The gathering of bee products by humans is evidenced in ancient rock art and archaeological discoveries, suggesting that beekeeping has a long-standing and well-established historical tradition.The health-promoting properties of honey bee products have been recognized for centuries in traditional medicine, and they hold significant promise for modern therapeutic use. Furthermore, these products are often linked to numerous health benefits and are considered valuable natural components of the human diet. (El-Seedi et al. 2022).

Pollen is a natural product gathered by bees, and when transported to the hive in the form of pollen loads, it is referred to as bee pollen. This substance is abundant in valuable constituents, including essential amino acids, phenolic compounds, vitamins, and pigments. (Kieliszek et al. 2018). Bee pollen is recognized as one of the oldest nutritional supplements in history and encompasses nearly all essential components required for a balanced diet. (Bakour et al. 2019). Bee pollen also known as apicultural, bee-collected or corbicular pollen can be obtained using a pollen trap installed at the entrance of the hive. As bees return, part of the pollen

adhering to their hind legs is dislodged and collected in the trap's collection tray. (Nanda & Thakur, 2020).

Pollen represents the male gametophyte units of flowering plants. After collecting pollen grains from flowers, bees mix them with their own secretions, which moistens the pollen and forms it into pellets. These pellets then adhere to the pollen baskets located on the bees' hind legs and are transported back to the hive. (Volkan Aylanc et al. 2021).

Bee bread possesses high nutritional value and contains bioactive compounds that positively influence human health, making it a recognized functional food. It is rich in proteins, simple sugars, essential amino acids, and omega fatty acids. These components boost the immune system and enhance the body's ability to combat bacteria, thereby supporting overall health and effective tissue repair. (Margaoan et al. 2019).

Bee bread is produced when honey and digestive enzymes are added to bee pollen during storage in the honeycomb, followed by lactic acid fermentation. During the transformation of bee pollen into bee bread, titratable acidity increases, while the levels of sitosterol and vitamins (ascorbic acid and pyridoxine) decrease. The chemical composition of bee bread is largely influenced by the floral sources available in the colony's region, showing similarities to bee pollen but varying according to its botanical origin. (Urcan et al. 2018).

Propolis, a resinous material synthesized by honeybees from diverse plant sources, has been employed in traditional medicine worldwide for millennia due to its wide range of therapeutic properties. The chemical composition of propolis exhibits a high degree of variability and depends on factors such as botanical origin, season of harvest, geographical location, local flora, climatic conditions, and the species of honeybee involved in its production. This apicultural product possesses considerable clinical potential, exhibiting a wide spectrum of biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, analgesic, antidepressant, and immunomodulatory effects. Moreover, propolis has been traditionally utilized for the treatment of purulent infections, enhancement of wound healing, and alleviation of associated symptoms and discomforts. (Hossain et al. 2022).

Specifically, propolis originates from resins predominantly obtained from the buds and bark of poplars, birches, and various coniferous species. Foraging bees collect these resins and combine them with pollen, waxes, and enzymatic secretions, resulting in a complex mixture of bioactive substances (Anjum et al. 2019).

The fatty acid content of bee bread plays a crucial role for honeybees, as polyunsaturated fatty acids are vital for proper development and productivity. Unsaturated fatty acids are essential not only for bees but also for human nutrition. For that reason, bee bread can serve as an excellent source of these important components (Margaoan et al. 2014). The rich polyphenol content of bee bread is of great medicinal interest. Among these polyphenolic compounds, flavonoids represent the predominant class present in both bee pollen and bee bread.(Silva et al. 2014).

Bee bread, a naturally fermented hive product abundant in bioactive compounds, has attracted growing attention for its broad spectrum of health-promoting effects and therapeutic potential. (Urcan, 2025).

Bee bread is a natural fermentation product derived from a mixture of pollen, nectar, and bee saliva, which undergoes microbial inoculation by diverse bacteria and yeasts essential for the fermentation process after being stored in honeycomb cells. It serves as the primary protein source for honeybees, particularly vital for the nourishment of larvae and adult bees. Historically, bee bread has been employed across diverse cultures for its nutritional and therapeutic benefits since antiquity. (Elashal et al. 2020).

The consumption of natural products has increased markedly, motivated by the perception that enhanced nutrition promotes overall health, supports well-being, and lowers the risk of various diseases. Among these natural products, bee derived substances particularly bee pollen and bee bread possess remarkable nutritional value and bioactive potential, classifying them as exceptional functional foods. Consequently, investigating their digestibility and the biochemical transformations of their phytochemicals throughout the digestive tract is crucial for elucidating the functional food properties of bee bread and bee pollen. (Aylanc et al. 2021). Bee pollen, propolis and bee bread are among the most commonly utilized bee products for health-related purposes. However, limited research has focused on the potential lipase inhibitory activities of these products.

In our study, the inhibitory effect of extracts of bee products (bee pollen, propolis and bee bread) on pancreatic lipase was evaluated using porcine pancreatic lipase. This study aims to compare the antilipase properties of different bee products such as bee pollen, propolis and bee bread.

2. MATERIALS and METHODS

The bee pollen and bee bread used in this study were obtained from beekeepers in Trabzon province. The bee pollen and bee bread samples were stored at -18°C. Prior to extraction, the bee bread and bee pollen samples were ground. Adequate amounts were weighed according to the experimental procedure and dissolved in buffer-DMSO. Extracts were obtained by filtration through coarse filter paper. A commercially available 30% propolis sample with water + ethanol solvent was used in the study. Propolis was stored at room temperature until analysis.

2.1 Pancreatic lipase inhibition assay

Pancreatic lipase assays were adapted from Bustanji et al. that a colorimetric assay measuring p-nitrophenol release (Bustanji et al. 2011). The enzyme solutions were freshly prepared prior to use. Crude porcine pancreatic lipase type II (Sigma, EC 3.1.1.3) was suspended in Tris–HCl buffer (1.0 M, pH 8.0) to give a concentration of 5 mg/mL (200 units/mL), mixed using a stirrer for 15 min. The solution was then centrifuged

at 1500 g for 10 min and the clear supernatant was recovered. The 0.10 mL of pancreatic lipase solution was preincubated with seven different solutions were prepared in the concentration range of 4000 – 25 mg/mL of the extract for 5 min at 37°C, then the PNPB substrate (10 mM in acetonitrile) was added. The volume was adjusted to 1 mL with Tris–HCl buffer prior to measuring the absorbance of the solution spectrophotometrically at 405 nm.The release of *p*-nitrophenol was determined by monitoring the increase in absorbance at 405 nm, using a denatured enzyme as the blank. and IC_{50} values were determined. The pancreatic lipase activity is related to the rate of *p*-nitrophenol release. The final concentration of DMSO was fixed and did not exceed 2.0%. The residual activity of pancreatic lipase for each compound was determined by comparing the enzyme activity in the presence and absence of the respective compound. All assays were performed in triplicate; therefore, the inhibition percentages represent the mean values of the three independent measurements. Orlistat, a well-established pancreatic lipase inhibitor, was employed as a positive control in the assay mixture. The results were analyzed and calculated using Microsoft Excel, and the data were expressed as the mean of each triplicate set. Enzyme inhibition was determined as follows:

Inhibition (%) = (Absorbance (blank) - Absorbance (sample) x 100 / Absorbance (blank) The

results of sample analyses were expressed as the mean ± standard deviation (SD).

3. RESULTS and DISCUSSION

According to our findings, bee bread exhibited the strongest anti-lipase activity, followed by propolis with the second highest inhibitory effect, low lipase inhibition was observed in bee pollen. It was observed that, 0.1 ± 0.002, 4.087 ± 0.451 and 363 ± 8.842 µg/mL values for bee bread, propolis and bee pollen samples, respectively. The results are given in Figure 1 and Table 1, results show that inhibition % values of the samples and standards.

Table 1. IC_{50} values of bee pollen, propolis and bee bread samples and orlistat

Lipase inhibitory activity	
Test samples	**IC50 (µg/mL)**
Orlistat	32.04 ± 4.516
Bee bread	0.1 ± 0.002
Propolis	4.087 ± 0.451
Bee pollen	363 ± 8.842

Bee pollen is increasingly recognized as a functional food due to its diverse nutritional profile and substantial therapeutic potential, demonstrating considerable value in both medical and gastronomic applications (Al-Suwailem et al. 2006).

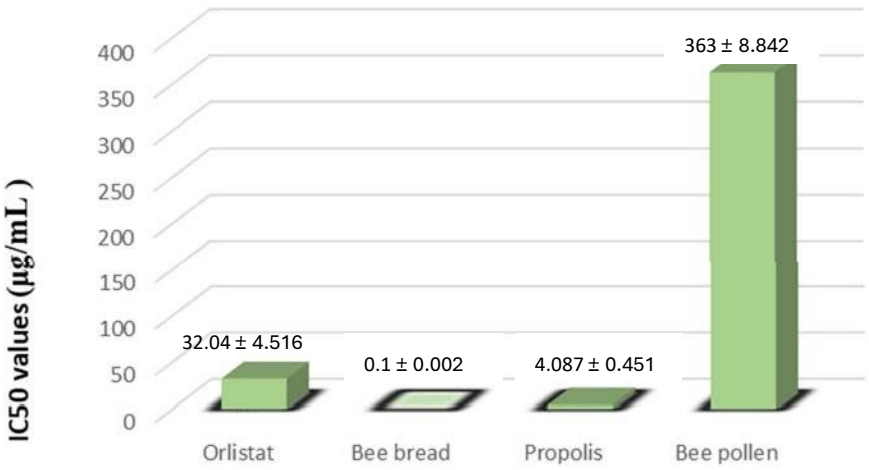

Figure 1. Comparison of lipase enzyme inhibition results of bee bread, propolis and bee pollen samples

A review conducted emphasizes key aspects of bee pollen composition particularly its phenolic constituents alongside its biological activities and underlying molecular mechanisms. Although the diverse composition of bee pollen contributes to its wide range of pharmacological benefits, the marked variability in its constituents presents a major obstacle to its consistent application in phytomedicine. Therefore, greater emphasis should be placed on standardization efforts, including the assessment of phenolic profiles and nutritional values of pollen from different botanical origins; the implementation of quality controls within beekeeping production practices; and the expansion of pharmacological and biochemical studies. Additionally, strategies to improve the bioavailability of bee pollen's bioactive compounds, to enhance its biofunctional and technofunctional properties for use in food such as the development of novel bee pollen-enriched products or dietary supplements and to increase clinical investigations assessing its health-promoting effects in humans and animals are warranted. (El Ghouizi et al. 2023).

In one study, the antilipase properties of bee bread, royal jelly and propolis from Iran province Fars were examined and it was determined that propolis exhibited antilipase activity similar to orlistat (Hashemirad et al. 2024). In a different study, Australian propolis was examined and its lipase enzyme inhibitory properties were found (Uddin et al. 2022). Another study examined the therapeutic potential of stingless bee (*Heterotrigona itama*) bee bread (fermented pollen) from Malaysia in mitigating obesity-associated hepatic lipid metabolism disorders. The researchers focused on the regulation of the Keap1/Nrf2 signaling pathway and suggested that this natural product may serve as a potential supplement for the management of obesity-related fatty liver disease. (Zakaria et al. 2022). In another study, four different bee products (honey, pollen, bee bread, and propolis) obtained from Bayburt province were compared and lipase enzyme inhibition was

evaluated. Accordingly, propolis showed the highest enzyme inhibition activity (Gercek et al. 2024).

4. CONCLUSION

This study demonstrated that bee products have the ability to inhibit lipase activity. These results are consistent with many studies investigating their anti-lipase effects. The significant inhibitory activity of some of these bee products suggests their potential use as important and useful natural sources of anti-obesity agents. The observed enzyme inhibitory effects of bee bread and propolis products highlight their potential application as functional food additives. These bioactive properties may play a beneficial role in the management of obesity, type 2 diabetes, metabolic syndrome and hyperlipidemia.

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The Use and Effect of Honey in Nursing Care: A Systematic Review Study

Balin Hemşirelik Bakiminda Kullanim Durumu ve Etkisi. Bir Sistematik Derleme Çalişmasi

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Özet

Amaç: Bu sistematik derlemenin amacı, hemşireler tarafından hasta ya da birey bakımında balın kullanımı ve etkilerini inceleyen çalışmaları sistematik olarak değerlendirmek ve bu konuya ilişkin mevcut en iyi kanıtları derlemektir.

Yöntem: Sistematik derleme sürecinde PRISMA-P bildirimi rehber olarak kullanılmıştır. Arama stratejisi kapsamında altı elektronik veri tabanı taranmıştır: PUBMED, CINAHL, EMBASE (OVID), Web of Science, Google Scholar ve DergiPark. Veri tabanları, herhangi bir tarih kısıtlaması olmaksızın 24–30 Temmuz 2025 tarihleri arasında İngilizce ve Türkçe dillerinde taranmıştır. Aramalarda "bal, hemşire, bakım veya uygulama, hasta veya birey" anahtar kelimeleri kullanılmıştır.

Bulgular: Yapılan tarama sonucunda konu ile ilgili toplam 22 çalışma belirlenmiştir. Çalışmalarda balın; yara, diyabetik ayak ülserleri, yanıklar, öksürük ve ishal üzerindeki etkileri incelenmiştir. Çalışmaların büyük çoğunluğunda balın etkili olduğu saptanmıştır. **Sonuç:** Kolay erişilebilir olması, iyileşme süresini kısaltarak tedavi maliyetlerini azaltması ve hasta/birey bakımından sorumlu hemşirelerin iş yükünü hafifletmesi gibi olumlu etkileri göz önünde bulundurulduğunda, balın yara bakımında alternatif bir tedavi seçeneği olarak kullanılması önerilmektedir.

Anahtar Kelimeler: Bal, bakım, hemşire, apiterapi

Abstract

Objective: The objective of this systematic review is to systematically evaluate studies examining the use and effects of honey in patient or individual care by nurses and to compile the best available evidence on this topic**. Method**: The PRISMA-P statement was used as a guide for the systematic review. Six electronic databases were used in the search strategy: PUBMED, CINAHL, EMBASE (OVID), Web Of Science, Google Scholar, and Dergipark. The databases were searched in English and Turkish between July 24 and July 30, 2025, without any date range specified. The keywords "honey, nurse, care or application, patient or individual" were used in the searches. **Findings:** Twenty-two studies were found on this topic. The studies examined the

effects of honey on wounds, diabetic foot ulcers, burns, cough, and diarrhea. Almost all of the studies determined that honey is effective**. Conclusions**: Due to its positive effects, such as being easily accessible, shortening the healing time and thus reducing treatment costs, and reducing the workload of nurses responsible for patient/individual care, honey should be used as an alternative treatment option in wound care.

Keywords: Honey, Care, Nurse, Apitherapy

1.INTRODUCTION

Apitherapy, one of the complementary and integrative medicine practices, is defined as the use of bees and bee products as complementary and supportive treatments for certain diseases (Elnady et al., 2013; Lotfy et al., 2006; Özkan and Bancar, 2015). It has been stated that honey is the most commonly consumed apitherapy product both worldwide and in our country. Honey is considered a high-energy and carbohydrate-rich food, containing vitamins, minerals, organic acids, flavonoids, phenolic acids, amino acids, and enzymes, making it easy to digest and nutritious. It also has protective and therapeutic properties against many diseases, which are the most important reasons for its widespread consumption.

Honey is a substance synthesized by bees from various flower nectars. Honey contains approximately 200 substances, primarily carbohydrates and water, along with various proportions of minerals, proteins, free amino acids, enzymes, and various vitamins (A, B1, B2, B3, B5, B6, B8, B9, B12, C, E). Thanks to these substances in honey, it has been reported to have an inhibitory effect on approximately 60 types of bacteria. The high viscosity of honey ensures the absorption of edema fluid formed in tissues, thereby increasing the blood supply to the tissue whose turgor has been restored. Due to its high sugar content, it is also a good source of energy in wounds with increased catabolism (Akbaş and Aykar, 2021; Bangroo et al., 2005; Bulut et al., 2013; Çürük and Savsar, 2016, İzgü, 2017; Özkan and Bancar, 2015).

Interest in apitherapy is growing in society today. This situation necessitates that nurses, who play a professional role and bear responsibility in the treatment, care, and monitoring of individuals, actively participate in apitherapy to meet the health needs of individuals, families, and society. Increasing nurses' knowledge of apitherapy will enable healthy/sick individuals to use apitherapy effectively and correctly. In addition, in order to improve the quality of care, accelerate recovery, and prevent complications, nurses should be knowledgeable about complementary and supportive products and should guide patients on how to use these products correctly and effectively. It has been reported that complementary and supportive treatment methods fall within the scope of the independent nursing roles of professional nurses who possess theoretical knowledge and scientific problem-solving skills (Akbaş and Aykar, 2021; Bulut et al., 2013; Çürük and Savsar, 2016, İzgü, 2017; Özkan and Bancar, 2015). Thus, by using complementary and supportive treatment methods in nursing care skills and basing the care provided on a holistic perspective, nurses will increase the quality of patient care.

1.1. Research Question

- What are the effect sizes of honey use in nursing care? What factors influence the effect size of honey?

2. MATERIALS AND METHODS

2.1. Type of Research:

This study was prepared according to the PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) guideline, which is used to guide authors in improving the presentation of systematic review and meta-analysis studies (Mahor et al., 2009).

2.2. Search strategy

Articles to be included in the study were searched in the Pubmed, Cınahl, Embase (Ovid), Web of Science, Google Scholar, and Dergipark databases. The databases were searched between August 1 and August 15, 2025, without any year restrictions. The search terms “honey, nursing, care, patient, or individual” were used in the searches.

2.3. Inclusion criteria

- Inclusion criteria were defined according to PICOS in the systematic review:
- Population: patients, healthy individuals
- Interventions: honey use
- Comparisons: studies not using honey
- Outcomes: results, influencing factors
- Study designs: RCTs, quasi-experimental studies.

Exclusion Criteria

- Articles for which the full text was not available
- Studies not in English or Turkish
- Studies not involving honey use
- Studies rated “poor” by the quality assessment tool

2.4. Selection of Studies

In the first stage, titles and abstracts were searched using key terms identified by researchers in databases. Studies found in different databases and duplicates were deleted. The first researcher examined the titles and

abstracts of the remaining studies to identify potential studies. The second researcher also read and evaluated the titles and abstracts of the identified articles. The full texts of 22 studies were reviewed in detail by both researchers. Figure 1 shows a flow diagram (PRISMA 2009 Flow Diagram) illustrating how the 13,864 studies identified through the search were narrowed down to the 22 studies included in the systematic review.

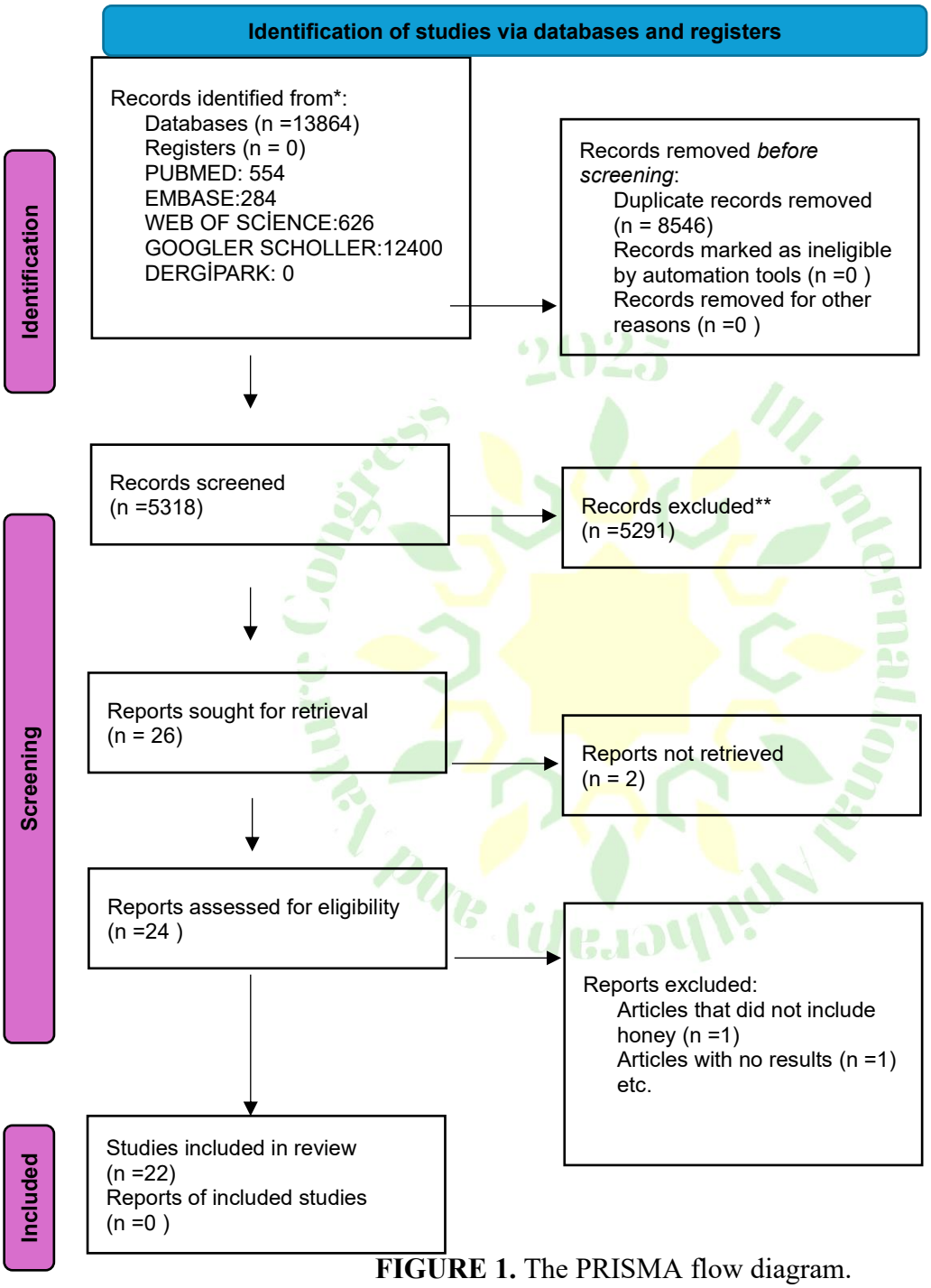

FIGURE 1. The PRISMA flow diagram.

2.5. Quality Assessment

The methodological quality assessment of the studies included in the research was conducted by two independent researchers according to the Joanna Briggs Institute (JBI) critical appraisal checklists, depending

on the selected research types. The Cronbach's alpha coefficient of the JBI quality assessment tools and checklists, whose validity and reliability in Turkish were established by Nahcivan and Seçginli, was found to be moderate. A high total score indicates high methodological quality of the study. In this study, inter-coder agreement was found to be 94%. In the reliability analysis, Cohen's kappa was found to be 0.87.

3. FINDINGS

Two studies were found on the effect of honey on cough. In one of the studies, 105 children aged 2-18 years were included in the study, which evaluated the effect of honey, dextromethorphan, and no treatment on nighttime cough and sleep quality in children/parents. Thirty minutes before bedtime, one group received dextromethorphan, the second group received honey, and the other group received no treatment. Compared to those receiving dextromethorphan or no treatment, the honey group showed a faster decrease in cough frequency and severity, as well as an improvement in both children's and parents' sleep quality (Paul et al., 2007). Another study indicated that honey had a greater therapeutic effect than dextromethorphan and diphenhydramine in terms of cough frequency, severity, and sleep quality in children and parents (Shadkam et al., 2010).

Five studies examining the effect of honey on wound healing have been identified. In one of these studies, it was noted that manuka honey (MediHoney), suitable for medical use, is an effective antibacterial agent in eliminating bacteria that can cause infection in chronic wounds (Robson et al., 2009). In a study conducted by Al-Waili and Salom (1999), honey dressings washed with normal saline were applied to treat wound inflammation that developed after cesarean section. The study found that patients treated with honey dressings had a shorter healing time, rapid elimination of bacterial inflammation, prevention of wound dehiscence, minimal scarring, and reduced hospital stays. In a study by Gülbeteki (2015), it was determined that honey milk applied to children undergoing tonsillectomy was effective in preventing bleeding, reducing pain, and accelerating wound healing. The most recent study examining the effect of honey on wounds was conducted by Kamaruddin et al. (2015), in which honey dressings were applied to 102 infected wounds that did not heal with conventional treatment. The study found no allergic reactions or side effects from the honey dressing in the cases examined. Furthermore, honey sterilized the wounds very quickly, and by the third week of honey dressing, the wounds were completely free of bacteria. MRSA penicillin-resistant staphylococcus aureus was reported to have been eliminated. Honey created a debridement effect on the dead tissue in the wound area, ensuring the rapid and effective removal of dead tissue. It also ensured that the unpleasant odor in the wound area disappeared in a short time. Honey was found to reduce edema and the need for amputation in the wound area. It stimulated rapid granulation tissue formation in the wound area. It was also noted that it provided a very suitable moist environment for protecting bone tissue as well as promoting wound healing.

A study examining the effect of honey on burns has been identified. In this study, 64 burn patients under the age of 12 were treated with silver sulfadiazine in half of the cases and sterile honey in the other half. It was found that the healing time was shorter in the group to which sterile honey was applied to the burn area compared to the other group (Bangroo, Khatri, & Chauhan, 2005).

Five studies examining the effect of honey on infection were found. In one of these studies, the effectiveness of pure sterile honey in treating oral mucositis was evaluated in 100 pediatric patients aged 6-12 years with chemotherapy-induced oral mucositis. A statistically significant difference was found in the healing time of stomatitis between the honey group and the control group (Abd-El-karim et al., 2013). In a study conducted in Turkey, oral care with honey applied to children receiving chemotherapy was shown to be effective in reducing mucositis levels and mucositis incidence rates, shortening the healing time of mucositis, and increasing the healing rate (Bulut, Tüfekçi, & Erduran, 2013). In a study conducted on this subject, it was reported that the use of honey dressings on infected wounds sterilized the wound area within 3-10 days (Vander, 2003). In a study conducted by Samdariye and colleagues, patients with head and neck cancer were asked to rinse their mouths with 20 milliliters of honey three times—15 minutes before treatment, 15 minutes after treatment, and 6 hours after treatment—in addition to routine care. The study reported that this practice alleviated radiotherapy-related oral mucositis pain. In the most recent study on this topic, a mixture of honey and coffee (300 grams of honey and 20 grams of instant coffee) was found to be more effective in the treatment of chemotherapy-related oral mucositis than honey alone (300 grams of honey) (Raeessi et al., 2014).

Eight studies have examined the effect of honey on diabetic foot ulcers. Upon reviewing these studies: In the study conducted by Kamaratos et al. (2014), a total of 63 patients with type 2 diabetes and neuropathic diabetic foot ulcers were randomized into two groups; the first group received dressings impregnated with manuka honey, while the second group received traditional dressings, and the wounds were monitored for 16 weeks. The study reported that the manuka honey-impregnated dressing reduced wound healing time and provided rapid disinfection. In a randomized study by Al Saeed (2013), 59 patients with diabetic foot ulcers were treated; one group received only conventional treatment, while the other group received conventional treatment and manuka honey-impregnated dressings. Infection rates, length of hospital stay, and healing rates were assessed after 6 weeks and 6 months. Compared to the control group, honey treatment showed a significant reduction in healing time and infection rate. The healing rate at 6 months was 87.1% in the honey treatment group and 42.3% in the control group. In a randomized study conducted by Moghazy et al. (2010) with 30 patients, honey dressings were applied to diabetic foot ulcers for three months until the wound healed or treatment failed. Complete healing was observed in 43.3% of the ulcers, while healthy granulation tissue and a reduction in wound size were observed in another 43.3% of patients. In the following weeks, bacterial localization was detected in the following weeks. Only 6.7% of the ulcers did not respond to treatment in the study. In a prospective study conducted by Shukrimi et al. (2008), 30 diabetic ulcer patients classified as grade

2 on the Wagner scale were treated with standard dressing (first povidone-iodine, then normal saline application) and honey dressing. Ulcers in the control group were ready for surgical closure in an average of 15.4 (9-36 days), while ulcers in the honey dressing group were ready in an average of 14.4 (7-26 days). The study found that patients in the honey group experienced less pain and that edema and foul-smelling inflammation resolved more quickly compared to the control group. In a study by Hammouri (2004), 200 patients with diabetic foot ulcers were divided into two groups based on dressing materials. One group received honey/normal saline dressings, while the other received povidone-iodine/hydrogen peroxide dressings. At the end of the study, it was found that the healing time was reduced by 34%, the length of hospital stay by 43%, the treatment cost by 50%, and the indication for amputation by 50% in patients treated with honey/normal saline dressing. In addition to all this, irritation and allergies caused by dressing materials have also decreased significantly in the honey group. In a study by Alzahrani et al. (2011) on diabetic foot ulcers using honey mixed with some natural medicines [Commiphora molmol (myrrh) and Nigella sativa (black seed)], it was observed that this application isolated bacteria from the wounds. Lotfy et al. (2006) applied a tablet consisting of a mixture of 800 mg of bee propolis and 50 mg of honey to a deep wound with tissue loss on the right foot of a 65-year-old male patient with diabetes and observed healing of the wound after four weeks of use. Makhdoom et al. (2009) treated 14 diabetic foot ulcers by first thoroughly washing them, removing necrotic tissue, and then applying honey-soaked wound dressings. It was found that treatment with natural honey-soaked wound dressings reduced amputations and disability rates while improving quality of life.

Two studies examined the effect of honey on diarrhea. In one of these studies, 169 children were assigned to one of two treatment groups. One group received standard routine treatment for diarrhea (oral rehydration solution), while the other group received oral rehydration solution prepared with 50 ml of pure honey per liter instead of glucose. In the honey group, the duration of diarrhea caused by bacteria such as Salmonella, Shigella, and E. coli was reduced (Haffejee & Moosa, 1985). Similar results were found in another study with comparable characteristics, where the honey group experienced a lower incidence of vomiting and diarrhea compared to the other group, and the recovery process accelerated after honey intake (Elnady et al., 2013).

4.DISCUSSION

In many cultures, honey is among the alternative treatments traditionally used for the treatment of diseases or patient/individual care. When studies are examined, honey has been used most frequently for diabetic foot ulcers and has been found to be effective. Although diabetic ulcers resemble other wounds, their healing processes differ from other wounds. The most important feature of diabetic ulcers is that their healing processes are very long (Alam et al. 2014; Al Saeed, 2013; Çürük and Savsar; 2016; Kamaratos et al., 2014; Moghazy et al., 2010). Due to the high cost, scientists are searching for cheaper, naturally sourced, and more

effective drugs for diabetic ulcers. Honey is a potential candidate for wound healing because it is readily available and natural (Alam et al. 2014; Çürük and Savsar; 2016).

Honey has been used in wound care after diabetic foot ulcers and in inflammatory conditions developing after infection, and has been found to be effective in five studies. Wound healing after surgical procedures is one of the most important factors for both the patient's recovery and the success of the surgery. Therefore, research is being conducted into the application of a natural method that will accelerate wound healing and enable a surgery that does not tolerate any complications to heal quickly and healthily. Although healing times were earlier in the honey group, no significant histological difference was observed in terms of regeneration formation as a result of microscopic evaluation. Researchers have suggested that honey, a natural food, can be safely used in addition to routine medical oral care products in children undergoing chemotherapy who do not have diabetes or honey allergies. Researchers recommend the use of honey in pediatric patients with stomatitis due to chemotherapy because it shortens the healing time and is inexpensive, natural, and effective in a short period of time. The evidence-based care consensus report in oncology nursing states that honey is ineffective in preventing oral mucositis but that its use in treatment reduces the severity of oral mucositis (Abd-El-karim et al., 2013; Arbabi-Kalati et al., 2013; Bulut et al., 2013; İzgü, 2017; Raeessi, 2014).

A study examining the effect of honey on burns was found, and as a result, researchers suggest that honey can be used as a cost-effective alternative in burn patients due to its high viscosity, formation of a physical barrier, and role as an enzyme catalyst, which inhibits bacterial growth, and its high nutritional content, which accelerates epithelialization and angiogenesis. A study evaluating the research conducted indicates that the quality of studies on honey use varies and that the results obtained suggest that honey can only be used in the treatment of low-to-moderate superficial and second-degree burns, recommending further research in this area (Akbaş and Aykar, 2021; Bangoo et al., 2005). A meta-analysis study (Akbaş and Aykar, 2021) compared the effects of honey and silver dressings on wound healing in burns. The study indicated that honey has an antibacterial effect on the skin without the toxic effects of silver. This meta-analysis concluded that honey is more effective than silver in shortening wound healing time. It was determined that honey has more antibacterial properties than silver and that in all studies involving burn-related wounds, honey has a more positive effect on wound healing than silver. In conclusion, honey's antibacterial properties are utilized in the treatment of wounds and burns. Honey has an acidic pH value, high osmolarity, and low water content, and the other substances it contains prevent the growth of microorganisms. Researchers emphasize that honey must be of medical grade, demonstrating sterility and antibacterial effects, to be used for the treatment of wounds and burns (Bangoo et al., 2005; Bulut et al., 2013; Raesssi, 2014; Sabaridiye, 2015; Vander, 2003).

Two studies have shown that honey is also used in patient care for coughs. The World Health Organization recommends honey for coughs and colds due to its antimicrobial and antibacterial properties and its local soothing effect. The World Health Organization recommends that honey and lemon mixture can be safely used

as an antitussive if the patient and family wish (WHO, 2001). Although honey is seen as an effective antitussive agent, its mechanism of action is not fully understood. It is thought that honey exhibits a positive antitussive effect by stimulating the sense of taste. The sweet taste of honey may reflexively cause salivation and mucus production in the respiratory tract. A Cochrane review summarizing recent studies suggests that honey can be used as an alternative to pharmacological interventions for acute cough due to these effects. A small amount of 1-2 tablespoons of honey reduces the severity of coughing, improving the quality of sleep for both children and parents (Özkan and Bancar, 2015; Paul et al., 2007; Shadkam et al., 2010).

Finally, honey has been used for diarrhea, and due to its antimicrobial effect against microorganisms and its anti-inflammatory effect, honey can be used in the treatment of Helicobacter pylori, which causes diarrhea and stomach ulcers (Elnady et al., 2013; Haffejee and Moosa, 1985; Özkan and Bancar, 2015).

5. CONCLUSIONS AND RECOMMENDATIONS

Recent studies have reported that honey, a low-cost, natural agent, is effective in the treatment and care of many diseases. Nurses play an active role in honey applications, one of the complementary supportive treatments used in diabetic foot ulcers, which require a multidisciplinary approach for patient follow-up and treatment. Therefore, it is important to raise nurses' awareness in this area. Nurses should conduct scientific studies on honey therapy as a complementary therapy, investigate its benefits and possible side effects, and inform patients, their families, and the community about these issues.

In conclusion, honey is readily available, has a high therapeutic effect compared to antibiotics and other dressings, its ability to reduce treatment costs by shortening the healing time, its prevention of infection development, its ease of application and minimal side effects, and its reduction of the workload of healthcare professionals responsible for wound care.

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Phenolic Composition and Antioxidant Capacity of Bee Pollen Collected from the Aran Region of Azerbaijan

Azerbaycan'ın Aran Bölgesinden Toplanan Arı Poleninin Fenolik Bileşimi ve Antioksidan Kapasitesi

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Abstract

Bee pollen is a nutrient-dense natural product collected by honeybees from flowering plants, serving as a primary food source within the colony. Its chemical composition is highly variable and influenced by the botanical and environmental characteristics of the region of origin. This study aimed to determine the phenolic profile and antioxidant capacity of bee pollen samples collected in 2024 from the Aran region of Azerbaijan. Total phenolic content (TPC) was 6.54 mg gallic acid equivalents (GAE)/g, while total flavonoid content (TFC) was 2.90 mg quercetin equivalents (QUE)/g. Antioxidant capacity, assessed by FRAP and DPPH assays, yielded 65.83 µmol $FeSO_4 \cdot 7H_2O$/g and 0.52 mg/mL, respectively. High-Performance Liquid Chromatography with Photodiode Array Detection (HPLC-PDA) using 26 phenolic standards revealed trans-cinnamic acid (0.36 mg/100 g), pinocembrin (1.52 mg/100 g), p-coumaric acid (1.15 mg/100 g), chrysin (0.50 mg/100 g), and p-benzoic acid (0.50 mg/100 g) as the predominant phenolic compounds. These results highlight the diverse and bioactive phenolic composition of Aran bee pollen and its potential as a functional food ingredient.

Keywords: Bee pollen, antioxidant, phenolic

1.INTRODUCTION

Bee pollen is a natural mixture of flower nectar, pollen, enzymes, and bee secretions produced by honeybees. It is one of the richest bee products in proteins, polysaccharides, polyphenols, lipids, minerals, and vitamins (Algethami et al., 2022). Due to its high protein content and comprehensive profile of essential amino acids, bee pollen is considered a highly nutritious bioactive food source for human consumption (El Ghouizi et al., 2023). The chemical composition of pollen varies according to its geographical origin and the plant species from which it is derived. On average, bee pollen contains approximately 55% carbohydrates, 20% proteins, 5% lipids, and 10% fiber (Bakour et al., 2023).

Azerbaijan, due to its unique geographical location, encompasses nine of the eleven global climate zones (Mehtiyeva and Zeynalova, 2013). Its diverse soil and climate conditions support a rich variety of plant genetic resources, with approximately 4,500 native plant species, 4.74% of which are endemic. Furthermore, 720

species in the country are classified as nectar-bearing plants (Çobanoğlu et al., 2025). The Aran region of Azerbaijan has a distinct climate and vegetation that provide valuable floral resources for honeybees. The climate is predominantly dry subtropical, characterized by hot, dry summers and long, cold winters (Yeşilbaş and Kapan, 2021).Although some studies have investigated honey and propolis from different regions of Azerbaijan, there is no published research on bee pollen from the Aran region. To the best of our knowledge, this is the first study to characterize the phenolic composition and antioxidant potential of bee pollen from the Aran region of Azerbaijan.

2.MATERIALS and METHODS

2.1. Bee pollen

Bee pollen samples were collected in May–July 2024 from apiaries located in the Aran region of Azerbaijan. Samples were cleaned of impurities, air-dried, and stored at −20 °C until analysis (Figure 1)..

Figure 1 Bee pollen from the Aran region of Azerbaijan

2.2. Total Phenolic Content Measurement

TPC was determined with Folin-Ciocalteu's method (Singleton and Rossi., 1965), using gallic acid (GA) as standard. Briefly, 680 µL of distilled water, 400 µL of 0.5 N Folin-Ciocalteu reagents and 20 µL of different concentrations of gallic acid were added to each sample, which were then vortexed. After 3 min, 400 µL of Na_2CO_3 solution (10%) was added and vortexed. The mixture was incubated for 2 h at 20° C with occasional shaking. At the end of that time, the absorbance was measured at 760 nm. TPC was calculated as milligrams of GA per gram (mg GAE/g) of pollen using a standard graph (Fukumoto and Mazza, 2000).

2.3. Total Flavonoid Measurement

TFC was calculated by a spectrophotometric method using quercetin as standard (Fukumoto and Mazza, 2000). First, 0.5 mL of pollen extract was mixed with 0.1 mL of 10% $AlCl_3$, and 0.1 mL of 1 M NH_4CH_3COO solution. This mixture was incubated at room temperature for 40 min, and the absorbance was measured against a blank at 415 nm. TFC was expressed as mg of quercetin equivalents (QUE) per 100 g sample.

2.4. Ferric Reducing/Antioxidant Power (FRAP) Assay

The antioxidant properties of the pollen samples were assessed using the method described by Benzie and Strain (1996). This is based on the reduction of the Fe $(TPTZ)^{3+}$ tripyridyltriazine complex to Fe $(TPTZ)^{2+}$ by antioxidants in the acidic medium. The FRAP reagent consisted of a mixture of 25 mL of 300 mM acetate buffer, with 2.5 mL of 10 mM TPTZ solution with 40 mM HCl and 2.5 mL of 20 mM $FeCl_3 \cdot 6H_2O$ solution. A 100 µL aliquot of sample was added to 3 mL of the freshly prepared FRAP reagent mixture, then incubated at 37° C for 4 min. The absorbance was determined at 595 nm against a blank of distilled water. FRAP assays were expressed as mM of ferrous equivalent Fe (II) per 100 g of sample.

2.5. DPPH Radical-Scavenging Activity

The radical scavenging activity of cistus pollen against the DPPH radical was determined as described by Molyneux et al. (2004). This technique relies on measuring the change from purple to yellow that takes place in the DPPH solution as the radical is neutralized by the antioxidants. Samples (0.75 mL, various concentrations) were mixed with 0.75 mL of DPPH (0.1 mM in methanol) and vortexed. After incubation in the dark at room temperature for 30 min, absorbance at 517 nm was recorded. Trolox was employed as standard, and the values were expressed as SC_{50} (mg sample per mL), the sample concentration causing 50% scavenging of DPPH radical.

2.6. Analysis of Phenolic Compounds by HPLC

Before measuring the phenolic components in methanolic bee pollen extracts using HPLC-PDA, phenolic component enrichment was performed by liquid-liquid extraction. For this purpose, 10 ml of the extract was taken, and the solvent was completely removed at 40 °C in a rotary evaporator (IKA®-Werke RV 05 Basic, Staufen, KG, Germany). Then, 10 mL of distilled water was added, and the pH was adjusted to 2 with concentrated HCl. The organic phases were combined after three extractions with diethyl ether and ethyl acetate. After all the solvent was removed, the residue remaining in the flasks was dissolved with 2 ml of methanol, passed through a 0.45 µm filter (RC membrane, 0.45 µm), and introduced into the instrument for phenolic analysis.

Phenolic composition analysis was performed according to the literature (Kara and Kolaylı, 2022). In this method, all validation procedures were completed against 26 phenolic standards using an RP-HPLC system (Shimadzu Corporation LC 20AT, Japan) coupled with a photodiode array (PDA) detector. The sample was injected into the HPLC system with a reverse-phase C18 column (250 mm × 4.6 mm, 5 mm; Fortis). Acetonitrile, water, and acetic acid were used as the mobile phase by applying a programmed gradient. The mobile phase contained (A) 2% acetic acid in water and (B) acetonitrile:water (70:30). The injection volume of samples and standards was 20 µL, the column temperature was 30 °C, and the flow rate was 1.0 mL/min.

Standard calibration curves of phenolic compounds were established using chromatograms recorded at 250, 280, 320, or 360 nm as maximum absorbance values. Calibration coefficients (R2) for all calculations were found to be between 0.998 and 1.000.

2.7. Statistical analysis

All measurements were performed in triplicate for chemical contents, total phenolics, total flavonoids, total condensed tannins, and antioxidant assays (TPC, TFC, FRAP and DPPH). Experimental values are expressed as the mean ± standard deviation (SD).

3. RESULTS and DISCUSSION

This study determined the TPC, TFC, and antioxidant properties of Aran bee pollen (Table 1). The total phenolic and flavonoid contents of Aran bee pollen were 6.540±0.436 (mgGAE/100 g) and 2.897±0.007 (mg QUE/100 g), respectively.

In this study, the total phenolic content and total flavonoid content of bee pollen collected from the Aran region indicate moderate-to-high phenolic content when compared with values reported in the literature from different regions. For example, while TPC values in multifloral bee pollen from Portugal have been reported to range from 4.5–9.3 mg GAE/100g (Morais et al., 2011), this value was found to be 6.29 to 31.91 mg GAE/100g in samples collected from the Central Anatolia region of Turkey (Kolaylı et al., 2024). This comparison demonstrates that bee pollen from the Aran region has a phenolic profile consistent with international standards.

A similar situation exists regarding flavonoid content. TFC values in Brazilian pollen samples generally range from 1,90 to 36,85 mg QUE/100g (de Arruda et al., 2021). The

Table 1. Total phenolic content, total flavonoid content and total antioxidant activities of bee pollen sample taken from Aran region of Azerbaijan

	TPC (mgGAE/100g)C	**TFC mg QUE/100g**	**FRAP (µmolFeSO$_4$.7H$_2$O/g)**	**DPPH SC$_{50}$ mg/mL**
Polen	6.540±0.436	2.897±0.007	65.830±0.618	0.524±0.016

2.90 mg QUE100/g value obtained in the Aran samples is particularly notable for the presence of pinocembrin and chrysin. Pinocembrin is a flavonoid frequently encountered in honeybee products with potent antimicrobial and antioxidant properties; it is also a dominant component in pollen from Turkey (Anatolia) and Greece (Özkök, et al.,2021). Antioxidant properties were analyzed using two different tests. The ferric reducing/antioxidant capacity (FRAP) test indicates the total antioxidant capacity of the samples. Total antioxidant capacity measured by FRAP was found to be 65.830±0.618 (µmolFeSO4.7H2O/g).DPPH

scavenging activity was calculated at SC_{50}, with lower values indicating higher antioxidant activity. SC_{50} values were determined as 0.524±0.016 mg/ml.

High-Performance Liquid Chromatography with Photodiode Array Detection (HPLC-PDA) using 26 phenolic standards revealed trans-cinnamic acid (0.36 mg/100 g), pinocembrin (1.52 mg/100 g), *p*-coumaric acid (1.15 mg/100 g), chrysin (0.50 mg/100 g), and *p*-benzoic acid (0.50 mg/100 g) as the predominant phenolic compounds.In terms of phenolic profile, five prominent compounds in Aran pollen—pinocembrin, *p*-coumaric acid, chrysin, *p*-benzoic acid, and trans-cinnamic acid—are commonly reported in European and Middle Eastern pollens. *p*-Coumaric acid and trans-cinnamic acid are the main products of the phenylpropanoid pathway and are known for their antioxidant and anti-inflammatory properties. Chrysin, a flavonoid derived from propolis and pollen, is particularly notable for its neuroprotective and anticancer potential.

4.CONCLUSION

These results indicate that the floristic diversity of the Aran region is directly reflected in the phenolic richness of the pollen. Therefore, the findings of this study demonstrate that bee pollen from the Aran region is rich in biologically active compounds, has high antioxidant capacity, and has functional food potential. Furthermore, it bears a unique chemical signature thanks to the biogeographic characteristics of the region.

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The Effects of Royal Jelly on Health and Its Reflections on Nursing Care: Review

Arı Sütünün Sağlık Üzerindeki Etkileri ve Hemşirelik Bakımına Yansımaları: Derleme

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Özet

Arı sütü, işçi arıların hipofaringeal bezleri tarafından salgılanan, yüksek besin değerine sahip doğal bir madde olup ana arının temel besin kaynağı olarak kullanılmaktadır. Bu çalışma, güncel bilimsel literatür ışığında arı sütünün insan sağlığı üzerindeki etkilerini ve hemşirelik bakımı açısından taşıdığı önemi incelemektedir. Yapılan araştırmalar, arı sütünün antibakteriyel, antioksidan, antiinflamatuvar, antitümöral ve immünomodülatör özelliklere sahip olduğunu göstermektedir.

Hemşirelik bakımı perspektifinden değerlendirildiğinde, hemşireler; hasta eğitimi, semptomatik tedavinin yönetimi, güvenlik önlemlerinin uygulanması ve olası yan etkilerin izlenmesi süreçlerinde kritik bir rol üstlenmektedir. Bu derlemenin amacı, arı sütünün sağlık üzerindeki etkileri ile hastalıkların önlenmesi ve tedavisindeki potansiyel kullanım alanlarına ilişkin güncel çalışmaları sentezlemek ve hemşirelik uygulamalarına yönelik çıkarımları değerlendirmektir.

Anahtar Kelimeler: Arı sütü, hemşirelik bakımı, hasta eğitimi, tamamlayıcı tedavi

Abstract

Royal jelly is a natural substance of high nutritional value, secreted by the hypopharyngeal glands of worker bees and used as the primary source of nutrition for the queen bee. This study examines the effects of royal jelly on human health and its implications for nursing care in light of current scientific literature. Research has demonstrated that royal jelly possesses antibacterial, antioxidant, anti-inflammatory, antitumoral, and immunomodulatory properties. From a nursing perspective, nurses play a pivotal role in patient education, management of symptomatic treatment, implementation of safety measures, and monitoring of adverse effects. The purpose of this review is to synthesize recent studies concerning the health effects of royal jelly and its potential applications in disease prevention and treatment, as well as to evaluate its implications for nursing practice.

Keywords: *Royal jelly, Nursing care, Patient education, Complementary therapy*

1.INTRODUCTION

Royal jelly is a creamy-white, gel-like secretion produced by the hypopharyngeal glands of worker bees aged 5–15 days (Akyol, 2015). It has attracted considerable attention as a natural product of high biological value with applications in health, cosmetics, and nutrition. The proteins, vitamins, lipids, minerals, hormones, neurotransmitters, flavonoids, and polyphenols it contains constitute the basis of its biological and therapeutic effects (Beltekin & Demir, 2022).

Royal jelly has been reported to exhibit diverse pharmacological activities, including vasodilatory, hypotensive, antihypercholesterolemic, antidiabetic, immunomodulatory, anti-inflammatory, antioxidant, anti-aging, neuroprotective, antimicrobial, estrogenic, antiallergic, antiosteoporotic, and antitumor effects (Dağdeviren & Ünal, 2019). Its antibacterial, antiviral, and fungicidal properties have been demonstrated in various scientific studies (Mutlu et al., 2023). Specifically, 10-HDA has been found to possess antibiotic activity and to be effective against several Gram-positive and Gram-negative bacteria (Artık & Konar, 2018). Due to its rich vitamin and mineral content, royal jelly is effective in eliminating free radicals and strengthening the immune system (Sevil et al., 2023). Through its immunomodulatory properties, it supports immune function and enhances resistance to diseases. Royal jelly also exhibits antioxidant and anti-inflammatory effects, reducing oxidative stress and preventing inflammation (Kara, 2024). In patients receiving radiotherapy or chemotherapy, royal jelly has been shown to alleviate discomfort and accelerate healing of oral mucositis (Sezen, 2023), which can serve as a valuable adjunct in oncology nursing care.

Owing to its antioxidant properties, royal jelly can reduce signs of aging and stimulate collagen synthesis in the skin (İzgü, 2016). By preventing the formation of senescent cells, it promotes the proliferation of young cells and accelerates wound and tissue healing (Çelik & Aşgun, 2020). The anti-aging and pro-healthy aging effects of royal jelly have been supported by scientific evidence (Uçar, 2018). It has also been shown to influence hippocampal functions such as depression, epilepsy, Alzheimer's disease, learning, and memory, potentially supporting healthy brain function through its antioxidant mechanisms (Artık & Konar, 2018).

Some studies suggest that royal jelly may improve certain type 2 diabetes symptoms in both men and women (Hahimoto et al., 2005; Aslan et al., 2023). It may enhance insulin sensitivity and improve glycemic control. As one of the most potent regenerative therapeutic formulations, royal jelly can promote the regeneration of damaged pancreatic cells and potentially prevent the progression of diabetes (Onbaşlı et al., 2019). In overweight adults, royal jelly supplementation has demonstrated beneficial effects on lipid profile, satiety, inflammation, and antioxidant capacity (Kundakçı, 2023).

Studies have also revealed positive effects of royal jelly on reproductive health and infertility. Moreover, it has been reported to alleviate menopausal symptoms, improve liver and kidney functions, and accelerate tissue

regeneration and wound healing (Oršolić et al., 2024). In this context, molecular mechanisms underlying the beneficial effects of royal jelly on various diseases and aging-related complications are being increasingly explored (Fang et al., 2023).

Current scientific evidence highlights the therapeutic potential of royal jelly as a health-promoting natural product and establishes a foundation for future comprehensive studies to support its clinical applications (Oršolić et al., 2024). Recognized for its exceptional nutritional value, royal jelly has gained a reputation as a "superfood" offering numerous health benefits to humans (İlkkaya et al., 2024).

In recent years, consumers and the food industry have become increasingly aware of functional foods and their contributions to the maintenance of human health (Tsopmo et al., 2022). Nutrition is now widely recognized as playing a critical role in the prevention and treatment of various diseases (Collazo et al., 2021). Royal jelly is known to exert positive effects on human health (Yücel, 2021) and is recommended in many countries, particularly in nutrition and cosmetics, as well as in pediatric and geriatric medicine (Oršolić et al., 2024).

Despite its numerous health benefits, certain adverse effects must also be considered. For instance, royal jelly may cause side effects such as weight gain, gastrointestinal discomfort, or facial redness/rashes. Due to insufficient safety data, its use is not recommended during pregnancy or lactation (Şaylıöz & Son, 2025). Individuals allergic to bee products or bee venom should strictly avoid royal jelly, as allergic reactions may have serious consequences and should be carefully evaluated in nursing practice (Karlıdağ & Keskin, 2020). Royal jelly may potentiate the effects of anticoagulant medications, increasing the risk of bleeding (Artık & Konar, 2018). Similarly, it can enhance the effects of cholesterol-lowering drugs (Onbaşlı et al., 2019). Within the scope of patient education, nurses may need to provide guidance on the safe use of royal jelly (Akça et al., 2021). Educational topics should include proper usage and storage, setting realistic expectations, and managing side effects and emergencies (Akça et al., 2021).

Recommendations for integrating royal jelly into nursing practice include: Education and awareness – Nurses should be equipped with up-to-date knowledge on complementary and alternative therapies and trained on the safe use of natural products such as royal jelly; Research and development – Nurses should actively participate in clinical studies investigating the efficacy and safety of royal jelly and contribute to the scientific knowledge base in this field.

2.CONCLUSION

In conclusion, gaining a deeper understanding of the latest molecular mechanisms and pharmacological targets of the active biological components of royal jelly is expected to provide broader opportunities for its application and production in the treatment of various diseases, thereby improving the quality of life for

individuals with specific health conditions. These emerging findings will contribute to a more comprehensive understanding and utilization of royal jelly, enhancing its effectiveness in health maintenance. Royal jelly may be considered a potential supportive option within nursing care. Promising results have been reported particularly in areas such as oral care (mucositis management), intensive care, and supportive nutrition. However, there is currently insufficient robust evidence to recommend its use as a standard nursing protocol. The number of studies remains limited, and large-scale, nursing-specific randomized controlled trials are lacking. There is also heterogeneity in variables such as dosage, duration of administration, and standardized product formulations.

To enable the integration of royal jelly into nursing practice, standardized application protocols and care algorithms need to be developed. Moreover, quality control criteria—including product standardization, purity, and storage conditions—have not yet been clearly established. Differences in cultural, geographical, and economic contexts, as well as variations in patient populations, limit the generalizability of current findings. Considering these factors, further research is warranted to expand the scientific evidence base. Given the remarkable biological properties of royal jelly and its wide range of applications—from pharmaceuticals and the food industry to cosmetic product development there is a pressing need for studies focusing on its standardization, qualitative and quantitative characteristics, and analytical evaluation.

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Characterization of Physicochemical and Bioactive Properties of Butterfly Honeydew Honey Originating from Ricania simulans Secretions

Ricania simulans Salgılarından Üretilen Kelebek Balının Fizikokimyasal ve Biyoaktif Özelliklerinin İncelenmesi

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Özet

Ricania simulans, bitkilerin iletim demetlerinden özsuyunu emerek beslenen, özellikle çay (*Camellia sinensis*) ve fındık (*Corylus avellana*) gibi ekonomik öneme sahip bitkilere zarar veren, Hemiptera takımına ait bir türdür. Halk arasında "vampir kelebek" olarak bilinen bu tür, bitkiler üzerinde bıraktığı şekerli salgılar aracılığıyla bal arılarını cezbetmekte ve bu salgılardan arılar tarafından kelebek balı adı verilen özel bir bal üretilmektedir.

Bu çalışmada, Doğu Karadeniz Bölgesi'nde *Ricania simulans* salgılarından Apis mellifera arıları tarafından üretilen kelebek balının fiziko-kimyasal özellikleri, antioksidan kapasitesi ve fenolik bileşen profili araştırılmıştır. Viskoz ve koyu renkli yapıya sahip bal örneklerinde elektriksel iletkenlik, nem oranı, pH, prolin, şeker ve fenolik bileşen analizleri yapılmıştır. HPLC ile belirlenen fenolik bileşikler arasında protokateşik asit, p-kumarik asit, kafeik asit, galangin, krisin ve pinosembrin öne çıkmıştır. Sonuçlar, kelebek balının salgı kökenli bir bal olduğunu ve fonksiyonel gıda bileşeni potansiyeli sunduğunu göstermektedir.

Anahtar Kelimeler: Kelebek Balı, *Ricania simulans*, Antioksidan, Fenolik Bileşikler, Salgı Kökenli Bal, Fiziko-Kimyasal Özellikler.

Abstract

Ricania simulans is a species belonging to the order Hemiptera that feeds by extracting sap from the vascular tissues of plants. It causes damage particularly to economically important crops such as tea (*Camellia sinensis*) and hazelnut (*Corylus avellana*). Commonly known as the "vampire moth" among the public, this insect attracts honey bees with the sugary secretions it leaves on plants. These secretions are collected by the bees and used to produce a unique type of honey known as butterfly honeydew honey.

This study investigated the physicochemical properties, antioxidant capacity, and phenolic compound profile of butterfly honeydew honey produced by *Apis mellifera* from *Ricania simulans* secretions in the Eastern

Black Sea Region. The honey samples, with viscous and dark appearance, were analyzed for electrical conductivity, moisture, pH, proline, sugar content, and phenolic compounds. HPLC analysis identified key phenolics such as protocatechuic acid, p-coumaric acid, caffeic acid, galangin, chrysin, and pinocembrin. The results indicate that honeydew honey is a secretion-derived honey and offers potential as a functional food component.

Keywords: Butterfly honeydew honey, *Ricania simulans*, antioxidant, phenolic compounds, honeydew honey, physicochemical properties.

1. INTRODUCTION

Ricania simulans (Walker, 1851) (Hemiptera: Ricaniidae) is an insect species first described in southern India (Bu and Liang, 2011). Species belonging to this family are herbivorous and can cause significant damage to plants in both agricultural and natural ecosystems. Due to its ability to feed on more than 60 economically important plant species, *R. simulans* has the potential to become a major agricultural pest (Wilson et al., 2016). In Türkiye, it is commonly found along the coastal areas of the Black Sea Region, affecting a wide range of plants including fruits, vegetables, and ornamentals (Güçlü et al., 2010).

Honey is a natural product produced by honey bees (*Apis mellifera*) through the collection and enzymatic transformation of floral nectar and plant secretions. It has been used throughout human history both as a food source and for its medicinal properties (Aparna et al., 1999; Kaškonienė et al., 2010). Based on its origin, honey is generally classified into two main types: blossom honey and honeydew honey. Honeydew honey is derived not from flower nectar, but from the secretions of plants or the excretions of plant-sap-feeding insects. In particular, insects such as aphids feed on plant sap and excrete sugary substances, which are then collected by honey bees and converted into honey. Pine, oak, and willow honeys are common examples of honeydew honey (Ülgentürk et al., 2013a). Butterfly honeydew honey is produced when honey bees collect and process the secretions left on plant surfaces by *Ricania simulans*, a planthopper species that feeds on plant sap.

In this study, several physicochemical properties, antioxidant capacity, and phenolic composition of butterfly honeydew honey were investigated in order to characterize this novel type of honey. Through this research, both the biological value of butterfly honeydew honey and its position among honeydew honeys were more clearly defined.

2.MATERIALS and METHODS

2.1. Materials

In this study, two different butterfly honeydew honey samples collected from local beekeepers in Pazar, a district of Rize province located in the Eastern Black Sea Region of Türkiye, were evaluated. One of the samples was obtained in 2016, and the other in 2024. The first sample was collected and analyzed in 2016,

while the second sample was collected and analyzed in 2024. The honey samples were stored at room temperature in a dark environment until analysis.

2.2. Chemicals and Reagents

All chemicals and reagents used in this study were of analytical grade. Standards for total polyphenols and total flavonoids were purchased from Sigma-Aldrich Chemie GmbH (Germany) and Merck (Darmstadt, Germany). Trolox was supplied by AppliChem (Darmstadt, Germany). Folin–Ciocalteu phenol reagent and TPTZ were obtained from Fluka Chemie GmbH (Switzerland). Iron(III) chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), 2,4,6-Tris(2-pyridyl)-s-triazine (TPTZ) and iron(II) sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$) were obtained from Sigma-Aldrich (St. Louis, MO, USA). Sodium acetate, ferric chloride, and glacial acetic acid were purchased from Merck. LC syringe filters (RC membrane, 0.45 µm), Sartorius Minisart RC 15, were supplied by Sartorius (Darmstadt, Germany).

2.3. Physicochemical Analysis of Honey Samples

Honey samples were analyzed in accordance with the official methods described by the AOAC (2005) and the International Honey Commission (2009).

Optical rotation measurements were conducted using a polarimeter (Atago, Tokyo, Japan). For each analysis, 12 g of honey was dissolved in distilled water, followed by the addition of 10mL Carrez I solution (10.6 g $K_4[Fe(CN)_6] \cdot 3H_2O$/100 mL) and 10 mL Carrez II solution (24 g $Zn(CH_3COO)_2 \cdot 2H_2O$, 3g glacial acetic acid/100 mL). The mixture was diluted to a final volume of 100 mL, left to stand at room temperature for 24 hours, and then filtered. The optical rotation of the resulting filtration was recorded (Junk & Pancoast, 1973).

Proline content was determined spectrophotometrically using a UV–VIS spectrophotometer (Thermo Scientific Evolution™ 201, USA). Measurements were taken at 510 nm, corresponding to the wavelength of maximum absorbance. A standard calibration curve was prepared using pure dry proline solutions, and results were expressed as mg proline per kg of honey (Ough, 1969).

Sugar analyses were performed using HPLC (Elite LaChrom, Hitachi, Japan) equipped with a refractive index detector (RID). A reverse-phase amide column (200/4.6 Nucleosil 100-5NH_2) was employed, and an isocratic elution program was applied using a mobile phase consisting of acetonitrile, water, and acetic acid. Qualitative and quantitative sugar analyses were conducted according to the method described by Ozturk et al. (2007). The calibration coefficients (R^2 values) ranged between 0.994 and 0.999.

2.4. Preparation of Methanolic Extracts

Methanolic extracts of samples were prepared for antioxidant and phenolic compound analyses. For extraction, 10 g of honey was mixed with 30 mL of 99% methanol. The mixtures were continuously stirred for 24 hours at room temperature using a shaker (Heidolph Promax 2020, Schwabach, Germany). After incubation, samples were filtered using Whatman filter paper, and the filtrates were adjusted to their final volumes with methanol. All antioxidant analyses were conducted spectrophotometrically using a UV–VIS spectrophotometer (Thermo Scientific Evolution TM 201, USA).

2.5. Total Phenolic Content Determination

The analysis was performed according to the method by Singleton and Rossi (1965). This method is based on the redox reaction of phenolic compounds with Folin-Ciocalteu reagent in an alkaline medium, resulting in the formation of a blue complex. The absorbance of this color was measured at 760 nm to calculate total phenolic content. Results were expressed as mg gallic acid equivalents per grams of sample (mg GAE/ g).

2.6. Ferric Reducing Antioxidant Power (FRAP) Assay

This antioxidant test is based on the method of Benzie and Strain (1996). In the presence of antioxidants, the Fe(III)-TPTZ complex is reduced to the blue-colored Fe(II)-TPTZ form, which absorbs at 593 nm. To 100 µL of sample, 3 mL of FRAP reagent (acetate buffer, TPTZ, and $FeCl_3$ in a 10:1:1 ratio) was added. Absorbance was measured after 4 minutes. Results were expressed as µmol Trolox equivalent per g.

2.7. Phenolic Compound Profile

2.7.1. Liquid–Liquid Extraction Method for the Quantification and Analysis of Phenolic Compounds

To determine the concentration of phenolic compounds present in the butterfly honeydew honeydew honey samples used in this study, a liquid–liquid extraction method was applied. This procedure was used identically for both honey samples. First, 10 mL of 70% ethanolic extract was evaporated using a rotary evaporator (IKA Werke, Staufen, Germany) at 40°C. The resulting residue was re-dissolved in 10 mL of distilled water, previously acidified to pH 2 with HCl. Subsequently, successive liquid–liquid extractions were performed using diethyl ether and ethyl acetate as organic solvents (Kolaylı and Birinci, 2024). After evaporating the organic solvents, the residue was dissolved in 2 mL of methanol, filtered through a 0.45 µm pore-sized RC membrane filter, and diluted appropriately before injection into the HPLC system.

2.7.2. HPLC-UV Analysis of the Phenolic Composition

The phenolic compound profile of the butterfly honeydew honeydew honey sample collected in 2016 was determined using an HPLC-UV system.

A total of 14 polyphenolic standard compounds (gallic acid, protocatechuic acid, p-hydroxybenzoic acid, catechin, vanillic acid, caffeic acid, syringic acid, epicatechin, p-coumaric acid, ferulic acid, rutin, daidzein, trans-cinnamic acid ve luteolin) were analyzed using a High-Performance Liquid Chromatography system (Elite LaChrome; Hitachi, Tokyo, Japan) equipped with a reversed-phase Fortis C18 column (Chromex Scientific, 150 mm × 4.6 mm, 5 µm). The mobile phase consisted of two solvents: reservoir A (2% acetic acid in water) and reservoir B (a 70:30 mixture of acetonitrile and water). A programmed gradient elution was applied, beginning with 95% reservoir A and 5% reservoir B for the first 3 minutes. The proportion of reservoir A was then gradually reduced to 20% over 30 minutes. Afterward, the gradient was returned to the initial condition (95% A) and maintained for an additional 20 minutes. Samples were individually injected at a volume of 20 µL, at room temperature, with a flow rate of 0.75 mL/min (Can et al., 2015). For quantitative determination, the regression coefficients of the calibration curves for each phenolic compound ranged between 0.998 and 1.000 (Can et al., 2015).

2.7.3. HPLC-DAD Analysis of the Phenolic Composition

A total of 26 phenolic compounds (gallic acid, protocatechuic acid, chlorogenic acid, catechin hydrate, p-hydroxybenzoic acid, epicatechin, caffeic acid, vanillic acid, syringic acid, p-coumaric acid, rutin, ellagic acid, ferulic acid, myricetin, daidzein, luteolin, quercetin, trans-cinnamic acid, naringenin, apigenin, hesperetin, rhamnetin, chrysin, pinocembrin ve CAPE) were identified in the 2024 butterfly honeydew honeydew honey sample using High-Performance Liquid Chromatography with a Photodiode Array Detector (HPLC-DAD) (Kara and Birinci, 2024). The analysis was conducted using an HPLC system (Shimadzu Liquid Corporation LC-20AT, Kyoto, Japan) equipped with a C18 column from GL Sciences (250 mm × 4.6 mm, 5 µm; 5020-01732).

Prior to analysis, calibration curves were constructed using 26 phenolic standards. The mobile phase consisted of two solvents: (A) 70% acetonitrile and 30% distilled water, and (B) distilled water containing 2% acetic acid. Both sample and standard injections were performed at a volume of 20 µL. The column temperature was maintained at 30°C, and the flow rate was set to 1.0 mL/min.

3.RESULTS and DISCUSSION

Physical and chemical analyses are essential for evaluating the quality of honey, and are often regulated by official standards and food codices (Codex Alimentarius, 2001; TS 28366, 2012). The primary quality parameters of the studied butterfly honeydew honeydew honey samples are presented in Table 1.

The moisture content of the samples was determined to be 18% in Butterfly honeydew honey-1 and 15% in Butterfly honeydew honey-2. These values fall within the acceptable range, indicating low water activity and favorable preservation characteristics. According to TS 28366, (2012) standards, such moisture levels suggest

that the honey is mature and less susceptible to microbial activity. Moisture content is a critical parameter influencing the shelf life and overall stability of honey. A moisture range of 15–18% indicates that the honey can maintain its stability under appropriate storage conditions (Saxena et al., 2010).

Electrical conductivity is closely associated with the mineral, organic acid, and protein content of honey and is also considered an indicator of its botanical origin (Andrade et al., 1997). Honeydew honeys generally exhibit higher mineral content, reflected by conductivity values above 800 µS/cm, whereas blossom honeys typically show lower values (Codex Alimentarius, 2001).

In this study, the electrical conductivity values were determined as 640 µS/cm for Butterfly honeydew honey-1 and 1210 µS/cm for Butterfly honeydew honey-2. The difference between these two values can be attributed to variations in environmental conditions and vegetation during the honey collection period. Factors such as soil composition, rainfall patterns, mineral uptake by plant species, and agricultural practices (e.g., fertilization) influence the mineral composition of plant sap, which indirectly affects the composition of insect secretions. Consequently, the ash content and electrical conductivity of honey produced by bees feeding on these secretions may vary.

Furthermore, the population density and secretion activity of *Ricania simulans* may fluctuate over the years. Higher insect populations or harvesting during peak secretion periods typically result in more concentrated and mineral-rich honeys. The elevated conductivity observed in the 2024 sample (1210 µS/cm) likely reflects such variations in infestation intensity and timing.

The pH values were recorded as 5.16 and 5.62 for Butterfly honeydew honey-1 and Butterfly honeydew honey-2, respectively. These slightly acidic pH levels are typical for honey and contribute to its microbial stability and antioxidant capacity. Moreover, such pH values have been reported to show a positive correlation with antioxidant activity (Karabagias et al., 2014).

Table 1. Physicochemical Properties of Honey Samples

Samples/Tests		Butterfly honeydew honey-1	Butterfly honeydew honey-2
Electrical Conductivity (µS/cm)		640±1.00	1210.00±1.00
Moisture		18±0.00	15±0.00
pH		5.16±0.00	5.62±0.00
Colour	L*	15.96±0.00	44.58±0.10
	a*	26.01±0.01	26.29±0.01
	b*	27.46±0.02	72.29±0.01
Optic Rotation		+1.51±0.01	+5.65±0.01
Proline (mg/kg)		386.38±20.55	380.10±1.00
Sugar	Glukoz (%)	45.77±0.10	47.68±0.10
	Fructose (%)	32.23±0.20	30.63±0.10
	Sukroz (%)	0,44±1.00	0.19±0.10
	G+F (%)	78.00	78.31

The color parameters were evaluated using the CIE Lab* system. The L values (lightness) of the samples were 15.96 and 44.58. indicating that the first sample is much darker than the second and exhibits a dark amber color. The a values (red-green scale) were similar at 26.01 and 26.29, while the b values (yellow-blue scale) differed significantly, being 27.46 in sample 1 and 72.29 in sample 2. These variations are attributed to differences in pigment composition of the honeydew honeys.

Optical rotation values were recorded as +1.51° and +5.65°. indicating that both samples contain optically active compounds. which may also reflect their botanical origin. Similar values have previously been observed in honeydew honeys such as oak and pine honey (Can et al., 2015). While blossom honeys generally exhibit negative optical rotation, honeydew honeys tend to show positive values (Junk & Pancoast, 1973). Therefore, these findings support the conclusion that butterfly honeydew honey is also of honeydew origin.

Proline content, a key indicator of honey maturity and bee enzyme activity, was measured as 386.38 mg/kg and 380.10 mg/kg for samples 1 and 2, respectively. Both values indicate high-quality and well-matured honey. Proline levels in honey are directly related to enzymes secreted by bees and the floral source. In this study, the measured proline content of 386.38 mg/kg exceeds the minimum values set by both Turkish and European codices (Codex Alimentarius, 2001). High proline content is an important biochemical marker that demonstrates the honey is genuine and mature (Cotte et al., 2004; Güler et al., 2007).

The proline content, ranging between 380–386 mg/kg, is consistent with the amino acid profiles commonly found in honeydew honeys, such as proline, phenylalanine, and glutamic acid. Proline level is widely accepted as an indicator of honey maturity and quality (Bertoncelj et al., 2007; Iglesias et al., 2004).

The sugar composition of Butterfly honeydew honey-1 (45.77% glucose, 32.23% fructose, 0.44% sucrose, and 78.00% total reducing sugars) further supports the typical characteristics of mature and natural honey. Although the sucrose content in this sample (0.44%) is slightly higher than in other sample, it remains well within the acceptable regulatory limits and does not indicate any form of adulteration. The high level of reducing sugars (78.00%) confirms compliance with international honey quality standards, which require a minimum of 65%.

Similarly, Butterfly honeydew honey-2 contained 47.68% glucose, 30.63% fructose, and a very low 0.19% sucrose, with total reducing sugars amounting to 78.31%. These results are consistent with the sugar profile expected in natural honey and meet the quality requirements established by international regulations (Codex Alimentarius, 2001).

In the honey samples, glucose content was found to range between 45.77% and 47.68%, while fructose ranged from 30.63% to 32.23%. This composition reflects a sugar profile characteristic of Butterfly honeydew honey. The low sucrose content (0.19–0.44%) indicates that the sugars have been effectively hydrolyzed due to invertase enzyme activity, suggesting that the honey is well-matured (Ouchemoukh et al., 2007).

The evaluation of total phenolic content (TPC) and antioxidant capacity is crucial in determining the functional quality and health-promoting properties of honey. These parameters were assessed in the butterfly honeydew honey samples and the results are presented in Table 2.

The total phenolic content (TPC), expressed as mg gallic acid equivalent per gram of sample (mg GAE/g) was determined to be 0.49±0.02 mg GAE/g in Butterfly honeydew honey-1 and 0.27±0.04 mg GAE/g in Butterfly honeydew honey-2. These results indicate that sample 1 contains a higher concentration of phenolic compounds which are known to contribute significantly to honey's antioxidant properties and biological activity.

Table 2. Antioxidant Properties of Honey Samples

Samples /Tests	**Butterfly honeydew honey-1**	**Butterfly honeydew honey-2**
TP (mg GAE/g honey)	0.49±0.02	0.27±0.04
FRAP (µmol FeSO4.7H2O/g honey)	1.82±0.01	1.49±0.01

The antioxidant capacity, measured by the Ferric Reducing Antioxidant Power (FRAP) assay and expressed as µmol $FeSO_4 \cdot 7H_2O$ per gram of sample, was found to be 1.82±0.01 µmol $FeSO_4$/g for sample 1 and 1.49±0.01 µmol $FeSO_4$/g for sample 2. These values suggest a relatively strong antioxidant potential, with sample 1 again showing higher activity, which correlates with its higher phenolic content. These results

indicate that Butterfly honeydew honey possesses a moderate level of antioxidant capacity (Estevinho et al., 2008). These findings emphasize the variability in bioactive compound levels between different honeydew honey samples.

The phenolic composition of Butterfly honeydew honey samples collected in 2016 and 2024 Primarily, the analytical methods employed differed; the 2016 sample was analyzed using HPLC-UV with 14 standard compounds, whereas the 2024 sample was examined using a more advanced HPLC-DAD system with 26 standard compounds. This methodological advancement enabled the detection of additional phenolics such as galangin (6.26 µg/g), chrysin (3.71 µg/g), and pinocembrin (5.83 µg/g) in the 2024 sample, which were not included in the earlier analysis (Tomás-Barberán et al., 2001).

Beyond methodological differences, genuine biological and environmental variations likely contributed to the observed compositional changes. The eight-year interval between collections suggests potential influences from the phenological stages, climatic conditions, and stress levels of the host plants, *Camellia sinensis* and *Corylus avellana*. Environmental stressors such as drought and extreme temperatures can substantially alter secondary metabolite synthesis, thereby affecting the chemical profile of insect secretions (Tomás-Barberán et al., 2001). Additionally, fluctuations in the population density and feeding behavior of *Ricania simulans* may have influenced both the quantity and quality of honeydew secretions. Variations in insect developmental stages and sex ratios further contribute to differences in the composition of honeydew (Ülgentürk et al., 2013b).

Quantitative analysis revealed that the 2016 sample contained notable amounts of protocatechuic acid (3.53 µg/g), p-coumaric acid (4.89 µg/g), rutin (3.78 µg/g), t-cinnamic acid (1.62 µg/g), ferulic acid (0.91 µg/g), caffeic acid (0.86 µg/g), epicatechin (0.95 µg/g), and luteolin (0.52 µg/g), indicating substantial antioxidant potential despite the limited number of analyzed compounds. In contrast, the 2024 sample displayed a broader phenolic profile with higher concentrations of gallic acid (2.01 µg/g), caffeic acid (3.05 µg/g), chrysin (3.71 µg/g), pinocembrin (5.83 µg/g), galangin (6.26 µg/g), and the bioactive caffeic acid phenethyl ester (CAPE) (0.68 µg/g), a compound exclusively detected in this sample (Banskota et al., 2001). These differences not only reflect the improved sensitivity and resolution of the HPLC-DAD method but also suggest genuine shifts in botanical and ecological factors influencing honey composition.

Furthermore, the higher concentrations of specific flavonoids such as galangin, chrysin, and pinocembrin in the 2024 sample are noteworthy. These compounds are commonly associated with propolis and considered markers of bee-derived contributions to honey, implying that the 2024 honey may have experienced greater propolis contact during hive processing or different bee foraging behaviors (Banskota et al., 2001).

Based on these results, both samples exhibited characteristic features of honeydew honey, such as positive optical rotation, elevated electrical conductivity, and moderate antioxidant capacity, confirming their authentic classification as Butterfly honeydew honey.

Table 3. Phenolic Compound Contents of Honey Samples

Phenolic content (µg phenolic /g honey)		
Samples /Phenolic Compounds	**Butterfly honeydew honey-1**	**Butterfly honeydew honey-2**
Gallic acid	0.44±0.00	2.01±0.01
Protocatechuic acid	3.53±0.03	1.16±0.01
Chlorogenic acid	-	nd
Catechin hydrate	nd	nd
***p*-OH Benzoic acid**	1.30±0.01	2.14±0.02
Epicatechin	0.95±0.01	nd
Caffeic acid	0.86±0.00	3.05±0.04
Vanillic acid	1.17±0.01	nd
Syringic acid	nd	nd
***p*-Coumaric acid**	4.89±0.05	2.50±0.02
Rutin	3.78±0.03	nd
Ellagic acid	-	nd
Ferulic acid	0.91±0.01	1.61±0.01
Myricetin	-	nd
Daidzein	nd	nd
Luteolin	0.52±0.01	nd
Quercetin	-	nd
***t*-Cinnamic acid**	1.62±0.01	1.35±0.01
Naringenin	-	nd
Apigenin	-	nd
Hesperetin	-	nd
Rhamnetin	-	nd
Chrysin	-	3.71±0.03
Pinocembrin	-	5.83±0.04
CAPE	-	0.68±0.01
Galangin	-	6.26±0.06

nd:not detected -:not standards in 2016

4. CONCLUCION

This study presents a comprehensive characterization of butterfly honeydew honey derived from *Ricania simulans* secretions. The honey demonstrated physicochemical and bioactive features consistent with high-quality honeydew honeys, including high electrical conductivity, low moisture, and significant antioxidant activity. The distinct phenolic profiles among the samples reveal the influence of not only geographical and botanical origins but also environmental variations related to years and seasonal changes.

Given its unique origin and bioactive potential, butterfly honeydew honey may serve as a promising functional food. Future studies should focus on isolating its key phenolic constituents, evaluating antimicrobial properties, and assessing its therapeutic effects in disease models such as oxidative stress, wound healing, or

metabolic disorders. Additionally, its commercialization could offer economic benefits in regions affected by *R. simulans* infestations.

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The effect of royal jelly on girls' sexual development: a natural supportive and regulatory influence.

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Abstract

Royal jelly is a rich secretion secreted from the glands of young worker bees and used in the nutrition of queen bees. The composition and function of this rich mixture of various proteins (especially major royal jelly proteins - MRJP), free amino acids, vitamins (especially B5 and B6), minerals, specific fatty acids are unknown. The increased fertility and life span of the queen bee, which has the same genetic structure as the worker bees, when fed with royal jelly has increased the interest in royal jelly. This bee product, which is claimed to have epigenetic and nutrigenetic properties, is the most commonly used product for infertility treatment among the public. In vivo studies with royal jelly consumed plain or in mixtures with honey, pollen and propolis show that it is highly effective against ovarian and testicular damage.

Keywords: Apitherapy, Nature, Food

1.INTRODUCTION

Introduction should provide information about the aims of the work and gives background to the study with related and current literature. Royal jelly is a secretion produced by the hypopharyngeal and mandibular glands of worker bees that are typically 5 to 15 days old. During this period, the hypopharyngeal and mandibular glands of young worker bees are active and secrete bee milk, particularly for the purpose of feeding larvae. The most active period for these glands is between the 6th and 12th days of a worker bee's life. This production process is temporary and depends on the age of bees; older worker bees lose this ability and take on different tasks in the hive (Pavel, 2011).

Royal jelly is a complex, nutrient-rich secretion produced by the hypopharyngeal and mandibular glands of nurse honeybees (Apis mellifera). Its composition includes approximately 60–70% water, 12–15% proteins (notably major royal jelly proteins, MRJPs), 10–16% sugars (mainly fructose and glucose), 3–6% lipids, and small amounts of vitamins, minerals, and bioactive compounds. Among its unique components are 10-hydroxy-2-decenoic acid (10-HDA), an unsaturated fatty acid with antimicrobial and immunomodulatory properties, and acetylcholine, which plays a role in neurodevelopment. This complex chemical profile contributes to royal jelly's biological activities and its critical role in queen bee development (Pavel,2011; Melliou, & Chinou, 2014).

Epigenetics is the scientific field that studies how gene expression is regulated by environmental factors and lifestyle without any changes to the DNA sequence. These mechanisms include DNA methylation, histone modifications, and small RNAs. Nutrigenetics, on the other hand, investigates how an individual's genetic makeup affects their biological response to nutrients. Both fields are complementary in understanding the interaction between nutrition and genetics; epigenetics show how nutrients alter gene expression, while nutritional factors explain how individual genetic differences determine sensitivity to nutrient components. These disciplines form an important foundation for personalized nutrition and disease prevention (REF).

Royal jelly is a nutrigenetically significant natural product. In particular, the major royal jelly proteins (MRJPs) it contains can affect gene expression through epigenetic mechanisms such as histone modifications and DNA methylation. This situation can be observed in concrete terms in genetically identical bee larvae, which develop into worker or queen bees solely due to differences in nutrition. It is thought that the bioactive compounds found in bee milk contribute to the reprogramming of genetic expression in physiological processes such as cell renewal, hormonal regulation, and reproductive function by affecting metabolic genes in mammalian systems (Alhosin 2023; Aparecida dos Santos France et al. 2024).

In this study, the effects of royal jelly on reproductive functions were examined based on studies conducted in literature.

2.RESULTS and DISCUSSION

Nutrition plays a fundamental role in the maintenance and improvement of reproductive health, significantly influencing both the quantity and quality of gametes. Sperm and oocyte quality are particularly sensitive to environmental stressors and oxidative damage. Antioxidant compounds—such as vitamins C and E, selenium, and zinc—neutralize reactive oxygen species (ROS), thereby preserving sperm DNA integrity, enhancing motility, and supporting oocyte maturation. Nutrients like omega-3 fatty acids, folic acid, and specific amino acids (e.g., L-arginine and L-carnitine) contribute to both spermatogenesis and oocyte development by supporting cellular energy metabolism and regeneration.

In females, adequate intake of folic acid, vitamin D, and high-quality proteins has been shown to positively affect follicular development and embryo quality. Accordingly, diets rich in micronutrients and antioxidants not only enhance fertility but also improve the success rates of assisted reproductive technologies (ART).

In the treatment of reproductive dysfunctions, alongside pharmacological hormone replacement therapies, the use of antioxidant-rich functional foods and phytochemicals aimed at reducing oxidative stress has gained increasing attention. Numerous recent experimental studies have demonstrated that plant-based products with high antioxidant capacity can reduce endoplasmic reticulum (ER) stress, support cellular homeostasis in reproductive organs, and thus improve gamete quality. Therefore, targeted nutritional strategies are being

increasingly recognized as complementary approaches to support fertility. The results of numerous experimental animal studies involving royal jelly (RJ) are summarized in Table 1. These studies demonstrate that RJ exerts protective effects on the reproductive system, particularly against oxidative stress-induced ovarian and testicular damage. In various experimental models, oxidative stress was induced using different chemical agents, and RJ administration was found to mitigate histological and functional impairments in gonadal tissues. The observed protective effects are primarily attributed to RJ's potent antioxidant and anti-apoptotic properties, which contribute to the preservation of reproductive tissue integrity under oxidative insult.

Table 1. Royal Jelly and Reproductive Functions of Experimental Studies

Model/Target Organ	Induced Damage	Effect of Royal Jelly	Reference
Rat/ Liver, Kidney	Cisplatin	Antioxidant, anti-apoptotic	Karadeniz et al., (2011)
Rat/ Ovary	Cyclophosphamide	Follicle preservation, antioxidant	Barberino et al., (2023)
Rat/ Prostate	Cyclophosphamide	Histological protection, immunomodulation	Abdel-Hafez et al., (2017)
Rat/ Testis	Cyclophosphamide	Histological protection, synergy with α-lipoic acid	Moustafa et al., (2020)
Mouse / Testis	Nicotine	Improved reproductive parameters	Azad et al., (2018)
Mouse / Testis	Nicotine	Anti-apoptotic, reduced oxidative stress	Azad et al., (2019)
Rat / Embryo	Nicotine	Enhanced embryo quality and IVF success	Khodabandeh et al., (2021)
Mouse / Testis and Sperm	Doxorubicin	Protected sperm parameters and testicular tissue	Pourzamani et al., (2022)
Livestock Reproductive performance /(general)	None (general review)	Improved fertility and sperm quality	Abdelnour et al., (2020)
Goat (in vitro)/Oocyte Maturation	None (in vitro)	Enhanced embryo development, reduced apoptosis	Veshkini et al., (2018)
Rat /Ovary	Doxorubicin	Reducing ER stress	Malkoç et al. (2025)

3.CONCLUSION

In conclusion, royal jelly (RJ) can be considered a promising natural nutrigenetic agent with high potential in the improvement and preservation of reproductive functions. Its demonstrated antioxidant, anti-apoptotic, and regulatory effects on gametogenesis in experimental models support its therapeutic relevance. However, despite the encouraging preclinical evidence, further well-designed clinical studies in humans are needed to confirm its efficacy, safety, and potential applications in reproductive medicine.

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Phenolic composition of licorice (Glycyrrhiza glabra) and propolis mixed extract

Meyan kökü (Glycyrrhiza glabra) ve propolis karışık ekstresinin fenolik bileşimi

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Abstract

Glycyrrhiza glabra (licorice root) is a perennial plant belonging to the Fabaceae family, and its roots contain glycyrrhizin, a compound responsible for its use as both a sweetener and a therapeutic agent. It has been traditionally employed in the treatment of cough, gastrointestinal disorders, and inflammatory diseases. Propolis, a resinous substance collected by honeybees from plant sources, exhibits multitherapeutic properties owing to its rich phenolic composition. Both natural products are recognized as important components of traditional and complementary medicine.

In this study, the antioxidant capacity and polyphenolic composition of an ethanolic extract prepared from a mixture of dried licorice root and raw propolis were determined. The analysis revealed that the extract was rich in galangin, pinocembrin, chrysin, and quercetin, indicating a high phenolic content. The results suggest that the combination of licorice root and propolis forms a polyphenol-rich natural blend with potent antioxidant properties.

Keywords: *Glycyrrhiza glabra*, propolis, mixture

INTRODUCTION

Glycyrrhiza glabra L., a perennial plant of the Fabaceae family, has been used by humans for nearly 4,000 years as a medicinal and functional ingredient. The genus Glycyrrhiza comprises about 30 species, of which 15 have been chemically investigated. Among them, *G. glabra*, *G. uralensis*, *G. inflata*, *G. aspera*, *G. korshinskyi*, and *G. eurycarpa* are recognized as primary sources of glycyrrhizic acid, a triterpenoid saponin that serves as the main bioactive and natural sweetening compound. Notably, only *G. glabra* and *G. uralensis* are officially listed as licorice in the Japanese Pharmacopoeia.

Licorice root extract is extensively employed in the pharmaceutical, food, and cosmetic industries as a natural sweetener, flavoring agent, coloring agent, and bioactive component in antiulcer, antitussive, and hepatoprotective formulations (Martins et al., 2015; Conidi et al., 2019). Its roots are particularly rich in glycyrrhizin (glycyrrhizic acid), flavonoids, saponins, and coumarins. Glycyrrhizin exhibits multiple pharmacological effects, including anti-inflammatory, antiviral, antioxidant, and hepatoprotective activities (Kaur et al., 2013). Traditionally, licorice root has been used to treat respiratory disorders, gastric ulcers, and

skin diseases. In recent years, the diverse bioactive profile and pharmacological potential of Glycyrrhiza glabra have attracted increasing attention in natural product and medicinal plant research (Gupta et al., 2008).

Propolis is a resinous bee product collected by honeybees (*Apis mellifera*) from plant buds, resins, and exudates, and mixed with beeswax. Bees use propolis to maintain hygiene, seal cracks, and inhibit the growth of microorganisms within the colony. Propolis extracts are typically prepared using ethanol, water, or glycol as solvents, and are rich in flavonoids, phenolic acids, esters, terpenoids, and aromatic compounds (Kolayli, 2024). These bioactive constituents confer antioxidants, antimicrobial, anti-inflammatory, and immunomodulatory properties to propolis. In recent years, propolis and its extracts have been extensively studied as natural bioactive agents in food preservation, pharmaceutical development, and functional food formulations(Kolaylı et al. 2023; Kolaylı, S., & Birinci, C. (2024).

Both of the extracts of *Glycyrrhiza glabra* and propolis are among the most widely used natural materials in traditional and complementary medicine. In this study, a novel extract was prepared for the first time by combining these two bioactive sources. The antioxidant properties and phenolic composition of the obtained extract were subsequently investigated.

MATERIALS AND METHODS

In this study, the *Glycyrrhiza glabra* plant was collected from Baku in July 2024, while the propolis sample was obtained from Trabzon. For extract preparation, 15 g of licorice powder and 15 g of propolis were combined in a 1:1 ratio and extracted with 200 mL of 70% ethanol. The extraction was carried out at 40 °C using a slow-speed stirring propolis extraction apparatus over 2–3 days. Continuous stirring was not required; intermittent mixing for approximately 3 hours per day, in 3–4 hour intervals, was sufficient. Prolonged extraction generally enhances the yield and quality of propolis extracts; however, a 5-day extraction period was considered adequate for this procedure. Following extraction, the propolis mixture was filtered, allowed to settle, and subsequently packaged for further use.

Total Phenolic and Flavanoid contents

The total phenolic content of the samples was determined using the method of Slinkard and Singleton (1977). Samples were first dissolved in water, and 680 µL of distilled water was added to each sample and standard. Then, 400 µL of 0.2 N Folin–Ciocalteu reagent was added, followed by 20 µL of each sample or diluted gallic acid standard. The mixtures were vortexed and incubated at room temperature for 3 minutes. Finally, 400 µL of 10% sodium carbonate (Na_2CO_3) solution was added, and the mixtures were incubated at room temperature for 2 hours. Absorbance was measured at 760 nm, and results were expressed as gallic acid equivalents (mg GAE/g).

The total flavonoid content (TFC) of the samples was determined following the method of Fukumoto and Mazza (2000). In brief, 0.25 µL of each extract was mixed with 50 µL of 10% aluminum nitrate ($Al(NO_3)_3$) and 50 µL of 1 M ammonium acetate (NH_4CH_3COO). The mixture was then brought to a final volume of 3 mL with 99% methanol and incubated at room temperature. After 40 minutes, the absorbance was recorded at 415 nm against a blank. The TFC values were calculated using a quercetin standard curve and expressed as mg quercetin equivalents (QUE) per gram of sample

Ferric Reducing Antioxidant Power (FRAP)

The ferric reducing antioxidant capacity of the samples was determined according to the method described by Benzie and Strain (1999). A standard curve was prepared using $FeSO_4 \cdot 7H_2O$ solutions in the range of 31.25–500 µmol/mL. The results were calculated based on this standard curve and expressed as µmol $FeSO_4 \cdot 7H_2O$ equivalents per gram of sample (µmol $FeSO_4 \cdot 7H_2O$/g sample).

DPPH Radical Scavenging Activity

The DPPH radical scavenging activity was determined according to the method described by Molyneux (2004). Results were expressed as the SC_{50} value, which is the sample concentration required to reduce 50% of DPPH• radicals. A lower SC_{50} value indicates higher radical scavenging (antioxidant) activity of the sample.

Phenolic Composition

Twenty-six phenolic standards (including gallic acid, chlorogenic acid, caffeic acid, quercetin, CAPE, and t-cinnamic acid) were analyzed using reversed-phase HPLC (RP-HPLC, Shimadzu LC 20AT) with a photodiode-array (PDA) detector (Kara and Biirnci 2024). Approximately 500 µL of each sample was injected into a C18 column (250 mm × 4.6 mm, 5 µm; Fortis) using a programmed gradient of 2% acetic acid in water (A) and acetonitrile in water 70:30 (B). The injection volume was 20 µL, with a column temperature of 30 °C and flow rate of 1.0 mL/min. Phenolic compounds were quantified using calibration curves constructed from their maximum absorbance at 250, 280, 320, or 360 nm.

RESULTS AND DISCUSSIONS

Table 1 summarizes the total phenolic content (TPC) and antioxidant properties of the propolis–licorice extract. The TPC, representing the sum of all polyphenolic compounds in the extract, was determined as 0.76 ± 0.51 mg GAE/mL. Polyphenols are among the most important secondary metabolites in propolis and many plant extracts, and higher levels are generally associated with greater biological activity (Abbas et al. 2017). Indeed, the content and specificity of these natural compounds are considered key quality indicators for both raw propolis and propolis extracts (REF). Flavonoids, which constitute the largest class of total polyphenols, are relatively less soluble in water and are more efficiently extracted with 70% ethanol. In the

licorice–propolis mixture, the total flavonoid content (TFC) was measured as 7.177 ± 0.29 mg QE/mL, indicating that approximately one-third of the extract consists of flavonoid compounds.

The antioxidant capacity of the extract was evaluated using two different assays, revealing a notably high antioxidant potential. The FRAP assay assessed the total antioxidant capacity, while the DPPH assay measured the extract's ability to scavenge free radicals.

Table 1 presents the phenolic composition of the propolis–licorice extract as determined by HPLC–PDA analysis. The quantification was performed using a method calibrated for 26 phenolic standards (Kara and Birinci, 2024). Among the hydroxybenzoic acids, only p-hydroxybenzoic acid and protocatechuic acid were detected, both at very low concentrations. Within the hydroxycinnamic acid group, all compounds except t-cinnamic acid were identified, with caffeic acid phenethyl ester (CAPE being the most abundant, followed by caffeic acid and ferulic acid. In the flavonol class, galangin showed the highest concentration, succeeded by rhamnetin and quercetin. Of the two flavan-3-ols analyzed, catechin was detected, whereas epicatechin remained below the quantification limit. Among the flavones, chrysin was the major component, with minor amounts of apigenin and luteolin. In the flavanone group, only pinocembrin was identified, exhibiting a relatively high concentration.

Table 1. Phenolic profile of the mixture

Phenolis subclass	(mg/L)
Hydroxybenzoic acids	
p-OH Benzoic acid	7,80
Protocatechuic acid	2,72
Gallic acid	-
Chlorogenic acid	-
Syringic acid	-
Ellagic acid	-
Vanillic acid	-
Hydroxycinnamic acids	
t-cinnamic acid	-
Ferulic acid	311,24
p-Coumaric acid	105,97
Caffeic acid	330,08
Caffeic acid phenethyl ester (CAPE)	619,16
Flavonol	
Rhamnetin	287,64

Quercetin	73,75
Rutin	-
Myricetin	-
Galangin	1444,88
Flavan-3-ols	
Epicatechin	-
Catechin hydrate	253,43
Flavones	
Chrysin	1252,15
Daidzein	-
Apigenin	173,90
Luteolin	52,28
Flavanones	
Pinocembrin	1812,15
Hesperetin	-
Naringenin	-

CONCLUSION

The findings of this study demonstrate that the ethanolic extract obtained from the mixture of *Glycyrrhiza glabra* root and raw propolis possesses a high concentration of bioactive polyphenols and exhibits remarkable antioxidant potential. The predominance of flavonoids such as galangin, pinocembrin, chrysin, and quercetin highlights the synergistic contribution of both components to the overall antioxidant profile of the extract. These results suggest that the combination of licorice root and propolis may serve as a promising natural source of bioactive compounds with potential applications in the development of nutraceuticals and functional foods aimed at preventing oxidative stress–related disorders.

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COP29: Azerbaijan's Major Contributions To Climate Change

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Abstract

As we know, a number of countries are already sounding the alarm in the fight against climate change and are trying to take various steps to combat it. However, this is not a process that can be prevented by the measures taken by only a few countries. That is why the 29th session of the Conference of the Parties to the UN Framework Convention on Climate Change (COP29) held in Baku was an important step in this direction. The adopted final document is a diplomatic victory for Azerbaijan. The purpose of this event (COP29) is to accelerate action to combat the factors that cause climate change and achieve the goals of the Paris Agreement, adopted at the 21st Conference of the Parties to the UN Framework Convention on Climate Change in December 2015. This document was signed by heads of state and government, foreign ministers, and environment ministers on behalf of the governments of 171 countries. The main goal of the Convention was to prevent all human interventions in the climate system that could be considered dangerous.

Key words: COP29, climate change, contributions, results

1. INTRODUCTION

The purpose of holding this event (COP29) is to accelerate the activities to prevent the factors that cause climate change and achieve the goals of the Paris Agreement adopted at the 21st Conference of the Parties to the UN Framework Convention on Climate Change in December 2015. This document was signed by heads of state and government, foreign affairs ministers, and environment ministers on behalf of the governments of 171 countries. The main goal of the Convention was to prevent all human interventions in the climate system that can be considered dangerous.

As a result of the 12-day International Conference, the COP29 Presidency has managed to resolve long-standing issues within the framework of multilateral international negotiations. This will create high-quality and transparent carbon markets where countries and companies can cooperate to achieve their climate goals, and Article 6 of the Paris Agreement will allow for annual savings of 250 billion US dollars when implementing national climate plans.

The COP29 Conference was an opportunity for participating countries to make new commitments and take concrete steps to address the climate crisis. Let's take a look at some of the results achieved:

1. A decade of negotiations were concluded and an important mechanism was launched to maintain the goal of limiting global warming to 1.5°C.

2. The conference participants agreed on a new target for climate finance for developing countries. Developed countries must ensure that at least 300 billion US dollars are allocated annually to combat climate change by 2035.

3. COP29's achievements include the approval of rules for international carbon trading.

4. Another positive outcome of the Baku conference is that participants approved the rules for international carbon trading. It is important that the agreements reached establish the principle of equal access of countries to the created carbon market infrastructure.

The agreement, reached after two weeks of intense negotiations, aims to boost international efforts to limit global warming in the coming year, when temperatures are expected to reach record highs. According to the agreement, $ 300 billion will be provided annually until 2035. This amount will go to developing countries that need funds to adapt to global warming in the future and will cover the costs.

This agreement will continue to increase clean energy and protect the lives of billions of people. Of course, if all countries fulfill their obligations.

As President Ilham Aliyev noted, "We are proud to receive high praise from all guests for the excellent organization of COP29, which was attended by 80 heads of state and government and more than 76,000 registered participants."

2. MATERIALS AND METHODS

The importance of COP29, Azerbaijan's hosting of this major event and its great contributions are discussed. Based on statistical indicators, an analysis of the areas most vulnerable to climate change in Azerbaijan was conducted and solutions were identified. Many activities have been identified at the national level on Climate Change in Azerbaijan. In this direction, many activities have been carried out at the national level on Climate Change in Azerbaijan. The results of the research work were recorded.

3. RESULTS AND DISCUSSION

COP29 is of great importance in eliminating the effects of global climate change and in taking joint steps by all countries of the world to reduce negative impacts. It is for this purpose that official representatives of various countries who gather at the COP every year make new decisions to eliminate the negative impacts of global climate change, and take active action to protect the environment and ensure security. The countries that joined the COP met for the first time in Berlin, Germany, in 1995.

The holding of COP29 in Azerbaijan in November 2024 is an indicator of the international community's confidence in our country. The holding of this prestigious event in our country has made its difference - with its high-level organization, attracting more participants and exploring ways to solve the most pressing problems that have attracted the attention of the whole world. The climate increase observed in our country

in recent years has been up to 0.4-1.3°C. Based on space data, we can say that one of the biggest negative consequences of temperature increase is the melting of glaciers in high mountain zones (the annual temperature in the high mountain zone of the Greater Caucasus Mountains has increased by 1.1-1.3 degrees Celsius). The biggest problems arising from climate change are more prominent in the following areas.

Table 1. Sectors in Azerbaijan More Vulnerable to Climate Change

Sectors More Vulnerable to Climate Change in Azerbaijan	**Solutions**
Water	Control of water consumption, demand, and losses during transportation, treatment and reuse of wastewater, etc.
Forests	Assisting natural restoration of forests, controlling afforestation and reforestation, restoring forests in forest fund lands
Agriculture	Supervision of various legal-organizational forms of farms and farmer-owned agricultural enterprises, introduction of drought-resistant crop varieties
Energy	Ensuring energy efficiency, transition to alternative energy
Healthcare	Physical adaptation to climate change, use of international solutions
Tourism	Ensuring conditions are suitable, development of new types of tourism

Table 2. National-Level Activities on Climate Change in Azerbaijan

Year	**Adopted State Programs**
2004	State Program on the Use of Alternative and Renewable Energy Sources
2008-2015	State Program on Poverty Reduction and Sustainable Development in the Republic of Azerbaijan
2008-2015	State Program on Reliable Food Supply for the Population of the Republic of Azerbaijan
2016	Strategic roadmap for production and processing of agricultural products in the Republic of Azerbaijan
2016 October	By the Presidential Decree dated October 6, 2016, the National Coordination Council on Sustainable Development (NCCSD) of Azerbaijan was established to achieve the Sustainable Development Goals
2019-2023	State Program on the Socio-Economic Development of Regions
2020	Azerbaijan 2020 – *Outlook for the Future* Development Concept
2024	President Ilham Aliyev declared 2024 the "Year of Solidarity for a Green World" in Azerbaijan
by 2050	The declaration of the liberated territories as a “Green Energy” zone and the plan to transform these areas into a “Net Zero Emission” zone

Satellite monitoring has been conducted in our country to observe lakes, rivers, transboundary water reservoirs, the Caspian Sea, snow cover and glaciers, drought levels, desertification, mountain vegetation, forest fires, methane concentration, temperature anomalies, etc.
Let us examine the satellite imagery of snow cover in mountainous areas for the period of 2017–2024.

Mountains (based on snow cover)	**2020**	**2021**	**2022**	**2023**	**2024**
Greater Caucasus	11 258	24 422	14 987	14 431	18 164
Lesser Caucasus	19 839	30 754	22 514	18 528	23 379
Talysh Mountains	1 647	1 340	1 918	2 549	1 834
Total	32 744	56 516	39 419	35 508	43 377

The table below presents the glacier area in the Greater Caucasus for the period of 2017–2024, based on satellite imagery. The data is provided in percentages.

Mountains (based on Glacier Area)	**2020**	**2021**	**2022**	**2023**	**2024**
Greater Caucasus	93.8	92.9	91.4	91.2	91.1

The ecological monitoring conducted in the Azerbaijani sector of the Caspian Sea demonstrates the effectiveness of satellite imagery. Let us examine the sea water temperature (in °C) based on statistics from the last five years.

Years	**2020**	**2021**	**2022**	**2023**	**2024**
Caspian Sea	26.3	28.2	27.1	28.1	26.8

Water surface temperature (°C) in August for the years 2020–2024
Satellite imagery once again proves that conducting such research is essential for preventing potential global environmental problems in advance. Based on satellite data, we can say that the drought risk level in our country, in terms of magnitude, sensitivity, and degree, has increased by up to 10% in 2024.

4. CONCLUSION

Within the framework of COP29, Azerbaijan has taken significant steps in combating climate change. The country has made progress in renewable energy by designating the liberated territories as “Green Energy” and “Net Zero Emission” zones. Ecological monitoring through satellite imagery and advanced technologies is a key component of Azerbaijan’s sustainable development strategy. Additionally, measures to combat drought and desertification are aimed at protecting the country’s ecosystems. Active participation in international cooperation has strengthened Azerbaijan’s role in climate diplomacy. Overall, Azerbaijan has made a

substantial contribution to global efforts against climate change at COP29 and demonstrated its commitment to achieving sustainable development goals.

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Biologically Active Components and Pharmacological Perspectives of Bee Venom

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Abstract

The article presents data on the biologically active components of bee venom – peptides (melittin, apamin, MCD peptide), enzymes (phospholipase A2, hyaluronidase), biogenic amines and other low-molecular compounds, their pharmacological potential. The molecular mechanisms of action are considered: membranotopic destruction, modulation of ion channels, anti-inflammatory and immunomodulatory activity, antimicrobial and cytotoxic action against tumor cells. Preclinical and clinical data are analyzed, indicating potential for use in inflammatory and degenerative diseases, pain syndromes, infections and oncology. Key problems limiting the clinical use of bee venom are noted: severe allergenicity and risk of anaphylaxis, systemic toxicity with uncontrolled administration, instability and short half-life of individual components, as well as insufficient selectivity for pathological targets. Based on the analysis of preclinical and clinical data, promising areas of development have been formulated: optimization of structural analogs and modifications of melittin and apamin, creation of controlled delivery systems, and combination therapeutic strategies.

Keywords : biologically active components; ion channel modulation; pharmacological potential; biogenic amines; anti-inflammatory and immunomodulatory activity; bee venom

Introduction

Bee venom (apitoxin) is a biologically active mixture produced by the honeybee Apis mellifera, consisting of peptides, enzymes, biogenic amines, and low-molecular-weight compounds [1–3; 5; 6]. For centuries, venom extracts have been used in traditional medicine for inflammation and pain; recent decades have seen growing interest in their molecular targets and pharmacological properties.

The aim of this article is to systematically present information on the main biologically active components of bee venom, analyze their mechanisms of action and pharmacological potential, and discuss existing limitations as well as prospects for future research and clinical development.

Bee venom (apitoxin) is a biologically active mixture produced by the honey bee (Apis mellifera) and includes peptides, enzymes, biogenic amines and a number of low molecular weight compounds [1-3; 5; 6]. For centuries, venom extracts have been used in folk medicine to treat inflammation and pain; in recent

decades, interest in its components has increased due to the discovery of their molecular targets and promising pharmacological properties. Studies have shown that individual components of bee venom - melittin, apamin, MCD-peptide, A $_2$ phospholipase, hyaluronidase, etc. - have obvious biological activities that are potentially useful in the fields of antimicrobial, anti-inflammatory, analgesia, neuromodulation and oncotherapeutics [12-14; 16; 17]. At the same time, the clinical use of bee venom components, due to their toxicity, hemolytic effects, and high allergenicity, requires strict standardization of drugs, development of safe doses, optimization of molecular properties, and development of targeted delivery systems to minimize side effects and immune responses. Modern approaches include the synthesis of modified peptides, the creation of nanotransport systems, and combination therapeutic strategies designed to increase efficacy while minimizing side effects.

The aim of this article is to systematically present information on the main biologically active components of bee venom, analyze their mechanisms of action and pharmacological potential, and also discuss current limitations and prospects for further research and clinical development.

1. Biological composition of bee venom:

1.1Melittin: the main peptide of bee venom (constitutes a significant part of the dry mass of the venom, about ten percent). An amphipathic peptide (~26 amino acids), it has the ability to integrate into lipid membranes and form pores, resulting in disruption of the integrity of cell membranes. Melittin has significant antimicrobial and cytolytic activity, induces apoptosis of tumor cells, modulates inflammatory pathways (also affects NF-κB, COX-2) and may have analgesic effects. However, its hemolytic and cytotoxic effects limit its direct use, which stimulates the development of modified peptides and targeted delivery systems;

1.2 Apamin: a cationic neurotoxic peptide (~18 amino acids) with disulfide bridges. Apamin selectively blocks SK-type small -conductance Ca^{2+} -activated K^{+} channels, leading to increased neuronal excitability, and is used as a tool in neurophysiology. In a therapeutic context, apamin is of interest as a modifier of neuronal activity, but its neurotoxicity and possible side effects limit its clinical application without specific modifications and targeted delivery systems;

1.3 MCD-peptide (*mast cell degranulating peptide*): a peptide that induces the degranulation of mast cells and the release of histamine, serotonin and other mediators. As a result, it enhances inflammation, pain and allergic reactions; at the same time, MCD-peptide has an immunomodulatory effect at low concentrations and is used in the study of allergy mechanisms [12; 13; 17].

Important protein components of bee venom are also phospholipase A $_2$ (PLA $_2$) and hyaluronidase:

1.4 Phospholipase A_2 (PLA_2): one of the largest and most active protein fractions of venom (and also one of the main allergens). This enzyme hydrolyzes membrane phospholipids at the sn-2 position to form arachidonic acid, a precursor of lysophospholipids and anti-inflammatory eicosanoids. PLA_2 enhances membrane damage and inflammation, causes allergic reactions, and, together with other components (e.g., melittin), has a neurotoxic effect;

1.5 Hyaluronidase (Api m 2): "Spread factor" hydrolyzes hyaluronic acid of the intercellular matrix, increasing tissue permeability and facilitating rapid penetration of other venom components; also considered an important allergen [8-11].

In addition, the venom also contains the following components: **adolapine** (a peptide with analgesic and anti-inflammatory properties; reduces the synthesis of prostaglandins and has an analgesic effect, is considered a prototype of new analgesics); **dipeptidyl-peptidase IV** (Api m 5) (serine protease that affects peptide mediators and immune responses; has also been identified as an allergen); **Icarapine** (Api m 10) and other allergenic proteins of unknown or partially characterized function (important for the diagnosis of allergen profiles in patients who have experienced anaphylaxis to bee venom); **secopines/apidacins/antimicrobial peptides** (e.g. *secapin, apidaecin-like fractions*), (small peptides that are important for the protection of the hive and have promising antibacterial activity as templates for antimicrobial agents); **triptychine** and other ion channel blockers (small peptides that affect specific K^+/Na^+ channels; of interest as a promising direction for the development of neurophysiological tools and drugs) [16; 17]. Among the components of bee venom, biogenic amines and low molecular weight compounds should also be noted: histamine, adrenaline, dopamine and other small molecules (they participate in the formation of the immediate reaction to the sting; enhance local pain and inflammatory response, cause vasodilation, increase vascular permeability and create conditions for the formation of edema; small organic acids and low molecular weight compounds affect the pH and can modify the activity of venom proteins; the interaction of these small molecules with protein components can enhance their toxicity and modulate the immune response).

2.Pharmacological effects of bee venom

The application of the main biologically active components of bee venom in pharmacology [3; 4; 6–14] has shown that these components have a fairly high potential, in particular, they:

2.1Anti-inflammatory and analgesic effect

Traditionally, clinical studies have examined the use of bee venom extracts and apitherapy in osteoarthritis, rheumatoid arthritis, and chronic pain; however, the available data are conflicting and rigorous randomized controlled trials (RCTs) are needed.

2.2 Antimicrobial and antibacterial effect

İncluding antifungal and antiviral activity; as well as suppression of biofilms due to peptide-targeted destabilization of the membranes of microorganisms (via melittin and other peptides).

2.3 Immunotherapy

Modulation of both innate and adaptive immune responses: some components (PLA_2, melittin, etc.) are involved in the induction of regulatory T-cells, modulation of dendritic cell and macrophage activity, alteration of the Th1/Th2 ratio, and enhancement of antitumor immune responses; they are considered promising both as independent immunomodulators and in combination with adjuvants and immune checkpoint inhibitors.

2.4 Anti-oncological effect

Cytotoxic and anti-metastatic activity: peptide components disrupt tumor cell membranes, induce apoptosis and mitochondrial dysfunction, and attenuate angiogenesis and invasiveness; of particular interest is targeted delivery and conjugation with nanocarriers/antibodies to reduce systemic toxicity and increase selectivity.

2.5 Wound healing and tissue regeneration

Studies conducted in vitro and in animal models show that some components have the ability to modulate angiogenesis, fibroblast proliferation, and extracellular matrix remodeling; local forms (gels, ointments, implants) are considered promising to accelerate epithelialization and reduce the risk of infection.

2.6 Neuroprotective and neuromodulatory effects

İndividual peptides of bee venom, including melittin and some enzymes, affect ion channels, the secretion of neurotransmitters, and inflammation-mediated sensitivity pathways; this creates the basis for their study in neurodegenerative conditions and central symptoms of chronic pain (model studies and tests for toxicity upon delivery to the CNS are needed).

2.7 Effects on metabolism and the cardiovascular system

İn experimental studies, both positive effects - antiatherogenic and anticoagulant effects, and potential negative effects - vasodilation, arrhythmogenicity during systemic intoxication are observed; when developing systemic drugs, it is important to evaluate hemolytic activity and effects on the coagulation system;

2.8 Pharmacokinetics, stability and delivery methods

Peptides are rapidly degraded by proteases and can be toxic upon systemic administration; main solutions: chemical modification (PEGylation, cytoprotective substitution of amino acids), encapsulation in liposomes/nanoparticles, targeting via antibodies or ligands (phenolic compounds of plant origin), local/topical dosing and prodrug strategies to reduce systemic exposure, etc.

Thus, bee venom is a complex mixture of peptides, enzymes and biogenic amines, the action of which at the molecular level is carried out through several interconnected mechanisms. Melittin, when interacting with the membrane, forms a structure that disrupts the 'packaging' of lipids and creates permeable sites or pores, which leads to the leakage of ions and macromolecules, disruption of the membrane potential and, in the case of significant damage, cytolysis of the cell [15]. This membrane-topical activity also facilitates the entry into the cell of other components of the venom, primarily phospholipase A_2; they hydrolyze membrane phospholipids to form lysophospholipids and arachidonic acid. The hydrolysis products additionally destabilize the membrane and activate intracellular signaling cascades [12; 13]. In addition to direct membrane disruption, bee venom components modulate ion channels, which significantly affect cell excitability. Disruption of ion channel function may be the cause of both pain and neurological effects, as well as changes in intracellular calcium concentrations, which secondarily affect apoptosis pathways in various cell types.

The antimicrobial activity of bee venom is mainly due to the membranotropic properties of its main peptide, melittin: the disruption of the cell membrane integrity caused by it leads to the rapid destruction of bacteria and fungi, as well as to the disruption of the survival and virulence mechanisms carried out by the pathogenicity mechanism. Melittin exhibits a broad spectrum of activity against both Gram-positive and Gram-negative bacteria; its affinity for lipopolysaccharides and membrane lipids also provides activity against some viruses and fungal pathogens [12; 16]. One of the limitations of the therapeutic potential is the relatively low selectivity and pronounced hemolytic activity against human cells, which necessitates the development of modified peptide analogues and targeted delivery systems. In response to these limitations, a number of strategies have been proposed and are currently being actively investigated to optimize melittin as a therapeutic agent (reviews: [12; 13; 16-18]). These include modifications of the primary structure (trimming/extension, replacement of basic residues with D-amino acids, cyclization, introduction of non-

standard amino acids) and chemical conjugations (PEG- or lipid-conjugation, adjustment of the hydrophilic-lipophilic balance); these are aimed at reducing hemolysis, increasing resistance to proteolysis, and tuning selectivity by adjusting the charge distribution with hydrophobicity. In parallel, targeted delivery platforms are being developed: encapsulation in liposomes and polymeric nanoparticles, formation of hybrid nanostructures with controlled release (pH-, enzyme- or temperature-sensitive), conjugation with targeting ligands (antibodies, RGD-type peptide motifs or folate), which ensures targeted localization in tumor or infected tissue.

Preclinical studies in experimental animals provide a large body of evidence on the potential efficacy of bee venom components in inflammatory and degenerative diseases, pain syndromes, infections and tumors [8–11; 13]. Anti-inflammatory effects and reduction of immunopathology have been demonstrated in models of inflammation, as well as in autoimmune lesions, as a result of the application of individual purified components or apitherapy/apipuncture; in particular in models of rheumatoid arthritis and experimental autoimmune encephalitis [16; 18]. Studies in neurodegenerative models have shown properties that can potentially slow the progression of cell death and modulate neuroinflammation, which justifies the increased interest in studying it in Parkinson's disease, Alzheimer's disease and multiple sclerosis. Antimicrobial activity, including activity against bacteria, fungi and some viruses, has been demonstrated mainly in vitro and in small preclinical experimental systems; where melittin's membranotropic mechanisms lead to rapid lysis of microorganisms. However, in vivo tolerance and selectivity remain limiting factors. Oncological studies in preclinical models have shown direct cytotoxic effects on tumor cells, induction of apoptosis, and potential synergy with chemotherapeutic agents when using targeted delivery systems. [14; 15]. Bee venom exhibits both direct cytotoxicity and the ability to modulate intracellular survival pathways in tumor cells. Direct disruption of the plasma membrane and induction of extracellular membrane permeability are associated with activation of the mitochondrial apoptosis pathway through increased levels of reactive oxygen species, loss of mitochondrial potential, and activation of caspases. In parallel, there is a weakening of protective cascades, such as some chains of the PI3K/AKT and MAPK signaling systems, which increases the propensity of tumor cells to apoptosis and slows down proliferation. One important direction is the development of targeted delivery methods for melittin to tumor cells; These include nanoparticles and hybrid peptide conjugates, which allow for increased local efficacy and reduced systemic toxicity.

Clinical data on the use of bee venom and its individual components are fragmentary and are characterized by significant methodological heterogeneity, low statistical power of individual studies, as well as a pronounced placebo effect in a number of interventions [13–17]. Randomized controlled trials of the effect of apitherapy in osteoarthritis, rheumatoid arthritis, and pain syndromes show conflicting results: in some studies, pain reduction and improvement in functional status are noted, while in other studies, no reliable advantage is

demonstrated compared to the control group [8; 9; 11]. The clinical base in the field of infectious diseases and oncology is significantly limited; preclinical data and early-phase studies mainly focused on assessing safety and pharmacodynamic properties during local or targeted application predominate. Serious limitations for clinical application include the risk of IgE-mediated allergic reactions, including anaphylactic reactions, as well as nonspecific side effects associated with the cytolytic (membranotropic) activity of the venom components and their systemic toxicity.

The prospects for clinical translation are based on several key areas: standardization and purification of drugs, development of safe dosage regimens and initial allergological screening evaluation, as well as the creation of targeted delivery systems that reduce systemic exposure and increase the local concentration of the active substance in the pathological focus. Technical strategies include modification of peptide sequences to improve selectivity and resistance to proteolysis, the creation of nanostructures and conjugates with targeting ligands, as well as protocols combined with existing pharmacotherapeutic regimens, which allow for synergy at lower doses. For justified application in clinical practice, high-quality, sufficiently statistically powered randomized studies, standardized drugs and careful monitoring of safety, as well as detailed pharmacokinetic and immunological studies that allow assessing long-term risks and efficacy in various nosologies are required. Only if these conditions are met and existing restrictions on safety and standardization are removed can one hope for the justified clinical use of individual components of bee venom or their modified forms in the therapy of inflammatory, degenerative, infectious and oncological diseases.

Summarizing the above, it should be emphasized that the most obvious and dangerous point is the high allergenicity of individual components of bee venom: in susceptible individuals, even a small dose can induce an immune response accompanied by the formation of specific IgE antibodies, activation of mast cells and basophils, which ultimately leads to a rapid release of inflammatory mediators. Clinically, this can lead to everything from local reactivity to generalized rashes, bronchospasm and anaphylactic shock - such cases require urgent intensive care and pose a serious risk to life [17]. The unpredictability of the immune response in different patients and the risk of anaphylactic shock remain the main obstacles to the widespread use of bee venom-based drugs in medicine. In addition to allergic reactions, there is also the systemic toxicity of the biomolecules themselves. The main components - melittin and phospholipase A_2 - have a direct cytotoxic effect: they damage cell membranes, induce hemolysis and destabilization of the lipid matrix, cause tissue necrosis and increased inflammation. In uncontrolled or excessive use, these effects can manifest as muscle and liver damage, renal dysfunction due to myoglobinuria or direct nephrotoxicity, as well as cardiovascular arrhythmias and hypotension [8]. The toxicity of individual components makes dosage and administration regimens extremely sensitive.

The third aspect is the pharmacokinetic instability of venom molecules. The peptides and enzymes that make up this mixture are prone to rapid degradation by plasma and tissue proteases, chemical oxidative destruction, and rapid elimination (clearance) processes through the kidneys and liver. As a result, many of the active components have short half-lives and low bioavailability during systemic administration, which makes it difficult to achieve a stable and controlled concentration at the target. Such features require either frequent administration or the development of carriers and forms that can provide protection and delivery, which increases the complexity and cost of drug development. The lack of selectivity for pathological targets further exacerbates the problems described above. Bee venom molecules usually affect the main structural elements of cell membranes or widespread signaling pathways, therefore they damage both pathological and healthy cells to the same extent. Lack of "targeting" increases the risk of side effects and limits the ability to increase the dose to enhance the therapeutic effect. This is especially critical for chronic or systemic diseases, where long-term effects on specific tissues are required – but minimal effects on the rest of the body.

Finally, practical and regulatory barriers are also important: the composition of natural venom varies depending on the bee species, collection conditions and purification methods, which makes it difficult to standardize and control the quality of preparations. The presence of impurities, allergenic proteins or bacterial contaminants increases the risk of complications and complicates the registration and implementation processes in clinical practice. All these factors together limit the current medical use of bee venom and require complex scientific and technological approaches to safely and effectively convert its components into clinical preparations.

Discussion and conclusions

Thus, the development of therapeutic products based on bee venom components requires targeted molecular optimization of melittin and apamin; here, the main focus should be on increasing the therapeutic index by reducing systemic toxicity and increasing selectivity. In the case of melittin, the main task is to maintain its antimicrobial and cytolytic activity, while reducing hemolysis and nonspecific damage to healthy cell membranes. This can be achieved through rational design of peptide molecules: targeted modification of the amino acid composition to change the hydrophobic-bipolar profile, the introduction of charged or polar residues in key domains, as well as the application of cyclization or chemical modifications (e.g., PEG-conjugation or modification of lysine residues) to increase resistance to proteolysis and reduce immunogenicity. Apamin is a highly selective blocker of small calcium-dependent (SK) potassium channels, and the main task is to redesign the molecule in such a way that neuromodulatory activity is preserved, while at the same time neurotoxicity and nonspecific effects are reduced. A number of strategies are being considered

for this: construction of short fragments that retain the core pharmacophore, precise mutations, as well as conformational stabilization to improve pharmacokinetic properties.

The use of modified venom components in combined therapeutic regimens is considered a promising direction for increasing the therapeutic index and reducing side effects. The application of modified melittin within the framework of antibacterial and antineoplastic strategies can enhance the direct cytotoxic or membrane-stabilizing effect, in addition to reducing the required dose due to synergy with classical antibiotics, cytostatic drugs or immunomodulators. In the oncological context, it is advisable to combine melittin with other substances that increase the permeability of the tumor microenvironment or with inhibitors of cell-protective signaling pathways; these approaches are aimed at enhancing selective cytotoxicity against target cells, while maintaining or reducing systemic toxicity. The issues of standardization, preclinical validation and safety assessment are of no small importance at the translational stages. The production of synthetically modified peptides and controlled delivery formulations must meet strict requirements in terms of reproducibility, purity and stability, since the variability of the starting natural material remains a significant obstacle.

Future research will focus on developing an integrated strategy that combines molecular design and deep preclinical pharmacology to translate modified peptides into the clinic. Computational design, mass spectrometry, and high-resolution spectroscopy are essential for further elucidation of structure-activity relationships. These approaches will allow for precise identification of pharmacophores, elucidation of mechanisms of interaction with membranes and ion channels, and ultimately the design of peptides with predictable kinetic and toxicological profiles.

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Apiculture and Apitherapy in the Ottoman Empire (1623-1923)

Osmanlı İmparatorluğu'nda Arıcılık ve Apiterapi (1623-1923)

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Özet

Osmanlı İmparatorluğu'nda arıcılık faaliyetleri, oldukça farklı yöntem ve tekniklerle yürütülmüştür. Arı ürünleri ise çok yönlü üretim ve kullanım alanlarına sahiptir. Evliya Çelebi Seyahatnamesi başta olmak üzere dönem kaynakları ve modern araştırmalar, Osmanlı'da arı ürünlerine dayalı uygulamaların yalnızca iktisadi değil, tıbbi ve kültürel boyutlara da sahip olduğunu ortaya koymaktadır. Bu bağlamda Osmanlı apiterapisinin, özellikle bal ve balmumu üzerine şekillendiği anlaşılmaktadır. Söz konusu ürünler; tıpta merhem, şurup, tiryak ve krem yapımında; ziraatte tütün ilaçlamasında; endüstride koku ve cam üretiminde kullanılmıştır. Ayrıca mimaride büyük ve kamusal yapıların aydınlatılmasında; sosyo-kültürel alanda ise takı ve süs eşyalarının imalinde kullanılmıştır. Bu çeşitlilik, arıcılığın Osmanlı toplumunda yalnızca bir üretim faaliyeti değil, çok yönlü bir bilgi ve uygulama alanı olarak konumlandığını göstermektedir.

Anahtar Kelimeler: Osmanlı İmparatorluğu, Arıcılık, Bal, Bal Mumu, Apiterapi.

Abstract

Beekeeping activities in the Ottoman Empire were carried out using a wide variety of methods and techniques. Bee products have also multifaceted production and usage areas. Historical sources, particularly Evliya Çelebi's Seyahatname (Book of Travels), and modern research reveal that practices based on bee products in the Ottoman Empire had not only economic but also medical and cultural dimensions. In this context, it is understood that Ottoman apitherapy was particularly shaped around honey and beeswax. These products were used in medicine for the production of ointments, syrups, antidotes, and creams; in agriculture for tobacco spraying; in industry for perfume and glass production; and in architecture for lighting large and public buildings; and in the socio-cultural sphere for the manufacture of jewelry and ornaments. This diversity demonstrates that beekeeping in Ottoman society was not merely a production activity but a multifaceted field of knowledge and application..

Keywords: Ottoman Empire, Beekeeping, Honey, Beeswax, Apitherapy.

1. GİRİŞ

Bu çalışmanın amacı, Osmanlı İmparatorluğu'nda XVII. yüzyıldan yıkılışına kadar uzanan süreçte arıcılık faaliyetlerini ve uygulanan apiterapi yöntemlerini, Evliya Çelebi Seyahatnamesi, arşiv kaynakları ve daha önce kaleme alınmış akademik çalışmalar ışığında inceleyerek Osmanlı apiterapisini ortaya koymaktır. Bu doğrultuda, Evliya Çelebi Seyehatnamesi'nde, bal ve bal ürünleri, arı kovanlarının çeşitleri ve balın tedavilerde kullanımı hakkında verilen bilgiler irdelenmiştir. Ayrıca Osmanlı Arşiv belgelerine göre yapılmış olan akademik çalışmalardaki bal ve bal ürünlerinin üretim tarzları, nerelerde kullanıldıkları, nasıl halka sunulduğu gibi bilgiler incelenmiştir.

Yapılan araştırmalarda, bal ürünlerinin sağlık alanında deri merhemi, diş ağrısı, tansiyon, çiban tedavisi gibi alanlarda kullanıldığı belirlenmiştir. Ayrıca Osmanlılarda bal mumu ile İstanbul, Bursa, Konya, Mekke, Medine, Suriye ve Mısır gibi yerlerdeki büyük camilerde aydınlatma amaçlı kullanıldığı tespit edilmiştir. Osmanlılarda bal mumunun en önemli ilaç ve aydınlanma unsuru olduğu görülmüştür. Bu bağlamda yapılan çalışmayla Osmanlı zamanındaki apiterapi faaliyetlerinin ortaya konulması sağlanacaktır.

2. OSMANLI İMPARATORLUĞU'NDA ARICILIK VE APİTERAPİ

2.1. Osmanlık İmparatorluğu'nda Arıcılık

Osmanlılar kendinden önceki devletlerin arıcılık ve Apiterapi alanındaki mirasını almış ve bu geleneği geliştirerek sürdürmüştür. Osmanlı arıcılığı modern Avrupai tarzlardaki kovanlar ile doğal yerlerde olan arı kolonilerinin sayesinde yapılan arıcılık modelini de kullanmıştır. Buna örnek olarak, doğal yerler olan ağaç kovukları, ağaç dalları ve kaya oyukları ile kaya altlarına yapılan arı yuvaları verilebilir. Nitekim Evliya Çelebi Seyahatnamesinde Balkan coğrafyasından bahsederken, Ballı Badra bölgesindeki arıcılığın bir selvi ağacında uzun yıllar boyunca yapıldığını ve balının oldukça tatlı ve meşhur olduğunu ifade etmesidir (EvliyaÇelebi, Evliya Çelebi Seyahatnamesi, 2011, s. 281-285). Osmanlı'da yapılan bir diğer arıcılık modeli ise kara kovanlar olarak adlandırılmaktaydı. Kara kovanlar, ladin, ıhlamur, kestane gibi ağaçların içi oyularak yapılan uygulamaydı. Yapılan bu kara kovanlar bölgeden bölgeye farklı uygulanmaktaydı. Örneğin Rize Güroluk Köyü buna iyi bir örnektir (Karataş, 2013, s. 1-23). Yine buna benzer örnek Evliya Çelebi Seyahatnamesi'nde Ahıska bölgesinden bahsederken yapılan arıcılık hakkındaki bilgilerdir. Evliya Çelebi Seyahatnamesinde, "tuhaflık ki Ahıska taifesinin çoğu beylerinin içini sanduk gibi ağaç içine koyup büyük ve yüksek bir ağacın çatal dalına mıhlayıp korlar, başı ucundan sanduka bir delik delerler. (Bozok) inançlarına göre o delikten cennete bakar nice yüz bin bal arısı o delikten girip bal yapar" şeklinde not edilmektedir (EvliyaÇelebi, Evliya Çelebi Seyahatnamesi, 2005, s. 129).

Bir diğer arıcılık metodu sepet kovanlardır. Sepet kovanlarda kovanın görüntüsü koç başını andıran boynuzlu, kaslı, gözlü, ağızlı, burunlu ve kulaklı bir şirin koç kellesini anımsatmaktaydı. Her sepette onar, on beşer, yirmişer okka gelen petek balı bulunmaktaydı. Sepet kovanların görüntüsü koç kellesini anımsattığı için "koç başı balı" diye de anılmaktaydı (EvliyaÇelebi, Evliya Çelebi Seyahatnamesi, 2011, s. 261-375). Osmanlılarda bir diğer arıcılık metodu kayaların oyulması ile yapılan arıcılıktı. Erzurum Eyaletine bağlı olan Şebinkarahisar bölgesinde yapılan arıcılık bu duruma iyi bir önek teşkil etmektedir. (EvliyaÇelebi, Evliya Çeelebi Seyahatnamesi, 2005, s. 228). Bu tarz arıcılığın Kapadokya bölgesinde de yapıldığı görülmektedir. Osmanlının Arap coğrafyasında ise çamur saman karışımı kovanlar, seramik kavanoz ve koni veya silindirik kap şeklinde yapılan kovanlar ile arıcılık da yapılmaktaydı (Taxel, 2006, s. 203-212).

2.1.1. Arı Ürünlerinin Kullanım Alanları

Osmanlılarda arı ürünleri çok farklı alanlarda kullanıldığı görülmektedir. Örnek olarak; Lost Watch (Kayıp Mum) ve Asitle aşındırma tekniği ile takı kalıplarının yapılması (Tok, 2017, s. 8-9-27); bal ve bal mumu gibi materyaller ile koku endüstrisinin gelişimine katkı sağlanması (Berat Tarusdağ & Bakkalbaşı, 2019, s. 768-769); yapılarda kullanılan camların dökümünde bal mumundan yararlanılması; seramik gibi bazı materyallerin kalıbının çıkarılmasında bal mumundan yararlanılması (Tok, 2017, s. 8-9-27) gösterilebilir.

Osmanlılarda aydınlanma aracı olarak da bal mumunun kullanılmasının oldukça önemli bir yere sahip olduğu belirlenmiştir. Saray, kütüphane ve cami gibi yapıların aydınlatılmasında en çok bal mumunun (şem-i asel) kullanıldığı tespit edilmiştir. Hatta bal mumunu kullanımı bununla da sınırlı kalmamıştır. Denizcilik alanında da fener aydınlatılmasında kullanıldığı görülmektedir (Kocaoğlu, 2018, s. 85-89). Başta Mekke ve Medine gibi dini açıdan önemli şehirlerdeki dini mabetlerde aydınlatma için dökülen bal mumuna ayrı bir önem verilmekteydi. Osmanlılar, Mescid-i Nebevi ve Ravza-i Mutahhara'nın aydınlatılması için sürekli olarak bal mumu göndermekteydi. Konya'daki Celaleddin-i Rumi Dergâhı da manevi bir öneme haiz olduğu için bal mumu gönderilen yerler arasındaydı. Bal mumunun üretimi iktisadi bir değere sahipti. Süleymaniye Camii'nin mihrabı önünde yanan mumlar yirmişer kantar mumdan dökülmekteydi. Bir adet bal mumundan dökülen mum 880 okka gelmekteydi. Süleymaniye Camii'nde yanan mum miktarına bakılırsa tonlarca bal mumu yanmaktaydı (Kılınç, 2011, s. 51-54).

Osmanlılarda bal mumunun tarımsal ilaçlamada da kullanıldığı gözlenmiştir. Bu kapsamda VI. Murad döneminde bal mumunun tarımsal ilaçlama alanında kullanılması bal mumunun kantarının 1400 akçeden 2400 akçeye yükselmesine sebep olmuştur (Kılınç, 2011, s. 51-54). Ancak bal mumunun, tütün zirai ilaçlamasında kullanılmasından dolayı bazı büyük yangınlara sebebiyet verdiği görülmektedir. Bundan dolayı bal mumunda arz talep dengesinin bozulduğu gözlenmiştir (Öztürk, 2011, s. 61-62), (Özen, 2012, s. 8).

2.2. Osmanlı İmparatorluğu'nda Apiterapi

Osmanlılarda kullanılan ilaçları incelediğinde, birçok ilacın hazırlanması için Apiterapi ürünü kullanıldığı görülmektedir. Osmanlıların uygulamış olduğu apiterapiyi, bal ve bal mumu kullanımı adı altında sınıflandırmak mümkündür.

2.2.1. Bal ile Yapılan İlaçlar

Osmanlılarda balın yaygın olarak tedavi amacıyla kullanıldığı görülmektedir. Bal ile yapılan ilaçları; şuruplar, merhemler ve macunlar olarak gruplayabiliriz. Osmanlı ordusunda bal, kabuk bağlamış çıban ve yara tedavisinde kullanılmaktaydı. Balın şerbet haline getirilerek balgam ve nikrise karşı faydalı olduğu ifade edilmektedir (Çağatay, 2024, s. 121-129). Bağışıklık sisteminde oluşan zayıflıkların tedavisi amacıyla bal ve turp kullanılmaktaydı (Yorulmaz Kahve, 2024).

Osmanlı topraklarına gelen yabancı seyyahlardan Theverot, Türklerin balı genellikle ilaç olarak kullandığını söylemektedir. 1650'li yıllarda Londra'da yayımlanan bir seyahatnamede Türklerin adetlerine göre hekimler tedavi amacıyla balı kullanmaktaydı. Bal, şurup yapılmak için de kullanılmaktaydı (Üçel Aybert, 2003, s. 370).

Osmanlı ordusunun kullandığı Dakik-i Mercimek (Lens Culunaris) adıyla bilinen ilaç boğaz ve göz şişliği tedavisinde kullanılmıştır. Ravend (Rheum Officinale) olarak bilinen ilaç bal ile kullanılarak romatizma, mide zayıflığına böbrek ve mesane rahatsızlığına, ciğer, sancı, dalak, marazlarına, ishale, balgama, şişliğe ve öksürüğe iyi gelmekteydi. Ak günlük (Bos wellia serrata) ilaç çiçek balıyla bel ağrısı ve soğukluğuna iyi gelmekteydi (Çağatay, 2024, s. 67-126).

Bal kullanılarak hazırlanan merhemler de bulunmaktaydı. Buna üküldür merhemi iyi bir örnek olacaktır. Ayrıca bu ilaç için bal mumu da kullanılmaktaydı (Bakır, 2021, s. 5). Diş ağrısı için "Karı" ağacı olarak bilinen ağacın kabuğu yakılarak külü bal ile karıştırılıp kullanılmaktaydı. Bal ile bambu kamışı içi, geyik boynuzu külü, deve kuşu yumurtaları kabuğu, püre temiz çini çanak döğülür ve sürülüp dişleri parlatmada kullanılmaktadır (Uzel, s. 8-12-13). Bal, sirke ile hazırlandığı zaman ağızda tutulduğun da oynamış dişleri sağlamlaştırmaktadır.

Ağız içinde dilde oluşan şişlik için sirkengübin şerbeti olarak bal kullanılmaktaydı (Uzel, s. 10). Bal aynı zamanda fıtık tedavisinde de kullanılmaktaydı (Bakır, 2021, s. 16). Osmanlı ordusunda sünger ve bal karışımı, çıban tedavisinde kullanılıyordu. Bunun yanı sıra şap, potasyum ve amonyum nitrat da bal ile beraber kullanılarak tedavi ilaçları hazırlanmaktaydı. Böbreklerde de idrar açıcı ve taşları kırıcı özelliğe sahip şap ile bal kullanılmaktaydı. Üzüm yaprağı ve bal pişirilerek uygulanınca çıban uyuzuna iyi gelmekteydi. Ayrıca

sarımsak, süt ve bal içerisine konulan safran ile hazırlanan ilacın, öksürük, bel ağrısı, kulunç, hafıza açma ve iştah kuvvetlendirmede kullanılmaktaydı.

Balda ballı macunlarda hazırlanmaktaydı. Bunu örnek olarak macun-ı sürincan gösterilir. Yine bu macun grubunun içinde yer alan panzehir özelliği olan tiryaklarda bunlardan bir tanesidir (Gümüşatam, 2022, s. 282-284). Bal vasıtasıyla bazı rahatsızlıklar için fitil hazırlanmaktaydı. Bu fitil bel soğukluğu, mide ve bağırsak hastalıkları, safra ve balgam hastalıkları gibi hastalıkların tedavisinde de kullanılmaktaydı (Bakır, 2021, s. 14).

2.2.2. Bal Mumu Kullanımı

Osmanlılarda bal mumu çeşitli alanlarda kullanılmıştır. Özellikle bal mumunu sünnet olan çocukların bulunduğu çadırın aydınlatılması ve sünnet olan çocukların yaralarının tedavi edilmesi amacıyla kullandığı görülmektedir (Üçel Aybert, 2003, s. 384). Buna ilaveten Frengi hastalığı, ayakta oluşan hastalıklar, ergenlik döneminde oluşan bazı hastalıklar ve gece yanığı gibi hastalıkların tedavisi amacıyla bal mumundan yapılan merhemler kullanılmıştır (Bakır, 2021, s. 15).

Deri hastalıklarının tedavisinde de bal mumu yardımıyla hazırlanan ilaçlar kullanılmaktaydı (Gümüşatam, 2022, s. 281-282). Bal mumu ile hazırlanan Şem-i Asel ilacıyla göğüs, boğaz ve ciğer ağrıları ile kuru öksürüğe fayda sağlamaktaydı. XVIII. Yüzyılda Osmanlı ordusunun da kullanmış olduğu önemli ilaçlardan bir tanesi çam sakızı – pinus (Terebenthına cammunis)'un adlı ilacın hazırlanmasında bal mumu da kullanılmaktaydı. Yine bal mumunun çıban tedavisinde de kullanıldığı görülmüştür (Çağatay, 2024, s. 121-129).

3. SONUÇ

Osmanlılar çok geniş bir coğrafyaya sahip olduğundan dolayı arıcılık ve apiterapi farklı yöntemler ile kullanılmıştır. Arıcılık alanında kullanılan oyma arıcılıklar, ağaç kovukları ve ağaç dalları ile yapılan arıcılık, kara kovana, sepet kovan, çamur saman karışımı kovanlar ve modern Avrupai kovanlar vasıtasıyla arıcılık yapılmaktaydı. Bu çeşitlilik altında üretilen arı ürünlerinin aydınlanma, gıda, ekonomi, gibi alanların yanı sıra apiterapide kullanımına şahit olmaktayız.

Osmanlı apiterapisinde, baldan merhem, şurup, tiryak ve krem yapılmaktaydı. Apiterapi ürünleri birçok hastalığı tedavi etmek amacıyla kullanılmaktaydı. Osmanlılar özellikle bal ve bal mumunu diş, fıtık, göz, ağız, mide, deri, çıban vs. hastalıkların tedavisi amacıyla kullanmaktaydı. Yapılan bu farklı hastalıkların ilacının ana maddesi olarak da en çok bal ve bal mumu kullanılmaktaydı.

Osmanlı arıcılığı ile arı ürünleri tıptan aydınlanmaya, tarımdan sanata kadar geniş bir alanda kullanarak çok yönlü bir yapıya sahip olduğunu göstermiştir. Kullanılan bu çok yönlü yapının sayesinde Osmanlılar apiterapi kültürünü kendinden öncekilerden alarak daha da geliştirip uygulamıştır.

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Особенности экологической ниши биоразнообразия полужестокрылых (*Heteroptera*)

Features of the ecological niche of biodiversity of Heteroptera

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Abstract

The paper examines the species composition and ecological features of hemipteran insects (Heteroptera) in the territory of Ile Alatau and Charyn State Nature Parks. Field studies were conducted to determine species, classify them according to their feeding habits, overwintering, number of generations, and life forms. Ile Alatau is dominated by plant-eating species, most of which overwinter as adults, while some are predators that act as natural pest controllers. In the Charyn Park, 65 species were identified, including predators, herbivores, and aquatic hemipterans, which regulate the abundance of aquatic invertebrates. These findings highlight the importance of these insects in maintaining biodiversity and ecological balance in Kazakhstan's mountainous and aquatic ecosystems.

Keywords: biodiversity, insects, entomology, ecology, population dynamics.

Резюме

Работа посвящена сравнительному анализу видового состава и экологических особенностей полужесткокрылых насекомых (Heteroptera) на территории Иле-Алатау и Чарынского государственных природных парков (2019-2024г.г.). Проведены полевые исследования с определением видов, анализом типа питания, способов зимовки, количества поколений и жизненных форм. В Иле-Алатау преобладают растительноядные виды, большинство зимует в стадии имаго, часть видов — хищники, выполняющие регулирующую роль в экосистеме. В Шарынском парке выявлено 65 видов, включая хищников, растительноядных и водных полужесткокрылых, которые участвуют в поддержании численности водных беспозвоночных. Исследование показало, что полужесткокрылые насекомые играют ключевую роль в сохранении биоразнообразия и поддержании экологического равновесия горных и водных экосистем Казахстана.

Основное

Насекомые играют важнейшую роль в функционировании экосистем: они участвуют в опылении растений, разложении органических материалов и поддержании баланса численности различных организмов. Природные условия Иле-Алатау и Шарынского региона Казахстана резко

различаются, что напрямую влияет на состав и богатство видового разнообразия насекомых. Горные и лесные экосистемы Иле-Алатау создают благоприятные условия для существования многочисленных видов, тогда как засушливые каньонные ландшафты Шарына формируют эндемичные комплексы насекомых, приспособленных к суровым и экстремальным условиям среды. Сопоставление этих территорий позволяет определить особенности их биоразнообразия, адаптивные механизмы видов и их экологические функции, что имеет существенное значение для природоохранной деятельности и экологического мониторинга. Проведение сравнительного анализа также дает возможность оценить различия природных характеристик, туристического потенциала и экологической ситуации регионов, что важно для сохранения природного наследия и рационального использования ресурсов.

Сравнительное исследование фауны полужесткокрылых (Heteroptera) в пределах Иле-Алатауского государственного национального природного парка и Шарынского региона

1. Общие географические и климатические различия

Иле-Алатауский ГНПП

- ✓ Северный Тянь-Шань, влажные горные экосистемы.
- ✓ Выраженная высотная поясность: степь → лес → субальпийские луга.
- ✓ Среднегодовая влажность выше, лето более прохладное.
- ✓ Высокое разнообразие местообитаний.

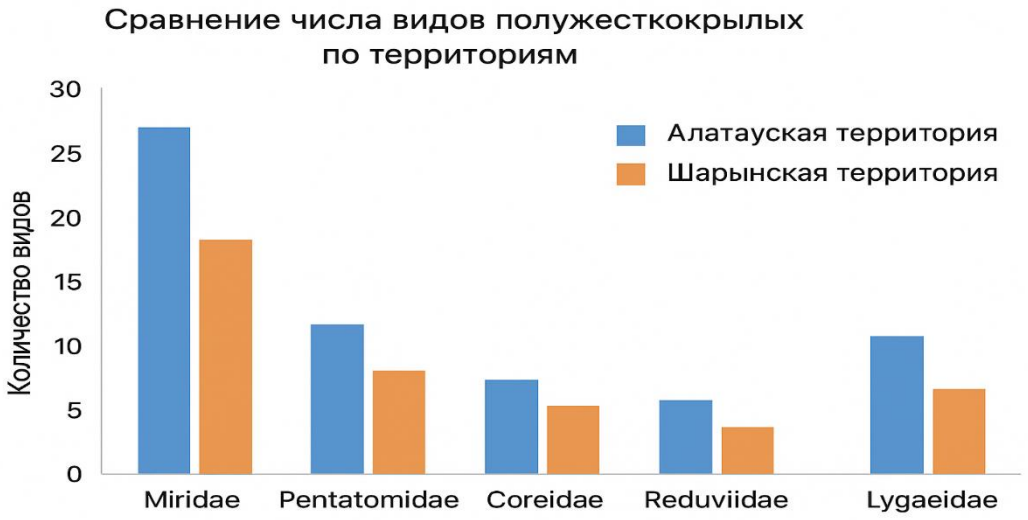
Шарынский каньон / Шарынский национальный парк

- ✓ Полупустынная зона юго-востока Казахстана.
- ✓ Климат резко аридный, с засушливым летом.
- ✓ Почти отсутствует лесной пояс.
- ✓ Флора ксерофитная, доминируют полупустынные ландшафты.

Природные условия Шарынского каньона более неустойчивы, соотвественно оказывает существенное влияние на структуру сообществ *Heteroptera*.

2. Таксономическое разнообразие Heteroptera

Параметр	**Иле-Алатауский ГНПП**	**Шарынский регион**
Количество видов	62	38–45 (по разным авторам)
Число семейств	10	9
Доминирующие семейства	Miridae, Pentatomidae, Coreidae	Lygaeidae, Pentatomidae, Reduviidae
Наличие редких видов	Есть (Tingidae, Miridae)	Меньше, в основном ксерофильные группы



Иле-Алатауский регион демонстрирует существенно более высокие показатели видового богатства, что обусловлено значительным разнообразием биоценотических условий и широкой экологической амплитудой местных местообитаний. Фауна полужесткокрылых Шарынского района, напротив, характеризуется доминированием ксерофильных и пустынных таксонов, сформировавшихся в результате длительной адаптации к экстремальным температурным режимам и выраженному дефициту влаги.

3. Экологические и трофические различия

Иле-Алатауский национальный парк характеризуется преобладанием фитофагов в структуре трофических групп полужесткокрылых: их доля составляет около 70,2%. Хищные формы представлены приблизительно 20%, тогда как сапрофаги формируют около 9,8% сообщества. Доминирование фитофагов связано с высокой продуктивностью лесных и луговых биотопов, обеспечивающих широкий спектр кормовых ресурсов. Существенная часть видов приурочена к древесной и луговой растительности, что отражает богатство растительного покрова и разнообразие экологических ниш.

В Шарынском каньоне трофическая структура имеет иную специфику: доля фитофагов снижена до 55–60%, тогда как численность хищных форм возрастает и достигает приблизительно 30%. Преобладание засушливых и открытых местообитаний способствует увеличению относительной доли представителей Reduviidae и других хищных таксонов. Общее видовое разнообразие здесь ниже, что обусловлено высокой степенью аридности и ограниченностью растительных ресурсов.

Таким образом, в Шарынском каньоне фиксируется выраженный сдвиг трофической структуры в сторону хищных форм, что является типичной реакцией сообществ на экстремальные и стрессовые условия среды.

4. Индикаторные виды

На территории Иле-Алатау отмечено присутствие представителей семейства Tingidae (кружевницы), которые рассматриваются как надёжные индикаторы экологически чистых, увлажнённых и относительно стабильных лесных экосистем. Семейство Miridae, отличающееся высоким уровнем видового богатства, в данном регионе также широко представлено, прежде всего в луговых и опушечных биотопах, где отмечается оптимальное сочетание кормовых растений и микроклиматических условий.

Для Шарынского каньона характерно иное семейственное доминирование. Здесь выявлены многочисленные представители Lygaeidae, типичные для сухих степей и полупустынных ландшафтов, что отражает аридный характер территории. Значительная доля хищников из семейства Reduviidae служит дополнительным индикатором экстремальной сухости и повышенной температурной нагрузки, что подтверждает адаптацию местных комплексов полужесткокрылых к жёстким условиям среды.

таблица 1 Показатели различии расположения

Критерий	**Иле-Алатауский парк**	**Шарынский регион**
Биоразнообразие	Высокое	Среднее
Климат	Умеренный горный	Аридный пустынно-степной
Индексы разнообразия	Высокие	Низкие–средние
Доминирующие формы	Фитофаги	Ксерофилы, хищники
Экологическое состояние	Стабильное	Локально нарушенное

На территории Иле-Алатау степень антропогенного давления оценивается как умеренная, главным образом в пределах рекреационно-туристических зон. Это позволяет сохранять большинство экосистем в близком к естественному состоянии, поддерживая структурную целостность и стабильность популяций полужесткокрылых.

В Шарынском каньоне наблюдается выраженная деградация почвенно-растительного покрова, локальные участки подвержены эрозионным процессам и механическому воздействию (вытаптыванию). Данные факторы приводят к уменьшению видового богатства и изменению трофической и структурной организации сообществ насекомых, что отражает высокую

чувствительность эндемичных и ксерофильных форм к антропогенным стрессам и аридным условиям среды.

Выводы

Сообщества полужесткокрылых (Heteroptera) Иле-Алатауского и Шарынского национальных парков характеризуются высокой видовой диверсификацией и выраженным функциональным разнообразием. В Иле-Алатау доминируют фитофаги, большинство которых зимует в стадии имаго и формирует одно поколение в год; хищные виды выполняют регуляторную функцию, ограничивая численность фитофагов и контролируя популяции вредителей.

В Шарынском парке зарегистрировано 65 видов полужесткокрылых, включающих хищников, фитофагов и водные формы. Водные полужесткокрылые регулируют численность водных беспозвоночных, что отражает адаптацию сообществ к аридным и водным биотопам. Таким образом, Иле-Алатау характеризуется доминированием растительноядных видов с присутствием хищников, а Шарынский регион демонстрирует более сбалансированное распределение трофических групп, что соответствует местным экологическим условиям и стрессовому аридному режиму.

В Шарынском национальном парке водные представители полужесткокрылых (Heteroptera) выполняют критическую экологическую функцию в пищевых цепях, регулируя численность водных беспозвоночных и поддерживая трофическое равновесие водных биотопов. Хищные виды в обоих парках обладают значительным биоэкономическим потенциалом, функционируя как естественные регуляторы численности фитофагов и вредоносных насекомых. Комплексное изучение их биологии, трофической структуры и экологических взаимодействий обеспечивает научную основу для сохранения биоразнообразия и поддержания структурно-функциональной устойчивости экосистем.

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Effects of Propolis on Obesity: A Review of Potential Mechanisms and Therapeutic Use

Propolisin Obezite Üzerine Etkileri: Potansiyel Mekanizmalar ve Terapötik Kullanım Üzerine Bir Derleme

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Özet

Obezite, anormal veya aşırı yağ birikimi ile karakterize edilen ve tip 2 diyabet, hipertansiyon ile kardiyovasküler hastalıklar gibi birçok kronik hastalığın zeminini hazırlayan küresel bir halk sağlığı sorunudur. Obezitenin patofizyolojisi; enerji dengesizliğinin yanı sıra yağ dokusu disfonksiyonu, kronik düşük düzeyli inflamasyon, insülin direnci ve adipokin salınımındaki bozuklukları içermektedir. Mevcut farmakolojik tedavilerin yan etkileri ve sınırlı etkinliği, obezite yönetiminde doğal ve alternatif yaklaşımlara olan ilgiyi artırmıştır.

Propolis, bal arıları tarafından toplanan, flavonoidler, fenolik asitler ve Kafeik Asit Fenetil Esteri (CAPE) gibi biyoaktif bileşikler bakımından zengin reçinemsi bir maddedir. Bu derlemenin amacı, güncel literatür ışığında propolisin obezitenin patofizyolojisi üzerindeki potansiyel terapötik etkilerini ve etki mekanizmalarını incelemektir. Yapılan araştırmalar, propolisin lipid metabolizmasını düzenleyerek hipertrigliseridemiyi ve hepatik steatozu azalttığını; HOMA-IR değerlerini düşürerek insülin duyarlılığını artırdığını; TNF-α gibi proinflamatuvar sitokinlerin salınımını baskıladığını ve adiponektin gibi antiinflamatuvar adipokinlerin düzeylerini yükselttiğini göstermektedir. Ayrıca, propolisin beyaz yağ dokusunun "kahverengileşmesini" (bejleşmesini) teşvik ederek ve UCP-1 ekspresyonunu artırarak enerji harcamasını yükseltebildiğine dair güçlü kanıtlar bulunmaktadır.

Bu çok hedefli etki mekanizmaları, propolisi obezite ve ilişkili metabolik bozuklukların tedavisinde umut vadeden doğal bir ajan olarak öne çıkarmaktadır.

Anahtar Kelimeler: Propolis, obezite, apiterapi

Abstract

Obesity, characterized by abnormal or excessive fat accumulation, is a global public health problem that lays the groundwork for many chronic conditions such as type 2 diabetes, hypertension, and cardiovascular diseases. Its pathophysiology includes energy imbalance as well as adipose tissue dysfunction, chronic low-grade inflammation, insulin resistance, and abnormalities in adipokine secretion. The side effects and limited efficacy of current pharmacological treatments have increased interest in natural and alternative approaches

to obesity management. Propolis is a resinous substance collected by honeybees, rich in bioactive compounds such as flavonoids, phenolic acids, and Caffeic Acid Phenethyl Ester (CAPE). This review aims to examine the potential therapeutic effects and mechanisms of action of propolis on the pathophysiology of obesity in light of current literature. Research shows that propolis regulates lipid metabolism, reducing hypertriglyceridemia and hepatic steatosis; increases insulin sensitivity by lowering HOMA-IR values; suppresses the release of pro-inflammatory cytokines (e.g.,TNF-α); and raises the levels of anti-inflammatory adipokines like adiponectin. Furthermore, there is strong evidence that propolis can increase energy expenditure by promoting the "browning" (beiging) of white adipose tissue and increasing UCP-1 expression. These multi-targeted mechanisms of action position propolis as a promising natural agent in the treatment of obesity and associated metabolic disorders.

Keywords: propolis, obesity, apitherapy

1.INTRODUCTION

Obesity is defined by the World Health Organization (WHO) as abnormal or excessive fat accumulation that presents a risk to health, and its prevalence has nearly tripled since 1975. This condition, now recognized as a global pandemic, is not merely an aesthetic issue but is also a major risk factor for serious morbidity and mortality, including type 2 diabetes (T2DM), hypertension, coronary heart disease, and some types of cancer (Anonymous, 2025; Bray et al., 2017; Chang & Kim, 2019).

Methods used in obesity treatment include medical nutrition therapy, exercise, pharmacological treatment, and bariatric surgery. Drugs approved for long-term use, such as Orlistat, generally work by reducing appetite or inhibiting fat absorption. However, the long-term use of these medications can cause side effects such as abdominal pain, diarrhea, headaches, and decreased levels of fat-soluble vitamins. These side effects, coupled with the limited success of treatments, have led to a significant increase in interest in natural food supplements for obesity management in recent years (Berberoğlu & Hocaoglu, 2021; Calderon et al., 2022; Erden et al., 2023).

Propolis is a mixture obtained from resin and bee products, collected by *Apis mellifera* L. and other species from the leaves, bark, and buds of some plants. The production of this mixture belongs to only a few worker bees inside the hive. After the resin collection process, these worker bees chew the resins and mix them with the salivary enzymes they secrete, beeswax, and some pollen to create propolis. In addition to its various health benefits, propolis has been found to have antibacterial, antioxidative, antifungal, anti-inflammatory, and anticarcinogenic properties (Esertaş et al., 2025; Forma & Bryś, 2021; Kurek-Górecka et al., 2022, 2023). Therefore, the use of propolis in food supplements and bio-cosmetic products is rapidly increasing. Propolis is also being investigated by modern science as a potential agent in the prevention and treatment of many metabolic diseases, including obesity. (Mountford-McAuley et al., 2023)

This review aims to summarize the fundamental pathophysiological mechanisms of obesity and to discuss the potential regulatory effects of propolis on these mechanisms in light of evidence from the literature.

1.1. PATHOPHYSIOLOGY OF OBESITY: ADIPOSE TISSUE AS AN ENDOCRINE ORGAN

Adipose (fat) tissue, which until recently was considered a passive energy store, is now understood to be a highly active endocrine organ (D'Anneo & Lauricella, 2022). Adipose tissue synthesizes and secretes numerous hormones, cytokines, and enzymes (collectively known as adipokines) that regulate energy balance, glucose homeostasis, inflammation, and appetite (Mączka et al., 2024).

In obesity, the increase in adipose tissue mass (hypertrophy and hyperplasia) leads to the disruption of this endocrine function. The main components of this dysfunction include an adipokine imbalance, where anti-inflammatory adipokines dominant in a healthy state (e.g., Adiponectin) decrease while pro-inflammatory adipokines (e.g., Leptin, Resistin) and cytokines (e.g., TNF-α, IL-6) increase (Guerreiro et al., 2022; Sethi & Hotamisligil, 2021). This is accompanied by insulin resistance, one of the most significant consequences of obesity, which is a condition where tissues (especially the liver, muscle, and adipose tissue) fail to respond to normal levels of insulin; increased pro-inflammatory cytokines (especially TNF-α) and free fatty acids directly contribute to this resistance by disrupting insulin signaling pathways (Lee et al., 2022; Park et al., 2015).

Finally, this dysfunction manifests as chronic low-grade inflammation, as obesity is considered a state of systemic chronic inflammation. Macrophage infiltration increases in adipose tissue, and these macrophages secrete cytokines such as TNF α and IL-6, which exacerbate insulin resistance and systemic inflammation (You et al., 2013).

1.2. BIOACTIVE COMPONENTS OF PROPOLIS

The chemical composition and, consequently, the biological activity of propolis vary greatly depending on the geographical region and plant source (flora) from which it is collected. For example, poplar-type propolis, common in Europe and China, is rich in flavonoids, while Brazilian green propolis is famous for its phenolic compound, Artepillin C (Balica et al., 2021; Kasote et al., 2022).

The rich plant diversity of Türkiye, home to more than 11,000 plant species, also makes the chemical structure of the propolis produced here unique. Studies on Turkish propolis have revealed that it is particularly rich in the following bioactive compounds: Phenolic Acids: Caffeic acid, ferulic acid, p-coumaric acid, t-cinnamic acid; Flavonoids: Chrysin, pinocembrin, quercetin, apigenin, luteolin; Phenolic Esters: Caffeic acid phenethyl ester (CAPE) (Kolaylı et al., 2023).

Each of these compounds is known to possess strong antioxidant and anti-inflammatory properties, and the synergy between these compounds forms the basis of propolis's anti-obesity effects (Bezerra et al., 2012; Nishikawa et al., 2016; Seo et al., 2015).

2. POTENTIAL ANTI-OBESITY MECHANISMS OF PROPOLIS

The effects of propolis against obesity can be explained by its targeting of multiple pathophysiological pathways of the disease.

2.1. Effects on Lipid Metabolism and Liver Health

Obesity is frequently accompanied by hyperlipidemia (high triglycerides and cholesterol) and fat accumulation in the liver (non-alcoholic fatty liver disease) (Zhang & Yao, 2025). Studies conducted in animal models fed high-fat (HFD) or cafeteria (CAF) diets have shown that propolis administration can ameliorate these obesity-related disorders (Kitamura, 2019). It has been reported that propolis supplementation leads to a significant decrease in serum triglyceride and total cholesterol levels (Oršolić et al., 2019). Concurrently, it has been observed to exhibit liver-protective effects by reducing the levels of liver function markers, AST and ALT enzymes, and by decreasing microvesicular lipid accumulation (steatosis) in the liver tissue.

2.2. Effects on Insulin Resistance and Glucose Metabolism

Insulin resistance is the key step in the transition from obesity to T2DM (Gupta et al., 2020). The effects of propolis on this process are promising. It has been shown that propolis extracts lower blood glucose and insulin levels in various diabetic animal models (Aoi et al., 2013; Kitamura et al., 2013). Specifically, it has been found to significantly reduce the HOMA-IR index, a marker of insulin resistance, in a dose-dependent manner (Cai et al., 2020). As an additional mechanism, propolis can also target carbohydrate-digesting enzymes, similar to some drugs used in T2DM treatment. Studies have shown that propolis inhibits α-amylase and especially α-glucosidase enzymes. This inhibition can help prevent sudden spikes in post-meal blood sugar (postprandial hyperglycemia) (Laaroussi et al., 2021).

2.3. Anti-inflammatory Effects and Adipokine Regulation

One of the best-known properties of propolis is its strong anti-inflammatory capacity. Considering that obesity is a state of chronic inflammation, this property is of critical importance (Beserra et al., 2021). It has been shown that propolis supplementation in obese animal models significantly reduces the levels of pro-inflammatory cytokines, TNF-α and IL-6, which are increased in adipose tissue and circulation. Propolis not only suppresses inflammation but also regulates the imbalanced adipokine balance. Propolis has been found to increase the expression and circulating levels of adiponectin, the "good" adipokine which is decreased in obese individuals and increases insulin sensitivity. Furthermore, it has been reported that the levels of leptin, the hormone found at high levels in obesity which leads to "leptin resistance," can be regulated (reduced) by propolis (Washio et al., 2015).

2.4. Effects on Energy Expenditure and Thermogenesis

Obesity is fundamentally a condition where energy intake exceeds energy expenditure. One way to increase energy expenditure is through the process of thermogenesis (heat production), which is carried out by brown adipose tissue (BAT) and "beige" adipocytes within white adipose tissue (WAT). The key to this process is the mitochondrial protein, Uncoupling Protein-1 (UCP-1) (Nishikawa et al., 2016). Recent research indicates that propolis and its bioactive components (e.g., Artepillin C in Brazilian propolis) can increase energy expenditure. It has been reported that propolis induces the "browning" of WAT (beige cell formation) and increases UCP-1 protein expression in BAT (Nishikawa et al., 2016). This mechanism offers a new way to combat obesity by allowing the body to dissipate stored excess energy as heat.

3.CONCLUSION AND FUTURE PERSPECTIVES

Propolis is a potent natural product candidate capable of acting on multiple targets involved in the pathophysiology of obesity. Its potential mechanisms, such as improving the lipid profile, breaking insulin resistance, suppressing chronic inflammation, and increasing energy expenditure, make it stand out as a support or alternative to pharmacological agents in the treatment of obesity and metabolic syndrome. However, more studies are needed for this potential to be fully understood and translated into clinical application. Future research should focus particularly on the detailed investigation of the interaction between obesity, propolis, and the gut microbiota; on the urgent need for well-designed, randomized controlled clinical trials to confirm the efficacy and safety of the promising results obtained in animal models for the treatment of human obesity; and on the comparison of the anti-obesity activities of different propolis types (Turkish, Brazilian, Poplar, etc.) along with the determination of effective dose ranges.

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The Cosmetic Potential of Moss Species Widespread in Azerbaijan

Azerbaycan'da Yaygın Bryophyta Türlerinin Kozmetik Potansiyeli

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Özet

Azerbaycan'ın farklı bölgelerinde gerçekleştirilen briyolojik araştırmalar kapsamında, kozmetoloji alanında kullanım potansiyeline sahip bazı yosun türlerinin tür bileşimi analiz edilmiştir. Briyolojik çalışmalar; dağlık alanlar, çayırlar, yol kenarları (taş, kaya ve toprak), ormanlık bölgeler ve yüksek rakımlı zonlarda toprak ve kayalar üzerinden örnekler toplanarak yürütülmüştür.

Son yıllarda kozmetoloji alanında doğal ve çevre dostu bileşenlere yönelik ilgi önemli ölçüde artış göstermiştir. Bu bağlamda, yüksek düzeyde biyoaktif bileşikler içeren briyofitler, günümüzde yeterince çalışılmamış olmalarına rağmen gelecek vadeden bir bitki grubu olarak değerlendirilmektedir. Güncel verilere göre Azerbaycan briyoflorasında 500'den fazla yosun türü kayıt altına alınmıştır.

Yapılan araştırmalar sonucunda, Azerbaycan genelinde yayılış gösteren sekiz familya ve sekiz cinse ait toplam sekiz yosun türünün kozmetoloji alanında kullanım potansiyeline sahip olduğu belirlenmiştir. Bu türler şunlardır: *Sphagnum subsecundum* Nees., *Polytrichum commune* Hedw., *Bryum argenteum* Hedw., *Funaria hygrometrica* Hedw., *Marchantia polymorpha* L., *Plagiomnium cuspidatum* (Hedw.) T.J. Kop., *Dicranum scoparium* Hedw. ve *Tortula muralis* Hedw.

Anahtar Kelimeler: Briyofitler, kozmetoloji, *Funaria*, *Sphagnum*

Abstract

During bryological research conducted across various regions of Azerbaijan, the species composition of certain mosses with potential applications in cosmetology has been analyzed. The bryological studies were carried out by collecting specimens from soils and rocks in mountainous areas, meadows, roadsides (stones, rocks, soil), forested regions, and high-altitude zones.

In recent years, there has been a significant increase in interest toward natural and environmentally friendly components in cosmetology. In this context, bryophytes, which contain high levels of bioactive compounds, are considered a promising group of plants for the future, despite being insufficiently studied so far. Currently, more than 500 moss species have been recorded in the bryoflora of Azerbaijan. As a result of the conducted research, eight moss species belonging to eight genera and eight families, widespread in the territory of Azerbaijan, have been identified as having potential for use in cosmetology. These species are as follows:

Sphagnum subsecundum Nees., *Polytrichum commune* Hedw., *Bryum argenteum* Hedw., *Funaria hygrometrica* Hedw., *Marchantia polymorpha* L., *Plagiomnium cuspidatum* (Hedw.) T.J. Kop., *Dicranum scoparium* Hedw., *Tortula muralis* Hedw.

Keywords: Bryophytes, cosmetology, *Funaria*, *Sphagnum*

1.INTRODUCTION

Bryophytes (mosses) are among the oldest and most morphologically simple plants in the plant kingdom and are widely distributed across various ecosystems. They play a crucial role in preventing soil erosion, maintaining soil moisture balance, and ensuring ecosystem stability. Additionally, due to their richness in bioactive compounds, mosses are increasingly used in fields such as pharmacology, cosmetology, and biotechnology. In recent years, the growing demand for natural, environmentally friendly, and biologically active plant-derived raw materials has made bryophytes a subject of renewed scientific interest.

Studies have shown that certain moss species, due to the presence of phenolic compounds, antioxidants, and antibacterial components, are used not only in traditional medicine but also in modern cosmetology and dermatology. Research has revealed that some moss species — particularly those belonging to the genera *Sphagnum*, *Polytrichum*, and *Bryum* — possess moisturizing, protective, and skin-rejuvenating effects thanks to their content of phenolic compounds, flavonoids, antioxidants, and antibacterial agents. For instance, extracts obtained from *Sphagnum palustre* and related species have been found to inhibit enzymes such as elastase and collagenase, which are responsible for collagen degradation in human skin, thus exhibiting an anti-aging effect (Hymas et al. 2023).

Moreover, some moss species inhibit the activity of the tyrosinase enzyme, which affects skin pigmentation. This makes them suitable for use in cosmetic products with whitening and skin tone-evening effects. A natural compound known as **sphagnic acid** has shown high efficacy in absorbing UV radiation, indicating its potential as a natural ingredient in sunscreen products (Hymas et al. 2023).

Scientific research on bryophytes in Azerbaijan began in the 1960s and continues to the present day. As a result of bryological studies, more than 500 moss species have been recorded in the country's bryoflora. However, their medicinal and cosmetic properties have not yet been studied in a systematic and comprehensive manner (Mammadova, 2022).

2.MATERIALS AND METHOD

The study is based on the herbarium collection stored at the BAK and newly collected specimens during last two years. Samples were collected by route and stationary methods. The collected herbarium materials were determined using hand magnifiers, light microscope (MBS-1; MBI-3) and identification key (Ignatov,

Ignatova, 2003), according to the systems of F.V. Brotherus, L.E. Anderson and M.I. Ignatov. Names of species were checked against the database of Tropicos.

3.RESULTS AND DISCUSSION

As a result of bryological research, eight moss species widely distributed in Azerbaijan and having potential applications in cosmetology have been identified. These species are distributed across various biotopes of the country, including the Greater Caucasus, Lesser Caucasus, and Talysh regions — in mountainous areas, forests, meadows, roadsides, and high-altitude zones. [Fig. 1].

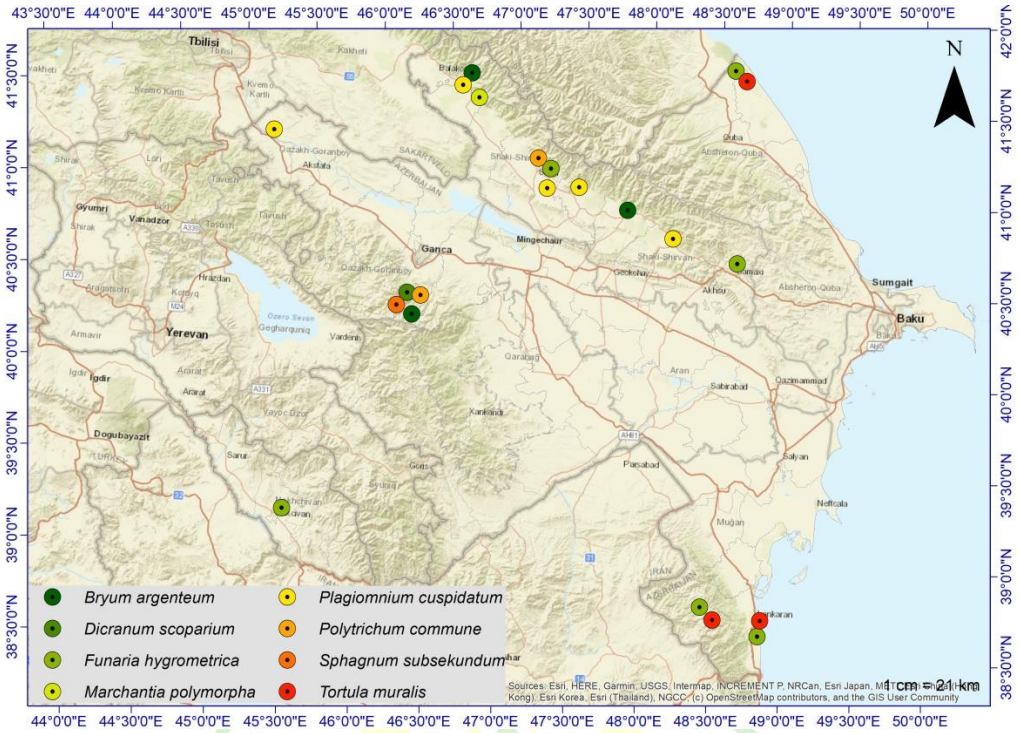

Figure 1. A map showing the distribution of the species. Species are indicated with different color on the map.

The high content of phenolic compounds, flavonoids, and antioxidants in bryophytes gives them anti-aging and moisturizing properties. Below is a systematic list of these species and their potential applications in cosmetology.

***Marchantiales* Bercht. & J. Presl**

***Marchantiaceae* Chevall.**

***Marchantia* Chevall.**

***Marchantia polymorpha* L.** - common liverwort. Recorded only in the Greater Caucasus (Zagatala district). *Marchantia polymorpha* is widely used in cosmetology due to its richness in bioactive compounds, particularly flavonoids, terpenoids, phenolic acids, and essential oils. Studies have shown that extracts of *M. polymorpha* possess strong antioxidant and antibacterial properties, making them beneficial for use in anti-inflammatory serums, anti-acne treatments, and skin-repair creams.

***Sphagnales* Limpr.**

***Sphagnaceae* Dumort.**

***Sphagnum* L.**

***Sphagnum subsekundum* Nees** - slender cowhorn bog-moss. It occurs in the districts of the Lesser Caucasus (Khanlar) and in the Goygol Reserve. Due to its high water-holding capacity, this moss species has the potential to be used as a natural raw material for moisturizing and protecting the skin (Hymas et al. 2023). In addition, its antimicrobial properties help prevent bacterial infections on the skin, which highlights its relevance for use in cosmetic preparations (Akatın et al., 2022; Bordunov, 1984).

***Polytrichales* Cavers**

***Polytrichaceae* Schwagr.**

***Polytrichum* Hedw.**

***Polytrichum commune* Hedw**. – common haircap moss. Mainly grows in mountain forests. It is collected in the Greater Caucasus (Sheki district); Lesser Caucasus (Kalbajar, Goygol National Park) and Talysh (Lankaran district). The extract of this species exhibits anti-aging effects by neutralizing free radicals in the skin and contributes to the protection of collagen. Moreover, *Polytrichum commune* can be used in moisturizing and protective creams due to its ability to stimulate cell regeneration and strengthen the skin's protective barrier.

***Bryales* Limpr.**

***Bryaceae* Rchb.**

***Bryum* Hedw.**

***Bryum argenteum* Hedw.** – silvergreen bryum moss. It is widely distributed in the districts of the Greater Caucasus (Zagatala, Gabala, Ismayilli, Absheron, Guba), Lesser Caucasus (Ganja, Goygol National Park, Lachin, Nakhchivan, Zangilan), Talysh (Lankaran). The extract of this species is distinguished by its antioxidant, anti-inflammatory, and UV-protective effects. In particular, *Bryum argenteum* contains natural phenolic compounds and flavonoids that help protect cell membranes from oxidative stress and support skin elasticity and freshness. Recent studies have shown that extracts of this species are suitable for use in cosmetic formulations aimed at restoring the skin barrier, providing moisturization, and delivering anti-aging effects (Paulsen., et al., 2025).

***Mniaceae* Schwagr.**

***Plagiomnium* T.J. Kop.**

***Plagiomnium cuspidatum* (Hedw.) T.J. Kop.** — It is widely distributed in the districts of the Greater Caucasus (Zagatala, Sheki, Oguz, Ismayilli, Gusar), Lesser Caucasus (Garayazi reserve), Talysh (Lankaran). This moss species is commonly found in moist, shaded areas and is known for its rapid regeneration. Due to

its content of polyphenols, flavonoids, and phytosterols, the extract of *Plagiomnium cuspidatum* possesses antioxidant, anti-inflammatory, and skin-repairing properties. Recent studies suggest that *P. cuspidatum* may be effective in reducing oxidative stress in the skin, preventing signs of aging, and strengthening the skin's barrier function.

Funariales M.Fleisch.

Funariaceae **Schwagr.**

Funaria hygrometrica **Hedw.** It is collected in the Greater Caucasus (Zagatala, Sheki, Shamakhi, Absheron island, Zugulba settlement, Mardakan settlement, Guba, Khachmaz); Lesser Caucasus (Ganja, Goygol, Kalbajar, Nakhchivan); Talish (Lankaran, Lerik). Studies have shown that the extract of this species possesses antioxidant, antibacterial, and cell-regenerating effects.

Dicranales **M.Fleisch.**

Dicranaceae **Schimp.**

Dicranum **Hedw.**

Dicranum scoparium **Hedw.** - It occurs in the districts of the Lesser Caucasus (Gence) and in the Goygol Reserve. The extract of this species exhibits antibacterial, antifungal, and soothing properties, and is particularly used for problematic and oily skin types. It is incorporated into cleansing gels and facial masks to help maintain the balance of the skin's microbiota and reduce the risk of inflammation. Additionally, due to the natural phytochemical compounds present in *Dicranum scoparium*, it has the ability to soothe irritated skin and accelerate regeneration.

Pottiales **M.Fleisch.**

Pottiaceae **Hampe**

Tortula **Hedw**.

Tortula muralis **Hedw**. - It is widely distributed in the districts of the Greater Caucasus (Zagatala, Gabala, Xachmaz, Absheron, Guba), Lesser Caucasus (Ganja, Goygol National Park, Lachin, Nakhchivan, Tovuz), Talysh (Lankaran, Lerik). The bioactive components of this species—particularly phenolic compounds and antioxidants—may enhance the skin's defense against oxidative stress. Tortula muralis extract provides protective effects against oxidative damage in the skin and improves overall skin tone. Due to these properties, it can be used in cosmetology, especially in protective and restorative skincare products (Wolski et al., 2021).Therefore, *Tortula muralis* extract can be considered a natural ingredient for use in sunscreen and brightening cosmetic products.

4.CONCLUSION

Bryological studies conducted in Azerbaijan have revealed that certain moss species possess significant potential for use in cosmetology. Scientific investigations in this field have demonstrated that the secondary metabolites found in bryophytes have the ability to stimulate skin cell regeneration, reduce inflammatory processes, and enhance defense mechanisms against the harmful effects of free radicals. As a result, these moss species should be considered an important and still underexplored natural resource for the creation of environmentally friendly and bioactive cosmetic products (Asakawa et al., 2013).

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Species on Gene Expression of Selected Enzymes in Normal Human Dermal Fibroblasts and Their Antioxidant Properties. Pharmaceuticals, 16(8), 1076.

Comparative Evaluation of Physical, Phenolic, and Antioxidant Properties of Oak, Chestnut, and Pine Honeys from Balıkesir, Türkiye

Balıkesir Yöresine Ait Meşe, Kestane ve Çam Ballarının Fiziksel, Fenolik ve Antioksidan Özelliklerinin Karşılaştırmalı İncelenmesi

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Özet

Bu çalışmada, Türkiye'nin Balıkesir ilinden elde edilen üç monofloral bal türü—meşe (*Quercus* spp.), kestane (*Castanea sativa* Mill.) ve çam (*Pinus* spp.)—fiziksel ve kimyasal özellikleri açısından karşılaştırmalı olarak değerlendirilmiştir. Bal örneklerinin renk, pH, elektriksel iletkenlik ve nem içerikleri belirlenmiştir. Toplam fenolik madde içeriği (TPC) Folin–Ciocalteu yöntemi kullanılarak ölçülürken, antioksidan kapasite Ferrik İndirgeme Antioksidan Gücü (FRAP) yöntemiyle değerlendirilmiştir. Ayrıca fenolik bileşim RP-HPLC-PDA ile karakterize edilmiş; glikoz, fruktoz, sakkaroz ve minör şekerleri içeren şeker profili analiz edilmiştir.

Elde edilen bulgular, bal türleri arasında önemli farklılıklar bulunduğunu ortaya koymuştur. Kestane balı, en yüksek elektriksel iletkenlik ve toplam fenolik madde içeriğine sahip olup buna bağlı olarak en yüksek antioksidan kapasiteyi göstermiştir. Çam balının nispeten daha düşük nem içeriğine sahip olduğu, meşe balının ise daha koyu renkte olduğu ve fenolik bileşikler bakımından zengin olduğu belirlenmiştir.

Genel olarak sonuçlar, Balıkesir yöresine ait meşe, kestane ve çam ballarının kendine özgü fiziksel ve biyokimyasal özelliklere sahip olduğunu göstermekte; bu balların değerli fonksiyonel gıda ürünleri olma potansiyelini vurgulamakta ve bölgenin botanik çeşitliliğini yansıtmaktadır.

Anahtar Kelimeler: Bal, Balıkesir, fenolik bileşikler, antioksidan kapasite

Abstract

In this study, three monofloral honey types — oak (*Quercus* spp.), chestnut (*Castanea sativa* Mill.), and pine (*Pinus* spp.) — obtained from the Balıkesir province of Türkiye were comparatively evaluated in terms of their physical and chemical properties. The color, pH, electrical conductivity, and moisture content of the honey samples were determined. Total phenolic content (TPC) was measured using the Folin–Ciocalteu method, while antioxidant capacity was assessed by the FRAP (Ferric Reducing Antioxidant Power) assay. In addition, the phenolic composition was characterized by RP-HPLC-PDA, and the sugar profile, including glucose, fructose, sucrose, and minor sugars, was analyzed.

The findings revealed significant differences among the honey types. Chestnut honey exhibited the highest electrical conductivity and total phenolic content, resulting in the greatest antioxidant capacity. Pine honey showed a relatively lower moisture content, whereas oak honey was darker in color and rich in phenolic compounds.

Overall, the results indicate that oak, chestnut, and pine honeys from the Balıkesir region possess distinctive physical and biochemical characteristics, highlighting their potential as valuable functional food products and reflecting the botanical diversity of the region.

Keywords: Honey, Balıkesir, phenolic compounds, antioxidant capacity

1. INTRODUCTION

Honey is one of the most natural substances that has served as both a nutritional source and a therapeutic agent for humans since ancient times. The honeybee (*Apis mellifera*) produces this naturally sweet product from floral nectar and honeydew secretions. Although the composition of honey varies depending on the botanical origin and geographical characteristics of the region where it is harvested, nearly 95% of its dry matter consists of sugars. Fructose and glucose are the predominant sugars, accompanied by approximately 25 other carbohydrate constituents such as sucrose, melibiose, melezitose, rhamnose, and trehalose. In addition to these major components, honey contains minor yet biologically significant compounds, including vitamins (e.g., ascorbic acid and carotene), polyphenols (phenolic acids and flavonoids), minerals, peptides, free amino acids, enzymes (such as glucose oxidase and catalase), and volatile aromatic compounds. These minor constituents are primarily responsible for the biological and functional properties of honey (Mureșan et al., 2022; Yıldız et al., 2022).

While the quality of honey is strongly influenced by the geographical and botanical characteristics of the region in which it is produced, factors such as appropriate production techniques, transportation, storage, and packaging conditions also play a decisive role in determining its physicochemical and sensory properties. In general, honeys are classified into two main categories based on their origin: blossom honey and honeydew honey (Soares et al., 2017; Tarapatskyy et al., 2021). Common analytical parameters used to evaluate honey quality include pH, electrical conductivity, color, sugar composition, diastase activity, moisture content, ash, proline, and hydroxymethylfurfural (HMF). However, the true quality and biological value of honey are primarily defined by its bioactive compounds. Metabolites such as polyphenols, vitamins, and volatile oils have been proposed as potential markers for determining the botanical and geographical origin of honey (Yıldız et al., 2022, Kaygusuz et al., 2016).

The therapeutic potential of honey has been widely examined through both animal and human clinical studies, with consistently encouraging results (Erejuwa et al., 2016; Gohar et al., 2020). Furthermore, a significant correlation has been reported between the total phenolic content of honey and its antimicrobial, anticancer,

antidiabetic, and antihypertensive properties (Erejuwa et al., 2016; Ahmed et al., 2017; Özdemir & Yıldızlar, 2025). Therefore, characterizing the physical, chemical, and antioxidant properties of honeys from regions with limited scientific data is of great importance. Such investigations not only contribute to the understanding of honey's compositional diversity but also support the identification of varieties with high apitherapeutic potential for future biomedical and nutritional studies.

This study aimed to comprehensively assess the quality characteristics of honeys collected from the Balıkesir region of Türkiye through conventional physicochemical and biochemical analyses. By comparing oak, chestnut, and pine honeys, the research sought to highlight their compositional similarities and distinctive properties. Furthermore, the study intended to identify honey varieties with remarkable apitherapeutic potential that could be valuable for future scientific and biomedical investigations.

2. MATERIALS AND METHODS

Honey samples were collected from experienced beekeepers by the Balıkesir Beekeepers in the August 2025 harvest season.

Physicochemical Analysis

The physicochemical properties of the honey samples, including pH, electrical conductivity, moisture content and Hunter color parameters, were determined following the standards established by the European Union (Bogdanov et al., 1999). All analyses were performed in triplicate for each sample to ensure analytical reliability. The color characteristics of the honeys were evaluated using a Hunter spectrophotometer (CR-400, Minolta, Osaka, Japan), and the results were expressed in terms of L* (lightness, 0 = black to 100 = white), a* (green to red), and b* (blue to yellow) values. Prior to measurement, the instrument was calibrated with black and white reference plates. The pH and electrical conductivity values were determined directly using a digital pH meter (Hanna HI 2030–02 edge®, Romania).

Preparation of Extracts and Determination of Antioxidant Properties

Methanolic extracts of the honey samples were prepared for the determination of total phenolic content and antioxidant activity. For extraction, 3 g of honey was dissolved in 30 mL of methanol (99%) and the solution was shaken continuously for 24 hours at room temperature. The resulting mixture was first filtered through coarse filter paper, followed by fine filtration to obtain a clear extract. The methanolic extracts were subsequently used for total phenolic content (TPC), antioxidant activity (FRAP), and phenolic composition analyses.

The TPC of the honey samples was determined using the Folin–Ciocalteu colorimetric method (Slinkard & Singleton, 1977). Briefly, 20 µL of the methanolic extract was mixed with 400 µL of 0.2 N Folin–Ciocalteu reagent and diluted with distilled water to a final volume of 680 µL. After 3 minutes, 400 µL of 10% (w/v)

sodium carbonate (Na_2CO_3) solution was added to the mixture. The samples were then incubated for 2 hours at room temperature in the dark. Following incubation, absorbance was measured at 760 nm using a UV–VIS spectrophotometer (Thermo Scientific Evolution™ 201, USA). Total phenolic content was quantified using a gallic acid calibration curve (0.031–1.0 mg GAE/mL), and results were expressed as milligrams of gallic acid equivalents (mg GAE) per gram of honey.

The total antioxidant capacity of the honey samples was evaluated using the ferric reducing antioxidant power (FRAP) assay as described by Benzie and Strain (Benzie & Strain, 1996). The FRAP reagent was freshly prepared by mixing ferric tripyridyltriazine (Fe^{3+}–TPTZ), $FeCl_3$, and acetate buffer (in 40 mM HCl). To prepare the working reagent, 2.5 mL of 20 mM $FeCl_3 \cdot 6H_2O$ solution was added to a total reaction volume of 20 mL.

For the analysis, 1,5 mL of the FRAP reagent was combined with 50 µL of honey extract, and the mixture was incubated at 37 °C for 4 minutes. The absorbance of the resulting solution was then measured at 595 nm using a UV–Vis spectrophotometer. A calibration curve was constructed using a series of $FeSO_4 \cdot 7H_2O$ standard solutions at concentrations ranging from 31.25 to 1000 µmol/mL. The antioxidant capacity of each honey sample was expressed as µmol $FeSO_4 \cdot 7H_2O$ equivalents per gram of sample.

Sugar Profile Analysis

The sugar composition of the honey samples was determined using high-performance liquid chromatography (HPLC) equipped with a refractive index detector (RID) (Hitachi Elite LaChrom, Tokyo, Japan). Standard solutions of eight sugars ribose, fructose, glucose, sucrose, maltose, trehalose, melibiose, and melezitose were prepared at concentrations of 40, 20, 10, 5, 2.5, and 1.25 mg/mL. Each standard and honey sample was filtered through a 0.45 µm membrane filter prior to injection into the HPLC system. Quantification of individual sugars was carried out according to the analytical method described by Can et al. (2015), with slight modifications optimized for honey matrices. The results were expressed as g of sugar per 100 g of honey.

3. RESULTS AND DISCUSSION

Although direct melissopalynological analysis was not performed, the physicochemical and biochemical characteristics of the honey samples provide strong indications regarding their botanical origins. The conductivity, color, pH, and phenolic composition of the samples correspond closely with those reported for honeys of known floral sources. The honey sample from the Balya region exhibited relatively high electrical conductivity and darker color values, consistent with the characteristics of oak (*Quercus sp.*) honey. The Kazdağı honey showed the highest total phenolic content and strong antioxidant activity, aligning well with the profile of chestnut (*Castanea sativa*) honey. The Akoluk honey, on the other hand, displayed lighter color, elevated conductivity, and lower glucose levels, which are typical features of pine (*Pinus sp.*) honey.

Therefore, the analytical findings strongly suggest that the Balıkesir honey samples can be attributed to oak, chestnut, and pine origins, respectively.

Table 1. Physicochemical and Biochemical Analysis Results of the Balıkesir honey samples

		Samples		
		Balya Oak	**Kazdağı Chestnut**	**Akoluk Pine**
Conductivity (µS/cm)		850	865	900
Moisture (%)		16	17	15
pH		5.12	5.34	4.98
Color	**L**	36.28	37.29	38.71
	a	36.78	36.88	36.28
	b	61.75	63.60	65.76
TP (mg GAE/ 100 g sample)		51.10±0.13	67.30±0.26	50.00±0.46
FRAP (µmol $FeSO_4.7H_2O$/ g sample)		2.60±0.24	2.82±0.40	3.43±0.41
Proline (mg/kg)		769.379±16.546	771.218±3.184	570.830±11.031
Sugar (%)	**Fructose**	29.09	29.26	29.36
	Glucose	22.48	22.29	19.08
	Sucrose	2.26	2.31	2.25
	Fru+Glu	51.58	51.55	48.44

Comparative evaluation of oak, chestnut, and pine honeys collected from the Balıkesir region revealed that all samples complied with the standard physicochemical parameters for natural honey (Table 1). Electrical conductivity ranged from 850 to 900 µS/cm, with the highest value detected in pine honey. Moisture content varied between 15% and 17%, indicating that the samples were properly matured and stable. The pH values (4.98–5.34) confirmed their mildly acidic character. In terms of color, pine honey exhibited a lighter tone (L* = 38.71), whereas chestnut honey appeared darker, consistent with its known botanical source.

Total phenolic content (TPC) was highest in Kazdağı chestnut honey (67.30 mg GAE/100 g), suggesting a richer phenolic profile and stronger antioxidant potential. FRAP assay results supported this, showing that pine honey had the greatest antioxidant capacity (3.43 µmol $FeSO_4 \cdot 7H_2O$/g), followed by chestnut and oak honeys. Proline contents ranged between 570 and 771 mg/kg, with the highest level also found in chestnut honey, confirming its natural origin and proteinaceous quality.

Regarding sugar composition, fructose and glucose were the predominant sugars in all honey types, whereas sucrose was found in relatively low amounts (~2%). The total content of fructose and glucose ranged between 48% and 52%, consistent with typical values for natural unadulterated honeys.

The results demonstrated that honeys from the Balıkesir region, particularly Kazdağı chestnut and Akoluk pine honeys, are rich in bioactive molecules such as phenolic compounds, which are closely related to antioxidant, antimicrobial, and anti-inflammatory effects. Therefore, these honeys exhibit a remarkable apitherapeutic potential. Their compositional diversity, depending on floral origin, suggests that Balıkesir

honeys could serve as valuable natural products for further biomedical and nutritional studies focusing on functional foods and natural therapeutics.

The data obtained from the oak, chestnut, and pine honeys collected from the Balıkesir region are consistent with previous findings reported for Kırklareli oak honey (Kara et al., 2019), Muğla pine honey (Kara, 2020), and chestnut honey (Kolaylı et al., 2016), supporting the general trend that dark-colored honeydew honeys tend to exhibit higher biological activity. Although the Kazdağı chestnut honey from Balıkesir showed the highest total phenolic content among the Balıkesir samples (67.30 mg GAE/100 g), this value lies near the lower limit of the range (70–105 mg GAE/100 g) reported for unifloral chestnut honeys from the Black Sea region (Kolaylı et al., 2016).

On the other hand, the total phenolic content of Balıkesir oak honey (51.10 mg GAE/100 g) is in good agreement with the range reported for Kırklareli oak honeys (44.75–75.58 mg GAE/100 g) (Kara et al., 2019). Similarly, the total phenolic content of Balıkesir pine honey (50.00 mg GAE/100 g) largely overlaps with the range determined for Muğla pine honeys (24.60–68.20 mg GAE/100 g) (Kara, 2020).

In terms of antioxidant capacity (FRAP), Balıkesir pine honey exhibited the highest activity among the Balıkesir samples (3.43 µmol $FeSO_4 \cdot 7H_2O$/g), showing comparable potential to the reported FRAP range of Kırklareli oak honeys (3.20–6.40 µmol $FeSO_4 \cdot 7H_2O$/g) (Kara et al., 2019). Regarding physicochemical characteristics, all Balıkesir honeys displayed the typical features of oak, pine, and chestnut honeys, including high electrical conductivity (850–900 µS/cm) and dark color values (Kara et al., 2019; Kara, 2020; Kolaylı et al., 2016). Among these samples, pine honey exhibited the highest conductivity (900 µS/cm) and the lightest color ($L^* = 38.71$).

These comparisons demonstrate that Balıkesir honeys possess biochemical properties and apitherapeutic potential comparable to other prominent Turkish honeys. However, regional and botanical variations contribute to differences in total phenolic content and FRAP values, reflecting the influence of floral and environmental diversity on honey composition and bioactivity.

4. CONCLUSION

In conclusion, the oak, chestnut, and pine honeys collected from the Balıkesir region exhibit physicochemical and bioactive characteristics consistent with the typical profiles of dark-colored honeydew honeys known for their strong antioxidant potential. The total phenolic content and FRAP results indicate that Balıkesir honeys share similar biochemical properties with regionally recognized unifloral honeys such as Kırklareli oak, Muğla pine, and Black Sea chestnut honeys.

Among the samples, Balıkesir chestnut honey demonstrated the highest phenolic concentration, while pine honey exhibited the greatest antioxidant capacity, suggesting that both floral and geographical factors

influence honey bioactivity. The relatively high electrical conductivity and dark coloration observed in all samples further support their honeydew or mixed-floral origin.

Overall, these findings confirm that Balıkesir honeys possess comparable apitherapeutic potential to other well-characterized Turkish honeys. However, minor variations in their total phenolic and antioxidant profiles highlight the importance of regional floral diversity and environmental conditions in shaping the biochemical composition and functional properties of honey.

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Exploring the Bioactive and Antioxidant Potential of Pollen from Distinct Regions of Türkiye

Türkiye'nin Farklı Bölgelerinden Toplanan Polenlerin Biyoaktif ve Antioksidan Potansiyelinin Araştırılması

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Özet

Polen, bal arıları tarafından toplanan doğal bir ürün olup, besinsel ve fonksiyonel açıdan önem taşıyan biyoaktif moleküller bakımından zengin bir kaynak olarak kabul edilmektedir. Polen bileşimi; botanik köken, coğrafi konum ve çevresel faktörlerden güçlü biçimde etkilenmekte olup bu durum, sağlıkla ilişkili özelliklerinde belirgin farklılıklara yol açabilmektedir. Polen bileşenleri arasında yer alan fenolik bileşikler ve flavonoidler, oksidatif stresi azaltmaya ve genel sağlığı desteklemeye katkı sağlayan iyi tanımlanmış antioksidan aktiviteleri nedeniyle özel bir ilgi alanı oluşturmaktadır.

Bu çalışmanın amacı, Türkiye'nin farklı illerinden toplanan üç polen örneğinin biyoaktif bileşimini ve antioksidan potansiyelini değerlendirmektir. Bu doğrultuda örneklerde; Toplam Fenolik Madde İçeriği (TPC) Folin–Ciocalteu yöntemiyle, Toplam Flavonoid İçeriği (TFC) alüminyum klorür kolorimetrik yöntemiyle ve antioksidan aktivite ise Ferrik İndirgeme Antioksidan Gücü (FRAP) ile 2,2-difenil-1-pikrilhidrazil (DPPH) serbest radikal giderme testleri kullanılarak analiz edilmektedir. Ayrıca, örneklerde 26 standart fenolik bileşiğin tanımlanması ve miktarlarının belirlenmesi amacıyla RP-HPLC-PDA analizi gerçekleştirilmiştir.

Bu çalışma, tamamlayıcı spektrofotometrik ve kromatografik tekniklerin birlikte kullanılmasıyla bölgesel polen örneklerinin biyoaktif profiline ilişkin kapsamlı bir karakterizasyon sunmayı hedeflemektedir.

Anahtar Kelimeler: Polen, TPC, TFC, DPPH, FRAP, RP-HPLC-PDA

Abstract

Pollen, a natural product collected by honeybees, is recognized as a valuable source of bioactive molecules with nutritional and functional significance. Its composition is strongly influenced by botanical origin, geographical location, and environmental factors, which can lead to marked variations in its health-related properties. Among its constituents, phenolic compounds and flavonoids are of particular interest due to their well-documented antioxidant activities that contribute to reducing oxidative stress and promoting overall health.

The aim of the present study is to evaluate the bioactive composition and antioxidant potential of three pollen samples collected from different provinces of Türkiye. To achieve this, the samples are being analyzed for their Total Phenolic Content (TPC) using the Folin–Ciocalteu method, Total Flavonoid Content (TFC) by aluminum chloride colorimetric assay, and antioxidant activity through both Ferric Reducing Antioxidant Power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assays. In addition, RP-HPLC-PDA analysis was performed to identify and quantify 26 standard phenolic compounds in the samples.

This study is designed to provide a comprehensive characterization of the bioactive profile of regional pollen samples by integrating complementary spectrophotometric and chromatographic techniques.

Keywords: Pollen, TPC, TFC, DPPH, FRAP, RP-HPLC-PDA

1. INTRODUCTION

Honeybee-collected pollen is a complex natural product that plays a crucial role in both the nutrition of honeybees and human health. It consists of floral pollen grains enriched with nectar and bee salivary secretions (Rupanar et al., 2024), forming a highly diverse matrix rich in carbohydrates, proteins, lipids, vitamins, minerals, and secondary metabolites (Boulfous et al., 2025). Owing to this complex composition, pollen is increasingly recognized as a functional food with remarkable biological activities, including antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory effects (Anjum et al., 2024).

The chemical composition of bee pollen is highly variable and primarily depends on its botanical origin, geographical location, and environmental conditions during collection. Variations in floral sources lead to significant differences in the levels and profiles of bioactive compounds, particularly phenolic acids and flavonoids, which are responsible for many of the product's health-promoting effects (Freire et al., 2012). These phenolic constituents act as powerful antioxidants, capable of scavenging free radicals, chelating metal ions, and modulating redox signaling pathways (Boulfous et al., 2025). As oxidative stress is closely linked to the onset of chronic diseases such as cardiovascular disorders, neurodegenerative conditions, and cancer, the antioxidant capacity of bee pollen is of considerable scientific and nutritional interest (Çobanoğlu, 2024).

Türkiye is recognized as one of the world's leading centers of biodiversity, hosting diverse climatic and botanical regions that strongly influence the composition of bee products. However, despite this ecological richness, studies investigating the phenolic composition and antioxidant capacity of Turkish pollen remain limited.

Therefore, the present study aims to evaluate the bioactive composition and antioxidant potential of three pollen samples collected from different provinces of Türkiye. To achieve this, the samples were analyzed for TPC, TFC, and antioxidant activity using FRAP and DPPH assays, while RP-HPLC–PDA was applied for the identification and quantification of 26 standard phenolic compounds. The results of this research are

expected to contribute to the understanding of the chemical diversity and functional potential of regional bee pollen, supporting its use as a natural source of antioxidants in food and pharmaceutical applications.

2. MATERIALS and METHODS

Bee pollen samples were collected from experienced beekeepers by the Beekeepers in the August 2025 harvest season.

Preparation of Extracts and Determination of Antioxidant Properties

Methanolic extracts of the pollen samples were prepared for the determination of total phenolic content and antioxidant activity. For extraction, 3 g of pollen was dissolved in 30 mL of methanol (80%) and the solution was shaken continuously for 24 hours at room temperature. The resulting mixture was first filtered through coarse filter paper, followed by fine filtration to obtain a clear extract. The methanolic extracts were subsequently used for total phenolic content (TPC), total flavonoid content (TFC), antioxidant activity (FRAP), DPPH radical scavenging activity and phenolic composition analyses by RP-HPLC-PDA.

The TPC of the pollen samples was determined using the Folin–Ciocalteu colorimetric method (Slinkard & Singleton, 1977). Briefly, 20 µL of the methanolic extract was mixed with 400 µL of 0.2 N Folin–Ciocalteu reagent and diluted with distilled water to a final volume of 680 µL. After 3 minutes, 400 µL of 10% (w/v) sodium carbonate (Na_2CO_3) solution was added to the mixture. The samples were then incubated for 2 hours at room temperature in the dark. Following incubation, absorbance was measured at 760 nm using a UV–VIS spectrophotometer (Thermo Scientific Evolution™ 201, USA). The results were expressed as milligrams of gallic acid equivalents (mg GAE) per gram of pollen.

The total flavonoid content of the pollen extract prepared in 80% ethanol was assessed using the method of Ghasemi et al., (2009). In this assay, 250 µL of the sample was mixed with 1.25 mL of methanol, 0.05 mL of 10% Al(NO3)3, and 0.05 mL of 1 M NH4CH3COO. The reaction mixture was incubated for 50 minutes at room temperature, and the absorbance was subsequently determined at 415 nm. Results were expressed in terms of milligrams of quercetin equivalents per gram of sample.

The total antioxidant capacity of the pollen samples was evaluated using the ferric reducing antioxidant power (FRAP) assay as described by Benzie and Strain (Benzie & Strain, 1996). The FRAP reagent was freshly prepared by mixing ferric tripyridyltriazine (Fe^{3+}–TPTZ), $FeCl_3$, and acetate buffer (in 40 mM HCl). To prepare the working reagent, 2.5 mL of 20 mM $FeCl_3 \cdot 6H_2O$ solution was added to a total reaction volume of 20 mL. For the analysis, 1,5 mL of the FRAP reagent was combined with 50 µL of pollen extract, and the mixture was incubated at 37 °C for 4 minutes. The absorbance of the resulting solution was then measured at 595 nm using a UV–Vis spectrophotometer. The antioxidant capacity of each

pollen sample was expressed as µmol $FeSO_4 \cdot 7H_2O$ equivalents per gram of sample.

2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity was determined in accordance with the method described by Molyneux (2004). The assay mixture contained 750 µL of various pollen samples and 750 µL of 40mM methanolic solution of DPPH. After 50 min of incubation at room temperature, in the dark, absorbance measurements were read at 517 nm. The results were compared with the Trolox standard, and the SC_{50} values were expressed in mg/mL.

High-performance liquid chromatography (HPLC) analysis was performed using a Shimadzu LC 20AT system equipped with a photodiode array (PDA) detector. Separation was achieved on a 250 mm × 4.6 mm analytical column with a 5 µm particle size, supplied by GL Sciences (Kara & Birinci, 2024). A gradient elution program was employed, using two mobile phases: 70% acetonitrile in ultrapure water (phase A) and 2% acetic acid in water (phase B). The flow rate was maintained at 1 mL/min, with an injection volume of 20 µL for both samples and standards. The column temperature was kept at 30 °C throughout the analysis. Detection was performed across the 250–360 nm range, with monitoring at 250, 280, 320, and 360 nm (Kara & Birinci, 2024).

3. RESULTS and DISCUSSION

The total phenolic content (TPC) and total flavonoid content (TFC) of the pollen samples are presented in Table 1. The TPC values ranged from **4.64 to 6.74 mg GAE/g**, with the highest concentration observed in sample **P1 (6.735 ± 0.284 mg GAE/g),** followed by **P3 (5.073 ± 0.140 mg GAE/g)** and **P2 (4.643 ± 0.012 mg GAE/g).** In contrast, the TFC results revealed a different trend, where **P2** exhibited the highest flavonoid level (**14.063 ± 0.878 mg QE/g**), while **P3** showed the lowest **(3.055 ± 0.260 mg QE/g**).

Table 1 TPC, TFC, FRAP and DPPH Pollen Samples

Samples	TPC (mgGAE/g sample)	TFC mg QE/g	FRAP (µmol$FeSO_4.7H_2O$/g)	DPPH SC_{50} mg/mL
P1 Trabzon	6.735±0.284	10.001±0,513	107.643±3.533	0.656±0.004
P2 Ardanuç	4.643±0.012	14.063±0.878	81.774±1.614	1.986±0.130
P3 İzmir	5.073±0.140	3.055±0.26	21.750±0.199	6.036±0.008
Trolox				0.004±0.000

The RP-HPLC-PDA analysis identified several phenolic acids and flavonoids, with remarkable differences among the samples (Table 2). ***t*-Cinnamic acid** was the dominant phenolic acid, detected at high levels in **P1 (24.23 µg/g)** and **P2 (19.21 µg/g).** Similarly, ***p*-coumaric acid** was abundant in **P1 (15.35 µg/g),** known for its capacity to neutralize free radicals and contribute to plant defense mechanisms (Boulfous et al., 2025).

Chlorogenic acid, a potent antioxidant reported in pollen from Asteraceae species (Morais et al., 2011), was uniquely detected in **P3 (11.71 µg/g),** suggesting a distinct botanical source for this sample. Among flavonoids, **quercetin (7.40 µg/g)** and **pinocembrin (9.18 µg/g)** were dominant in **P1,** whereas **rutin (8.74 µg/g)** and **myricetin (16.57 µg/g)** were more abundant in **P2.** These compounds are well-documented for their antioxidant and anti-inflammatory activities (Anjum et al., 2024; Balasundram et al., 2006). Particularly, pinocembrin is a characteristic flavanone in bee products, contributing to neuroprotective and antimicrobial effects (Boulfous et al., 2025). The lower diversity and concentration of flavonoids in **P3** correlate with its reduced antioxidant performance, emphasizing that **synergistic interactions among multiple phenolic subclasses** are crucial for overall antioxidant potential (Arnao et al., 2001). In summary, pollen from **Trabzon (P1)** exhibited the richest phenolic profile and strongest antioxidant activity, likely due to its diverse flora and humid climatic conditions favorable for phenolic biosynthesis. **Ardanuç (P2),** with higher flavonoid content, also demonstrated notable antioxidant activity, whereas **İzmir (P3)** displayed a limited phenolic spectrum and lower bioactivity. These regional differences are consistent with previous reports highlighting the **impact of floral diversity and environmental stress factors** on secondary metabolite accumulation in bee pollen (Çobanoğlu, 2024; Boulfous et al., 2025). Overall, the results confirm that Turkish bee pollen is a **rich and regionally diverse source of phenolic compounds,** reinforcing its potential as a **natural antioxidant ingredient** for nutraceutical and functional food applications.

4. CONCLUSION

The findings of this study revealed that bee pollen collected from different regions of Türkiye exhibits remarkable differences in its phenolic composition and antioxidant capacity. These variations are closely related to the botanical diversity and environmental conditions of each region. Among the analyzed samples, the Trabzon pollen demonstrated the highest phenolic content and antioxidant potential, indicating a rich composition of bioactive compounds. The Ardanuç sample showed a higher concentration of flavonoids, suggesting that regional flora significantly influences the type and amount of secondary metabolites present in pollen. In contrast, the İzmir sample contained fewer phenolic compounds and displayed lower antioxidant activity. Overall, the results highlight that bee pollen is a valuable natural source of phenolic compounds with considerable antioxidant potential. The chemical diversity observed among regional samples underscores the importance of Türkiye's floral richness and supports the potential use of bee pollen as a functional food ingredient and a natural antioxidant in health-promoting products.

Table 2 Phenolic Compounds of Pollen Samples

Phenolic Standards (µg phenolic/g)	**P1**	**P2**	**P3**

p-OH Benzoic acid	0.765	-	2.796
Protocathehuic acid	-	-	-
Gallic acid	-	-	-
Chlorogenic acid	-	-	11.712
Syringic acid	-	-	-
Ellagic acid	-	-	-
Vanillic acid	-	-	-
t-cinnamic acid	24.229	19.213	-
Ferulic acid	-	-	-
p-Coumaric acid		15.345	6.256
Caffeic acid	-	-	-
Caffeic acid phenethyl ester (CAPE)	-	-	-
Rhamnetin	-	-	-
Quercetin	-	-	7.399
Rutin	-	8.738	-
Myricetin	-	-	16.572
Galangin	-	-	-
Flavan-3-ols	-	-	-
Epicatechin	-	-	-
Catechin hydrate	-	-	-
Flavones	-	-	-
Chrysin	-	-	-
Daidzein	-	-	-
Apigenin	-	-	-
Luteolin	-	-	-
Pinocembrin	9.180	2.726	-
Hesperetin	-	-	-
Naringenin	-	-	-

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The phenolic composition of licorice honey (Glycyrrhiza glabra L.)

Meyan balının (Glycyrrhiza glabra L.) fenolik bileşimi

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Özet

Meyan kökü (Glycyrrhiza glabra L.), köklerinde biriken biyolojik olarak aktif bileşikleriyle dikkat çeken, Fabaceae familyasına ait çok yıllık bir bitkidir. Bu bileşikler anti-enflamatuar, antiviral, antimikrobiyal ve antioksidan özellikler sergiler. Solunum yolu rahatsızlıkları, mide ülserleri ve karaciğer hastalıklarının tedavisinde geleneksel kullanımının yanı sıra, meyan kökü gıda, kozmetik ve ilaç endüstrilerinde de yaygın olarak kullanılmaktadır.

Bu çalışmada, 2024 yılında Bakü'den elde edilen ve "Meyan Balı" olarak üretilen bir bal örneği analiz edilmiştir. Melissopalynolojik inceleme, balın yaklaşık %20 Glycyrrhiza poleni, %20 Brassicaceae, %20 Fabaceae ve %10 Ranunculus poleni içerdiğini ortaya koymuştur. 26 fenolik standart kullanılarak HPLC-PDA ile gerçekleştirilen fenolik profil analizi, pinocembrin ve galanginin ana bileşikler olduğunu, krizin, p-kumarik asit, p-hidroksibenzoik asit ve kuersetinin ise ikincil bileşenler olarak tanımlandığını göstermiştir.

Anahtar kelimeler: Meyan kökü, Glycyrrhiza glabra, bal

Abstract

Licorice (Glycyrrhiza glabra L.) is a perennial herb belonging to the Fabaceae family, notable for the biologically active compounds accumulated in its roots. These compounds exhibit anti-inflammatory, antiviral, antimicrobial, and antioxidant properties. In addition to its traditional use in the treatment of respiratory disorders, gastric ulcers, and liver diseases, licorice is widely utilized in the food, cosmetic, and pharmaceutical industries.

In this study, a honey sample produced as “Licorice Honey” and obtained from Baku in 2024 was analyzed. Melissopalynological examination revealed that the honey contained approximately 20% Glycyrrhiza pollen, 20% Brassicaceae, 20% Fabaceae, and 10% Ranunculus pollen. Phenolic profiling performed by HPLC-PDA using 26 phenolic standards indicated that pinocembrin and galangin were the major compounds, while chrysin, p-coumaric acid, p-hydroxybenzoic acid, and quercetin were identified as minor constituents.

Keywords: Licorice, *Glycyrrhiza glabra*, honey

Introduction

Licorice (Glycyrrhiza glabra L.) is a perennial herb of the Fabaceae family, widely recognized for the diverse biologically active compounds accumulated in its roots. These phytochemicals—including glycyrrhizin, flavonoids, coumarins, and triterpenoids—exhibit strong anti-inflammatory, antiviral, antimicrobial, and antioxidant properties. For centuries, licorice has played a significant role in traditional medicine, particularly in the treatment of respiratory disorders, gastric ulcers, hepatic dysfunctions, and various inflammatory conditions. Beyond its medicinal applications, licorice extracts are extensively used in the food, cosmetic, and pharmaceutical industries due to their sweetening capacity, aroma profile, and functional bioactivity (El- Saber et. al., 2020).

Melissopalynology, the microscopic analysis of pollen grains in honey, is the most widely accepted and reliable method for determining the botanical and geographical origin of honey. This approach enables precise identification of plant taxa visited by honey bees and plays a crucial role in verifying the authenticity of monofloral honey types. Recent palynological studies conducted in Azerbaijan have highlighted that Fabaceae is one of the most dominant nectar- and pollen-producing families for honey bees in the region, with *Glycyrrhiza glabra* frequently appearing as a major pollen contributor. In a comprehensive survey of 23 honey samples from the Ganja–Gazakh region, *Glycyrrhiza glabra* pollen was identified in 16 samples and Fabaceae pollen was present in all samples, demonstrating the strong melliferous potential of licorice in the regional flora (Çobanoğlu et al., 2025).

Considering the emerging interest in licorice-derived honey and the limited scientific data available, the present study aims to characterize a licorice honey sample obtained from Baku in 2024 through melissopalynological and phenolic analyses. Specifically, the study (i) determines the pollen composition of the honey to confirm its botanical origin and (ii) identifies its phenolic profile using HPLC-PDA based on 26 phenolic standards. By integrating botanical and chemical evidence, this research contributes valuable data to the growing literature on licorice honey and supports future efforts toward its quality assessment, authentication, and potential therapeutic evaluation.

Materials and Methods

In this study, the *Glycyrrhiza glabra* honey was collected from Baku in July 2024.

Melissopalynological Analysis

The floral origin of the honey samples was assessed using melissopalynological techniques. Pollen preparation followed the acetolysis procedure of Louveaux et al. (1978). For each sample, microscope slides were made and at least 500 pollen grains were counted to obtain statistically reliable data. Pollen types were then identified by comparison with reference collections and standard pollen morphology atlases.

Total Phenolic and Flavanoid contents

The total phenolic content of the samples was determined using the method of Singleton et. al. (1999). Samples were first dissolved in water, and 680 µL of distilled water was added to each sample and standard. Then, 400 µL of 0.2 N Folin–Ciocalteu reagent was added, followed by 20 µL of each sample or diluted gallic acid standard. The mixtures were vortexed and incubated at room temperature for 3 minutes. Finally, 400 µL of 10% sodium carbonate (Na_2CO_3) solution was added, and the mixtures were incubated at room temperature for 2 hours. Absorbance was measured at 760 nm, and results were expressed as gallic acid equivalents (mg GAE/g).

The total flavonoid content (TFC) of the samples was determined following the method of Fukumoto and Mazza (2000). In brief, 0.25 µL of each extract was mixed with 50 µL of 10% aluminum nitrate ($Al(NO_3)_3$) and 50 µL of 1 M ammonium acetate (NH_4CH_3COO). The mixture was then brought to a final volume of 3 mL with 99% methanol and incubated at room temperature. After 40 minutes, the absorbance was recorded at 415 nm against a blank. The TFC values were calculated using a quercetin standard curve and expressed as mg quercetin equivalents (QUE) per gram of sample

Ferric Reducing Antioxidant Power (FRAP)

The ferric reducing antioxidant capacity of the samples was determined according to the method described by Benzie and Strain (1999). A standard curve was prepared using $FeSO_4 \cdot 7H_2O$ solutions in the range of 31.25–500 µmol/mL. The results were calculated based on this standard curve and expressed as µmol $FeSO_4 \cdot 7H_2O$ equivalents per gram of sample (µmol $FeSO_4 \cdot 7H_2O$/g sample).

DPPH Radical Scavenging Activity

The DPPH radical scavenging activity was determined according to the method described by Molyneux (2004). Results were expressed as the SC_{50} value, which is the sample concentration required to reduce 50% of DPPH• radicals. A lower SC_{50} value indicates higher radical scavenging (antioxidant) activity of the sample.

Phenolic Composition

Twenty-six phenolic standards (including gallic acid, chlorogenic acid, caffeic acid, quercetin, CAPE, and t-cinnamic acid) were analyzed using reversed-phase HPLC (RP-HPLC, Shimadzu LC 20AT) with a photodiode-array (PDA) detector (Kara and Biirnci 2024). Approximately 500 µL of each sample was injected into a C18 column (250 mm × 4.6 mm, 5 µm; Fortis) using a programmed gradient of 2% acetic acid in water (A) and acetonitrile in water 70:30 (B). The injection volume was 20 µL, with a column temperature of 30 °C and flow rate of 1.0 mL/min. Phenolic compounds were quantified using calibration curves constructed from their maximum absorbance at 250, 280, 320, or 360 nm.

Results and Discussions

In the present study, a honey sample marketed as "Licorice Honey" and produced in Baku in 2024 was subjected to melissopalynological analysis. The pollen spectrum showed approximately 20% Glycyrrhiza, 20% Brassicaceae, 20% other Fabaceae, and 10% Ranunculus pollen, with the remaining ~30% belonging to various minor taxa. According to the Louveaux classification used by Çobanoğlu et al. – predominant pollen >45%, secondary pollen 16–45%, important minor pollen 3–15%, and minor pollen <3% – all major taxa in the Baku sample fall into the secondary pollen category. Thus, there is no single predominant pollen type, and the sample should be regarded palynologically as multifloral honey with a notable Glycyrrhiza contribution, rather than a strictly monofloral licorice honey.

The melissopalynological profile of the Baku honey is broadly consistent with the flora reported for western Azerbaijan by Çobanoğlu et al. They found that Fabaceae pollen was present in all 23 honey samples (11.5–66%), and identified Glycyrrhiza glabra as the most prevalent species within this family, occurring in 16 of the samples. In addition, families such as Asteraceae, Rosaceae, Lamiaceae and Plantaginaceae were frequently represented, reflecting the high melliferous potential of the regional flora. The presence of about 20% Glycyrrhiza pollen and a further 20% Fabaceae pollen in the Baku licorice honey fits well with this pattern and confirms that Fabaceae – and particularly Glycyrrhiza – are important nectar and pollen sources for bees in Azerbaijan, not only in the Ganja–Gazakh region but also around Baku.

Table 1. Total phenolics and antioxidant capacity of the Licorice honey

	Licorice Honey
Total phenolic compound (TPC) (mg GAE/mL)	0,008±0,001
Total Flavanoid compound (TFC (mg QUE/ml)	0,006±0,001
Total antioxidant capacity (FRAP) (µmol $FeSO_4.7H_2O$/ mL)	0,168±0,004
DPPH radical scavenging (SC_{50}: mg /mL)	125,400±12,863

Table 1 presents the phenolic composition of the licorice honey as determined by HPLC–PDA analysis. The quantification was performed using a method calibrated for 26 phenolic standards (Kara and Birinci, 2024). The total phenolic, flavonoid and antioxidant properties of the licorice honey sample were determined and compared with the multifloral honey reported by Kurtdede and Sevin. The licorice honey showed a total phenolic content of 0.008 ± 0.001 mg GAE/mL and a total flavonoid content of 0.006 ± 0.001 mg QUE/mL. In contrast, Kurtdede and Sevin reported 31.1 ± 1.75 mg QE/100 g phenolics and 2.51 ± 0.42 mg GAE/100 g flavonoids for multifloral honey. Although the use of different standards (GAE vs QE, QUE) and units (per mL vs per 100 g) prevents a strict numerical comparison, the data indicate that licorice honey contains lower levels of phenolic and flavonoid compounds than the multifloral honey.

The ferric reducing antioxidant power (FRAP) of licorice honey was 0.168 ± 0.004 µmol $FeSO_4 \cdot 7H_2O$/mL, while the multifloral honey exhibited a much higher value of 101.97 ± 9.12 µmol Trolox/g, suggesting a lower reducing capacity for licorice honey. Similarly, the DPPH radical scavenging activity of licorice honey (SC_{50} 125.40 ± 12.863 mg/mL) was weaker than that of the multifloral honey (SC_{50} 58.61 ± 3.24 mg/mL), as reflected by its higher SC_{50} value. Overall, licorice honey exhibited detectable but relatively modest antioxidant activity compared with multifloral honey, which may be related to its monofloral botanical origin and differences in phenolic composition, as well as methodological differences between studies.

Table 2. Phenolic profile of the Licorice honey

	Phenolic Standards (µg phenolic/mL)	Licorice Honey
--Phenolic acids	*Hydroxybenzoic acids*	
	p-OH Benzoic acid	0,297
	Protocathehuic acid	-
	Gallic acid	-
	Chlorogenic acid	-
	Syringic acid	-
	Ellagic acid	-
	Vanillic acid	-
	Hydroxycinnamic acids	
	t-cinnamic acid	-
	Ferulic acid	-
	p-Coumaric acid	0,214
	Caffeic acid	-
	Caffeic acid phenethyl ester (CAPE)	-
Flavanoids	*Flavonol*	
	Rhamnetin	-
	Quercetin	0,194
	Rutin	-
	Myricetin	-
	Galangin	1,013
	Flavan-3-ols	
	Epicatechin	-
	Catechin hydrate	-
	Flavones	
	Chrysin	0,666
	Daidzein	-
	Apigenin	-
	Luteolin	-
	Flavanones	
	Pinocembrin	1,083
	Hesperetin	-
	Naringenin	-

HPLC–UV analysis of the Baku "Licorice honey" showed a rather narrow phenolic profile. Out of 26 tested standards, only six compounds were quantified: the hydroxybenzoic acid p-OH benzoic acid (0.297 µg/mL), the hydroxycinnamic acid p-coumaric acid (0.214 µg/mL), and the flavonoids quercetin (0.194 µg/mL), galangin (1.013 µg/mL), chrysin (0.666 µg/mL), and pinocembrin (1.053 µg/mL). All other hydroxybenzoic acids (protocatechuic, gallic, chlorogenic, syringic, ellagic, vanillic), hydroxycinnamic acids (t-cinnamic, ferulic, caffeic, CAPE) and flavonoids (rhamnetin, rutin, myricetin, epicatechin, catechin hydrate, daidzein, apigenin, luteolin, hesperetin, naringenin) were below the detection limit. When converted to a honey basis (assuming ~1.4 g/mL), these values correspond only to tens of µg per 100 g honey (≈0.02–0.08 mg/100 g), indicating very low concentrations of individual phenolics.

In contrast, Anzer honey showed both a much richer and much more concentrated phenolic profile. Using a very similar HPLC-UV panel of 19 standards, Malkoç et al. reported that all compounds except syringic acid and daidzein were detected in Anzer honey. Pinocembrin, hesperidin and chrysin were identified as the major flavonoids (mean 4837, 4020 and 3972 µg/100 g, respectively), while protocatechuic acid, p-coumaric acid, catechin, CAPE, p-OH benzoic acid and caffeic acid occurred at moderate levels, and epicatechin, rutin, t-cinnamic acid, gallic acid, myricetin, luteolin, ferulic acid and resveratrol at minor levels. When the Baku licorice honey values are expressed on the same µg/100 g scale, its pinocembrin and chrysin concentrations (≈75 and 48 µg/100 g) are roughly 60–80 times lower than those in Anzer honey, and p-coumaric acid and p-OH benzoic acid are also several-fold lower. Thus, the licorice honey contains only a small subset of the Anzer phenolic spectrum and at much lower levels, which is consistent with its lower total phenolic content and weaker antioxidant activity.

The Ankara multifloral honey studied by Kurtdede and Sevin did not include an HPLC profile, but it showed markedly higher total phenolic and flavonoid contents (31.1 mg QE/100 g and 2.51 mg GAE/100 g, respectively) and stronger FRAP and DPPH responses than the licorice honey. Kurtdede and Sevin attribute this activity to the synergistic action of a complex mixture of phenolic substances and other bioactive compounds. The very limited set of phenolics actually detected in the licorice honey (only one simple benzoic acid, one cinnamic acid and four flavonoids) supports this interpretation and helps explain why its TPC, TFC and antioxidant indices fall well below those reported for Ankara and Anzer honeys.

The global review by Becerril-Sánchez et al. also highlights how unusual the Baku licorice honey profile is. Across many monofloral and multifloral honeys, the most commonly reported phenolic acids are p-coumaric, caffeic, chlorogenic, protocatechuic and vanillic acids, and the most frequent flavonoids include rutin, myricetin, apigenin and quercetin. Our licorice honey contains only two of these "typical" compounds—p-coumaric acid and quercetin—while caffeic, chlorogenic, protocatechuic and vanillic acids, rutin, myricetin and apigenin were not detected. On the other hand, the presence of pinocembrin, chrysin and galangin agrees with reports that these flavonoids, often associated with propolis, occur at high levels in some special honeys

such as Anzer honey and in many samples reviewed by Becerril-Sánchez et al., where pinocembrin is highlighted for its antioxidant and anti-inflammatory properties.

Finally, although Ismail et al. did not determine individual phenolic compounds, they showed that Malaysian Trigona honeys with very high TPC and TFC (e.g. Trigona K1: 60.21 mg GAE/100 g and 65.86 mg QE/100 g) also had very low DPPH IC_{50} and high FRAP values, confirming a strong link between a rich phenolic profile and antioxidant capacity. Compared with these honeys, the Baku licorice honey, with only a few phenolics at trace levels, can be placed at the low end of the phenolic-richness spectrum.

Overall, comparison with Anzer honey, Ankara multifloral honey, Malaysian Apis/Trigona honeys and the broader literature shows that the Baku licorice honey is characterized by low total amounts of individual phenolics, a reduced diversity of phenolic acids, and a flavonoid profile dominated by low levels of pinocembrin, galangin and chrysin. This restricted phenolic signature is in line with its modest antioxidant indices and with its melissopalynological classification as a multifloral honey containing only secondary levels of Glycyrrhiza pollen.

Conclusion

In conclusion, this study provides the first detailed melissopalynological and phenolic characterization of a honey marketed as “Licorice honey” from Baku (2024). The pollen spectrum, dominated by secondary levels of Glycyrrhiza (20%), Brassicaceae (20%) and other Fabaceae (20%) with additional Ranunculus and minor taxa, shows that the sample should be classified as a multifloral honey with a notable Glycyrrhiza contribution rather than a strictly monofloral product. HPLC–PDA analysis using 26 phenolic standards revealed a narrow phenolic profile in which pinocembrin and galangin were the major compounds, while chrysin, p-coumaric acid, p-hydroxybenzoic acid and quercetin were present at low levels. These findings indicate low overall phenolic richness and are in agreement with the modest TPC, TFC, FRAP and DPPH values obtained for this sample.

When compared with Anzer honey, Ankara multifloral honey and high-phenolic Malaysian Trigona honeys, the Baku licorice honey clearly occupies the lower end of the spectrum in terms of both the diversity and concentration of phenolic constituents and the associated antioxidant capacity. Nevertheless, the presence of characteristic flavonoids such as pinocembrin, galangin and chrysin suggests a potential contribution from propolis and highlights that this honey still contains bioactive components of interest. Overall, the results underline the strong influence of botanical origin on the chemical and functional properties of honey and provide baseline data for the future authentication, quality control and possible therapeutic evaluation of licorice-derived honeys from Azerbaijan. Further studies including a larger number of samples from different regions and seasons, as well as complementary biological assays, are needed to fully clarify the functional potential of this emerging honey type.

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Carbon Dot-Based Strategies for Vitamin Detection

Vitamin Tayininde Karbon Nokta Tabanlı Stratejiler

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Özet

Vitaminler, normal fizyolojik işlevlerin ve gelişimsel süreçlerin sürdürülebilmesi için düzenli olarak yeterli miktarlarda alınması gereken, vazgeçilmez besinsel mikro besin öğeleridir; çünkü çoğu vitamin insan vücudu tarafından sentezlenememektedir. Yetersiz alım, sağlıksız beslenme alışkanlıkları, emilim bozuklukları ve bazı hastalıklar sonucunda ortaya çıkan vitamin eksiklikleri, dünya genelinde iki milyardan fazla insanı etkileyen önemli bir küresel sağlık sorunu olarak kabul edilmektedir. Vitaminler; pişirme, gıda işleme ve uzun süreli depolama sırasında kolaylıkla kayba uğrayabildiğinden, gıda işleme sürecinde vitaminlerin korunmasına yönelik çeşitli stratejiler uygulanmaktadır. Bunun yanı sıra, vitaminler fonksiyonel gıdaların geliştirilmesi amacıyla sıklıkla gıda formülasyonlarına katkı maddesi olarak dâhil edilmektedir. Amerika Birleşik Devletleri Gıda ve İlaç Dairesi (FDA) ve Avrupa Parlamentosu, günlük alım miktarlarının değerlendirilmesi amacıyla vitaminlerin gıda etiketlerinde belirtilmesini zorunlu kılmıştır.

Bu düzenlemeler ve vitaminlerin hayati rolleri göz önünde bulundurulduğunda, gıdalardaki vitamin düzeylerinin doğru bir şekilde izlenebilmesi için hassas, doğru, hızlı ve güvenilir analiz yöntemlerinin geliştirilmesi büyük önem taşımaktadır. Bu bağlamda, karbon nokta (carbon dot) tabanlı floresan sensörler; yüksek hassasiyet, seçicilik ve hızlı tespit yetenekleri sunmaları sayesinde umut vadeden bir alternatif olarak öne çıkmaktadır ve hem gıda kalitesinin değerlendirilmesi hem de beslenme çalışmalarında kullanıma uygundur. Ayarlanabilir fotolüminesans özellikleri, mükemmel suda dağılabilirlikleri, düşük toksisiteleri, yüzey modifikasyonuna elverişli yapıları ve düşük maliyetli sentez yöntemleri sayesinde, belirli vitamin hedeflerine yönelik olarak özelleştirilebilen çok yönlü algılama platformlarının geliştirilmesine olanak tanımaktadır.

Günümüze kadar, suda çözünebilen B ve C vitaminlerinden yağda çözünebilen D vitaminine kadar geniş bir yelpazede vitaminlerin hızlı taranmasına yönelik çok sayıda karbon nokta tabanlı floresan sensör geliştirilmiştir. Bu çalışma, karbon noktalarının farklı vitaminlerin tespitindeki uygulanabilirliğini ele alırken, aynı zamanda yapısal özellikleri ve sentez stratejilerine ilişkin genel bir değerlendirme sunmayı amaçlamaktadır.

Anahtar Kelimeler: Karbon Noktaları, Vitamin, Biyosensör, Gıda

Abstract

Vitamins, indispensable dietary micronutrients, must be consumed regularly in adequate amounts to sustain normal physiological functions and developmental processes, as most of them cannot be synthesized by the human body. Vitamin deficiencies resulting from inadequate intake, poor dietary habits, malabsorption, and certain diseases, are considered a major global health challenge, affecting over two billion people worldwide. As vitamins are easily lost during cooking, food processing, and long-term storage, various strategies are employed to protect vitamins during food processing. Besides, vitamins are frequently incorporated into food formulations as additives for the development of functional foods. The U.S. Food and Drug Administration (FDA) and the European Parliament have mandated the inclusion of vitamins on food labels to evaluate their daily intake. Given these regulations and the crucial roles of vitamins, the development of sensitive, accurate, rapid, and reliable methods for vitamin analysis is essential to accurately monitor their levels in foods. In this context, carbon dot-based fluorescent sensors have emerged as a promising alternative, offering high sensitivity, selectivity, and rapid detection capabilities, making them suitable for both food quality assessment and nutritional studies. Their unique properties, including tunable photoluminescence, excellent water dispersibility, low toxicity, ease of surface modification, and low-cost synthesis procedures, enable versatile sensing platforms tailored to specific vitamin targets. To date, numerous carbon dot-based fluorescent sensors have been developed for the rapid screening of vitamins, ranging from water-soluble B and C vitamins to fat-soluble vitamin D. This study will explore the applicability of carbon dots in the detection of different vitamins, while also providing an overview of their structural characteristics and synthesis strategies.

Keywords: Carbon dots, Vitamin, Biosensor, Food.

1.INTRODUCTION

Vitamins, essential nutrients, play an important role in human growth, development, and overall health. Since the human body cannot produce most vitamins endogenously, adequate intake through diet or supplementation is necessary. When consumption is insufficient—due to poor dietary habits, inadequate nutrient intake, malabsorption, or various medical conditions—vitamin deficiencies may occur. Such deficiencies can lead to a wide range of adverse health outcomes, including impaired physical and cognitive development in children, increased susceptibility to infections, intellectual disabilities, and, in severe cases, conditions such as blindness or death (Kayani et al., 2025; X. Li et al., 2025).

Vitamins are inherently sensitive compounds and are prone to degradation when exposed to environmental factors such as light, heat, and oxygen. To mitigate nutrient loss during food processing, cooking or prolonged storage, many food products are enriched or fortified with vitamins. Common fortified foods include grains, milk, bread, and various packaged products. In addition, vitamin supplements offer an effective means of

preventing or reducing the risk of deficiency, particularly in populations with increased nutritional needs or limited dietary diversity (X. Li et al., 2025).

The Food and Drug Administration mandates nutritional labeling on all foods and beverages, providing a standardized framework for evaluating daily vitamin intake. Similarly, the European Parliament requires the declaration of both naturally occurring and added vitamins and minerals on food labels (Campos & Pena, 2025; X. Li et al., 2025). In this context, the development of sensitive, accurate, rapid, and reliable analytical methods for vitamin determination has become increasingly important.

Current vitamin detection techniques encompass spectroscopy-, liquid chromatography–mass spectrometry (LC–MS)-, electrochemistry-, sensor-, and immunoassay-based methods. Traditional approaches such as HPLC and LC–MS, while highly accurate, are often costly, time-consuming, and labour-intensive. Immunoassays also offer strong potential for high-throughput vitamin analysis, yet they still require further refinement to enhance specificity and reproducibility (Guo et al., 2025; X. Li et al., 2025).

Recent advances in nanomaterial-based systems and biosensor technologies have introduced promising alternatives that offer improved speed, cost-effectiveness, and sensitivity (Khan & Patil, 2020). Among these nanomaterials, carbon dots (CDs) have garnered significant attention owing to their unique physicochemical and optical properties. These features make CDs highly suitable for the development of sensitive and effective fluorescence-based sensing platforms for vitamin detection (J. Li et al., 2025). In this study, the potential utilization of CDs in fluorescence-based sensing of vitamins will be examined, alongside their properties and synthesis methods.

2. A BRIEF OVERVIEW OF CDs

CDs, primarily composed of carbon, hydrogen and oxygen, are defined as zero-dimensional fluorescent carbon nanoparticles, typically smaller than 10 nm in diameter (Manzoor et al., 2023; Mei et al., 2024). They were first discovered accidentally in 2004 during the purification of single-walled carbon nanotubes via gel electrophoresis, when researchers observed a bright, rapidly migrating fluorescent band in the gel. This unexpected material was initially described as “fluorescent carbon” (Xu et al., 2004). Two years later, researchers successfully synthesized stable fluorescent carbon nanoparticles, which were formally termed carbon dots (Sun et al., 2006). Since their accidental discovery, CDs have emerged as a rapidly advancing nanomaterial owing to their exceptional physicochemical properties and broad range of potential applications. Similar traditional quantum dots, carbon dots exhibit remarkable electrical and optical properties with their behaviour strongly influenced by particle size and concentration. Their fluorescence emission spans a broad range—from blue to red—and can even extend into the near-infrared region. Unlike conventional quantum dots, they are free of heavy metals and exhibit favorable biocompatibility, low toxicity, and environmentally benign characteristics. CDs bearing carboxyl, hydroxyl, or other hydrophilic surface groups demonstrate

excellent water solubility, and these functionalities also enable straightforward surface modification with a variety of organic and inorganic molecules. They can be synthesized through simple, green, and cost-effective methods, and they possess strong photostability, chemical stability, and overall chemical inertness. For these reasons, CDs are increasingly regarded as a promising alternative to traditional quantum dots (Dinç & Günhan, 2020).

So far, CDs have been applied in a wide range of areas from medical applications to energy storage and conversion and their application fields continue to expand such as their application in the development of novel food packaging (Deepika et al., 2023). CDs show enormous potential to improve food analysis by enabling safer, more efficient, and environmentally friendly techniques for ensuring food quality and safety. To date, carbon dots (CDs) have been successfully applied in the detection of food contaminants, additives, and fortification agents, as well as in the identification of foodborne pathogens, adulteration, and the monitoring of overall food quality (Das et al., 2025).

3. SYNTHESIS METHODS OF CDs

CDs with diverse properties have been synthesized from various carbon sources, including natural biomass, chemicals, coal, and carbon nanoparticles, using different methods. Their characteristics—such as size, optical/electrical properties, toxicity, and biological interactions—depend on both the precursor and the synthesis approach, with chemically derived CDs generally exhibiting higher cytotoxicity than those produced via green methods. (Dinç et al., 2022) . In order to preserve environmental sustainability and health protection, green CD synthesis techniques become increasingly important (Ezati et al., 2022).

The synthesis of CDs is generally divided into two main approaches: top-down and bottom-up. Top-down methods, such as arc discharge, laser ablation, and electrochemical oxidation, are composed of the chemical or physical cleavage of larger carbon structures, including graphite and carbon nanotubes. In contrast, bottom-up strategies generate CDs by assembling smaller carbon precursors through techniques such as hydrothermal treatment, microwave-assisted synthesis, combustion, and pyrolysis. Owing to their suitability for large-scale production and alignment with green chemistry principles, bottom-up methods are more widely adopted than top-down approaches (Jiang et al., 2021; Lodha et al., 2024)).

Interestingly, CDs can also form spontaneously during the thermal processing of food and food waste, like bottom-up synthesis. In our laboratory, we successfully extracted endogenous CDs from sugar beet molasses using a green extraction method (Dinç, 2016). These sugar beet-derived CDs exhibit strong blue fluorescence, biocompatibility, and low toxicity, making them promising candidates for applications in biosensing, agriculture, and medicine (Akbıyık et al., 2023; Kara et al., 2024; Yavuz et al., 2019).

4. CARBON DOT-BASED VITAMIN SENSORS

To date, numerous carbon dot-based vitamin sensors have been developed, utilizing fluorescence quenching mechanisms, including fluorescence resonance energy transfer (FRET), photo-induced electron transfer (PET), the inner filter effect (IFE), as well as static and dynamic quenching (X. Li et al., 2025). Some of them are presented below.

Sotolongo-Garcia et al. (2021) fabricated a riboflavin sensor based on the FRET mechanism, in which carbon dots (CDs) functioned as the fluorescent donor and riboflavin as the acceptor. FRET is a non-radiative process in which energy is transferred from a donor fluorophore to an acceptor molecule. For efficient energy transfer, the donor's emission spectrum must overlap with the acceptor's absorption spectrum, and the two molecules must be separated by 1–10 nm. The developed sensor exhibited high sensitivity, achieving a detection limit of 0.025 µM (Sotolongo-Garcia et al., 2021).

In another study by Fan et al. (2022), nitrogen and sulfur co-doped carbon dots (N,S-CDs) exhibiting orange fluorescence were produced from o-phenylenediamine and thiourea via a hydrothermal method. Due to significant overlap between the emission spectrum of the N,S-CDs and the absorption spectrum of vitamin B12, an inner filter effect (IFE) occurs between the CDs and B12. Leveraging this mechanism, a sensitive B12 detection method was developed, achieving a detection limit of 77.5 nM (Fan et al., 2022).

Preethi et al. (2022) developed a vitamin C sensor using nitrogen-doped CDs derived from potato starch. The fluorescence emission of the N-CQDs is effectively quenched by vitamin C, and this quenching mechanism was employed to develop a sensitive vitamin C biosensing platform, achieving a detection limit of 0.093 µM (Preethi et al., 2022).

Liu et al. (2025) developed a dual-mode vitamin C sensor based on a ratiometric fluorescence system using dual-emission carbon dots, coupled with smartphone-assisted analysis. Dual-emission carbon dots were synthesized via the hydrothermal reaction of riboflavin and o-phenylenediamine. Upon addition of ascorbic acid, the fluorescence emission at 560 nm was significantly quenched, while the emission at 496 nm remained unchanged, resulting in a visible color change from yellow to blue. This ratiometric response enables highly sensitive and reliable detection of vitamin C. By integrating the sensor with a smartphone readout, the platform allows rapid, on-site analysis without the need for sophisticated instrumentation. The dual-mode design facilitates both visual and quantitative detection, enhancing the practicality and user-friendliness of the system (Liu et al., 2025).

Almalki et al. (2024) used carbon dots functionalized with 25(OH)D_3-tetraphenylborate to quantify 25(OH)D_3 in serum using a fluorescence-quenching mechanism. The method was fully validated and applied to compare serum levels between autistic and healthy children. The results revealed significantly lower 25(OH)D_3

concentrations in autistic children, indicating a potential link between vitamin D deficiency and autism (Almalki et al., 2024).

Mei et al. (2024) presented a dual-emission carbon dots-based sensor to detect vitamin B2, B9, and B12. Dual- emission CDs were synthesized from rhodamine and ethylenediamine via a hydrothermal method. These CDs exhibit differential responses to the three B vitamins. Vitamin B2 primarily quenches the 404 nm emission while generating its own fluorescence peak, enabling quantification via changes in F_{404}. Vitamins B9 and B12 both quench the emissions and cause wavelength shifts, allowing their concentrations to be measured using the fluorescence ratio F_{589}/F_{404}. Each vitamin induces a distinct spectral and color change, reflecting differences in their molecular structures and interactions with the carbon dots. Overall, this system offers a selective and sensitive fluorescence-based method for detecting B2, B9, and B12 (Mei et al., 2024).

5. CONCLUSIONS

Sensitive and selective detection of vitamins is in high demand across a wide range of applications. CDs offer significant potential for the development of vitamin sensors, owing to their unique properties, including strong fluorescence, efficient quenching capabilities, high surface area for functionalization or loading of other species, water solubility, and biocompatibility.

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Bridging Biology to Engineering Solutions: Biomimetics

Biyolojiden Mühendislik Çözümlerine Köprü: Biyobenzetim

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Abstract

Biomimetics, also referred to as biomimicry, is an interdisciplinary field that systematically studies biological systems and natural phenomena to elucidate the underlying principles governing their function. These insights are subsequently translated into innovative applications across scientific, engineering, and medical disciplines. It is an interdisciplinary field in which principles of engineering, chemistry, and biology are applied to the synthesis of materials, synthetic systems, or machines that have functions similar to biological processes. Biomimetics is not a recent study or trend, but it is the idea of looking into nature for inspiration, and it has been in practical use since the first human. This paper aims to review some prominent examples of biomimicry including Japanese Shinkansen train, aircraft winglets, Velcro and bee-inspired designs and solutions as well as exemplary works by authors, and an undergraduate course developed on biomimicry.

Keywords: Nature-inspired design, Biomimetics, Course Development

1.INTRODUCTION

The term biomimetics, also dubbed as biomimicry, originates from combination of two Greek words “bios” (life), and “mimesis” (to imitate). Biomimetics is regarded as an interdisciplinary study in which various principles from biology, chemistry, and engineering are applied to the design of new materials, mechanisms, and machines. The common features of all those is that mimicking biological processes. Other commonly used terminologies are nature-inspired design, bio-inspired design. Authors, on the other hand, prefer to use term “inspired by creation”. Even though the term Biomimetics was first coined by Otto Schmitt in 1957, the application of biomimicry is as old as human history. The son of the first Prophet Adam, Cain killed his brother Abel (the first murder of the mankind) and he repented and did not what to do with the corpse of his brother as narrated in the Holy Quran as - Then Allah sent a crow who scratched the ground to show murderer said, *“Woe to me! Am I not even able to be as this crow and to hide the dead body of my brother?”* Then he became of those who regretted. - (Al-Maidah, verse: 31). Though it was not a product, this incident can be regarded as the first biomimetic application in human history.

One of the first recorded applications of biomimicry belongs to Badi' al-Zaman al-Jazari (1136–1206), a polymath and mechanical engineer from the Islamic Golden Age. He is known as the Father of Robotics, and

designed and built automata (self-operating machines) that mimicked human and animal behavior. Some of his inventions include humanoid robots (Anonymous, 2025a), essentially an early example of a bio-inspired service robot, mechanical peacocks and birds, which showcased early understanding of mimicry and kinetics in animal-like forms. In 1206, he completed an outstanding book on engineering entitled Al-Jami' bayn al-'ilm wa-'l-'amal al-nafi' fi sinat'at al-hiyal in Arabic (Al-Hassan, 2001). About eight centuries later, it was translated into in English as "The Book of Knowledge of Ingenious Mechanical Devices" by Hill (1976). Al-Jazari documented these inventions in detail, and it is considered a foundational text in both biomimetic design and robotics. His work clearly demonstrated biomimetic principles, combining natural inspiration with practical mechanical design, centuries ahead of modern terminology like "biomimicry" or "robotics. About 250 years later, Leonardo da Vinci recorded some designs of a humanoid robot, and over 200 flying machine concepts (Anonymous, 2025b).

The desire for flying has represented a persistent engineering challenge and a central focus of technological advancement throughout human history. The next sections are intended to review some of the prominent applications of biomimicry inspired by flying masters, followed by bee-inspired advancements in various fields, and finally brief introduction of efforts by authors in this area.

2.BIOMIMETIC SOLUTIONS IN ENGINEERING

Among the innumerable examples of biomimicry, one of the most famous is Japanese Shinkansen (bullet) trains design change. During its early design use, the trains were fast, but they were quite loud. The micro-pressure wave produced along the tunnel was producing a sonic boom like effect when trains exiting tunnel. The problems were solved by Eiji Nakatsu, a railway engineer, and birdwatcher, by imitating the kingfisher's beak in the nose section of trains (Figure 1). The streamlined shape of the kingfisher's beak enables it to dive into water with minimal splashes, reducing wave formation and allowing it to catch fish more effectively by minimizing the chance for prey to detect and evade the strike.

Figure 1. Kingfisher's beak inspired the Shinkansen trains' nose section design.

The redesigned train not only inspired from kingfisher but also from owls (for pantograph shape, and Adelie penguin (for pantograph supoorting structure). As a result of these improvements, the noise level of trains were reduced to below 70 dB along with 10% increase in speed, 15% decrease in electricity usage.

Eagle is another source of inspiration for one of the transportation problems. It was until late 1970's that aircraft had no winglets. Winglets or wingtips are vertical extension of the wing at the tip. Without winglets, tip vortices occur when high pressure air from lower surface of the wing moves around at tip and reach upper surface and creaste turbulence. This results in uncomfort in flight, higher fuel consumption, lower range and aircraft speed. Nowadays, almost all airplanes have winglets which provide 5% less fuel consumption, so the CO_2 emissions, and saving of about 2 million liters of aviation fuel for each commercial passenger annually. Figure 2 shows a typical winglet use in a commerical airplanes which also introduction slide of the undergraduate selective course developed by secound author at the department of mechanical engineering in Karadeniz Technical University. When it was first offered in 2018, the course is one of the first dedicated courses on biomimetics developed for undergraduate engineering student in Türkiye (Cora, 2018).

Figure 2. Eagle's wing tip inspired the winglet use in airplanes

Another fascinating example of bio-inspired design is the fastest fighter jet SR-71 Blackbird. Fighters with supersonic speed capabilities suffer airflow problems into the jet engine. The fastest bird in the world (with a diving speed of 320 km/h), the Peregrine Falcon, inspired the SR-71's air intake design by mimicking the falcon's nasal cavity, resulting in smoother air flow into the engine without choking.

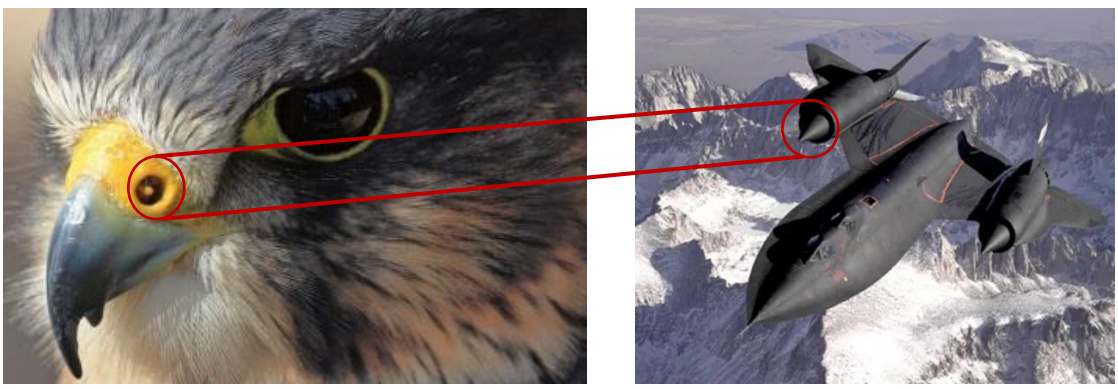
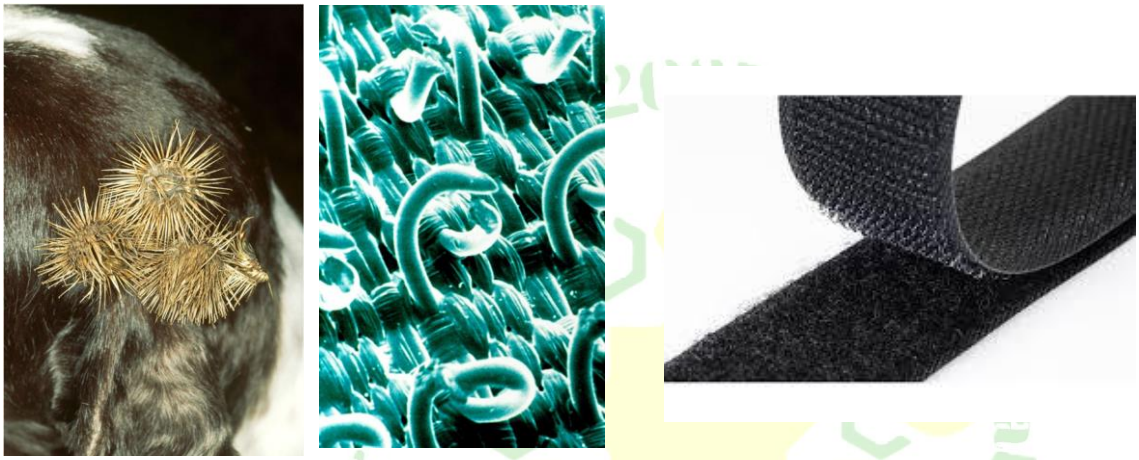


Figure 3. The protrusion inside the nasal cavity of Peregrine Falcon prevents hazards associated with high-speed flights including lung damage induced by high wind pressure.

The Velcro (Hook and loop fastener) is regarded as the first patented application of biomimicry. George de Mastral, a Swiss electrical engineer noticed burdock burrs that sticked his clothes and dog's fur (Figure 4.a) while hunting in the Jura mountains in Switzerland, in 1941. He examined them under a microscope and saw the tiny, stiff hooks that latched onto any loop or fibrous material (Figure 4.b). He spent several years replicating this hook-and-loop system using synthetic materials (initially cotton, later nylon) and finally filed its patent in 1951. The patent (Velvet Type Fabric and Method of Producing Same, US Patent # US 2,717,437,) was granted in 1955. The name "Velcro" comes from the French words *velours* (velvet) and *crochet* (hook). The global hook-and-loop fastener market was valued at approximately USD 3.16 billion in 2025 and Velcro Companies, with 18% share, is the dominant player in the market (Anonymous, 2025c).

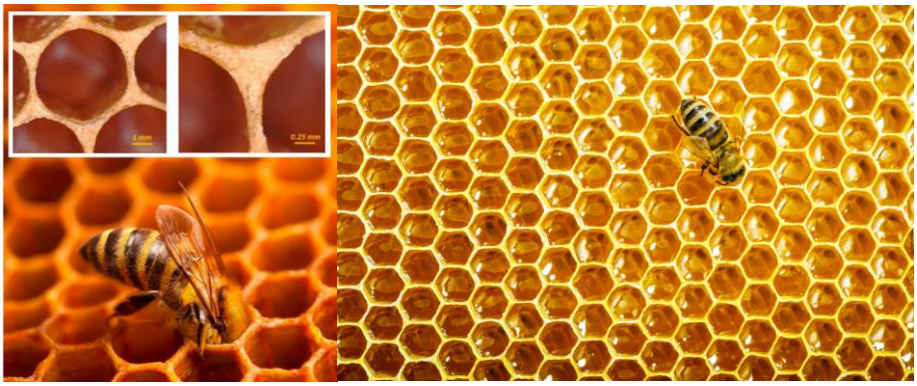


a) b) c)

Figure 4. a) Burdock burrs sticked to dog fur, b) microscopic view of burdock burrs, c) commercial product Velcro

3.BEE-INSPIRED BIOMIMICRY SOLUTIONS

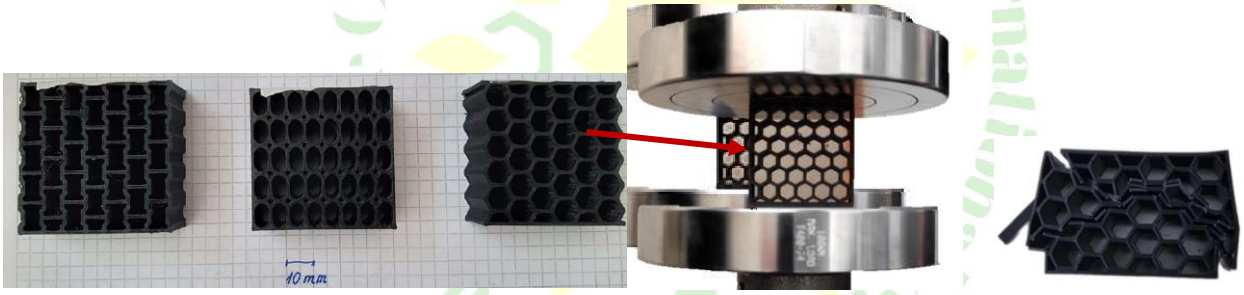
Bees are important to biodiversity, and survival of human being is partially depend on bees as they provide high-quality food—honey, royal jelly and pollen — and other products such as beeswax, propolis and honeybee venom (Anonymous, 2022). Apart from these, bees and their way of life inspired various designs in engineering. Honeycombs, for example, is just one them. It is one most commonly preferred composite geometry as those have unique features including 1) excellent strength-to weight ratio, 2) lightweight, 3) high-stiffness, 4) efficient load distribution, 5) energy absorption, 6) thermal and acoustic insulation, and 7) ease of manufacturability. As a results of these, honeycombs had found several applications in different fields, including architecture, transportation, mechanical engineering, chemical engineering, nanofabrication and, biomedicine (Qiancheng et al., 2015). Rajeev et al. (2022) revealed that hexagonal repeating units of honeycombs are not sharp cornered but rather those are rounded (Figure 5) which provides higher effective modulus and lower stresses when compared to that for sharp-cornered features which is a typical human-based design (Anonymous, 2025d).



a) b)

Figure 5. a) Honeycomb structure, b) and its microscopic view (Rajeev et al. ,2022)

In a similar context, the second author investigated effects of several different bio-inspired designs in terms of energy absorption characteristics. To this goal, samples were prepared using filaments including ABS, PLA, CF-PLA and then the parts were subjected to compression tests, and force-displacement graphs are plotted to evaluate the performance of each design (Özbey et al., 2025). More recently, 3d printed cellular structures inspired from mantis shrimp was studied in a similar manner (Acuner et al., 2025). Other notable bee-inspired solutions can be listed as follows, and it is illustrated in Figure 7.



a) b) c)

Figure 6. a) Examples to bio-inspired cellular 3-d printed structures a) cobblestone (on the left), cuttlefish's bone (in the middle), and honeycomb (on the right), b) Honeycomb sample before commpression test, c) the honeycomb sample after compression test (Özbey et al. ,2025)

- **Swarm Intelligence Algorithms:** Developed by Prof. Derviş Karaboğa of Erciyes University first in 2005, Artificial Bee Colony (ABC) algorithm inspired from intelligent foraging behavior of honey bees (Karaboga and Basturk, 2007). It has applications in robotics, path optimization, and distributed decision-making.

- **Bee Eye-Inspired Visual Sensors:** Wide-angle, anti-reflective or motion-sensitive visual systems in drones or cameras (Choi et al., 2024).

- **Thermoregulation and Ventilation in Architecture**: Passive airflow and cooling systems modeled after beehive ventilation (Peters et al., 2024).

- **Robotic Pollinators Inspired by Bee Behavior:** Drones for crop pollination and environmental monitoring (Miyoshi, 2025; Ponti, 2017).

- **Bee-Inspired Communication Systems**: Data transfer and coordination based on the waggle dance or pheromone trails (Landgraf et. al, 2011).

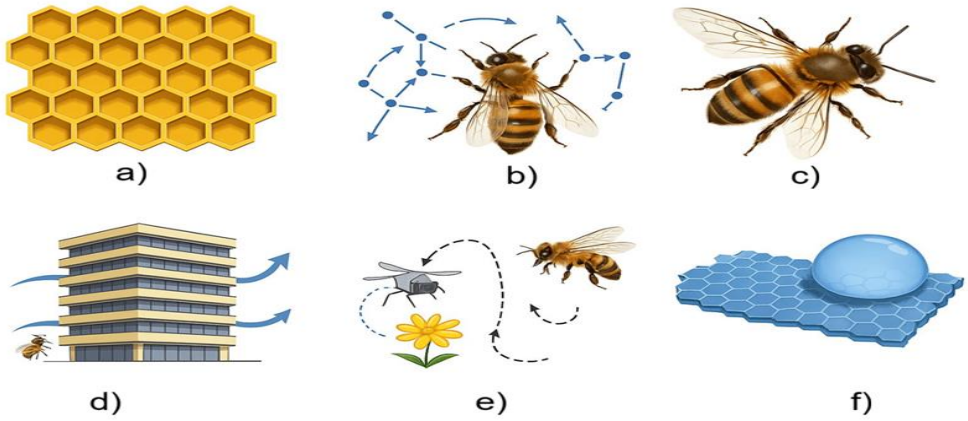


Figure 7. Some examples to bee-inspired engineering solutions a) honeycomb hexagonal cells, b) Swarm intelligence algorithms, c) ventilation and thermoregulation, d) communication systems, e) pollination robotics, f) anti-reflective and water-repellent surfaces

4.CONCLUSION

Biomimetic is not a new branch of science but continuing practice since the first human being. There are still millions of inspiration sources from creatures, and a lot to investigate and understand the wisdom of creation and opportunity to implement them in engineering solutions. To this goal, a multidisciplinary approach is needed.

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Effect of Flupyradifurone (Butenoloid) on Memory and Learning Behavior of Honeybees

Flupyradifurone'un (Butenoloid) Bal Arılarının Öğrenme ve Hafıza Davranışına Etkisi

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Özet

Arılar, yabani ve kültüre alınmış bitkilerin tozlaşmasındaki hayati rolleri ve insan gıdası üretimine olan katkıları nedeniyle ekosistemlerin sürdürülebilirliği açısından kritik öneme sahiptir. Ancak, ekosistemler için vazgeçilmez olan arılar üzerinde pestisitlerin yıkıcı etkileri bulunmaktadır. Tarımsal zararlılarla mücadelede yaygın olarak kullanılan neonikotinoidler, merkezi sinir sistemi üzerinde etkili olarak felç ve ölüme yol açan sistemik etkiye sahip pestisitlerdir. Neonikotinoidlerin arılar üzerindeki olumsuz etkilerine ilişkin bulgular nedeniyle son yıllarda bu maddelerin kullanımı kısıtlanmış ve "arılar için daha güvenli" olduğu düşünülen yeni insektisitlerin kullanımı tercih edilmeye başlanmıştır. Bu çalışma, yeni nesil bir insektisit olan Flupyradifurone'un işçi bal arılarının öğrenme ve hafıza yetenekleri üzerindeki etkilerini belirlemek amacıyla planlanmıştır. Çalışmada, Flupyradifurone'un önerilen arazi dozunun (60 ml/L) dört farklı düzeyi (0 (kontrol), 1/10, 1/1 ve 2/1) test edilmiştir. İşçi arıların lavanta kokusuna verdikleri tepkiler klasik koşullanma yöntemiyle değerlendirilmiş, bellek performansları ise belirli zaman aralıklarında ölçülmüştür. Kontrol grubundaki işçi arıların hortum uzatma oranı %76 iken, 1/10, 1/1 ve 2/1 dozları uygulanan gruplarda bu oran sırasıyla %82, %66 ve %46 olarak belirlenmiştir. Sonuçlar, yüksek dozda Flupyradifurone maruziyetinin bal arılarının öğrenme hızını ve hafıza yeteneklerini olumsuz yönde etkilediğini göstermektedir.

Anahtar kelimeler: bal arısı, Flupyradifurone, öğrenme, hafıza yeteneği

Abstract

Bees are of critical importance for the sustainability of ecosystems due to their vital importance in pollinating wild and cultivated plants and their contribution to human food production. However, pesticides have a devastating effect on bees, which are essential for ecosystems. Neonicotinoids, which have a systemic effect and cause paralysis and death by affecting the central nervous system, are used extensively in the fight against agricultural pests. Due to the findings regarding their negative effects on bees, the use of neonicotinoids has been restricted in recent years and new insecticides that are considered "safer for bees" have begun to be preferred. This work was planned to determine the effects of Flupyradifurone, a new generation insecticide, on the learning and memory abilities in honeybee workers. Four different doses (0 (control), 1/10, 1/1 and 2/1) of the recommended field dose of Flupyradifurone (60ml/L) were tested. The responses of workers to the

scent of lavender were tested using classical conditioning and their memories were tested at specific time intervals. While the rate of proboscis extension in workers in the control group was 76%, this rate was determined as 82%, 66%, and 46% in the groups treated with 1/10, 1/1, and 2/1 doses, respectively. The results indicated that exposure to high doses of Flupyradifuron reduced the learning speed and memory abilities of honeybees.

Keywords: honeybee, Flupyradifurone, learning, memory ability

1. INTRODUCTION

Pollination is a fundamental biological process in angiosperms, occurring through the transfer of pollen grains from the male to the female floral organs, and enabling reproduction in approximately 87% of flowering plant species (Ollerton et al., 2011). This mechanism is critical not only from an evolutionary perspective but also in ecological and economic terms. Gallai et al. (2009) estimated the global economic value of pollination services at 153 billion euros, while Klein et al. (2007) demonstrated that 35% of global crop production depends on animal pollinators. Among pollinators, insects constitute the dominant group, and bees—with more than 20,000 species—are the primary actors in this process (Allsopp et al., 2008; Michener, 2007). In particular, the honey bee (Apis mellifera) is a key species that directly contributes to one-third of global food production (Klein et al., 2007).

In modern agricultural systems, pesticides used to increase productivity impose significant ecological pressures on pollinator communities. According to FAO data, global pesticide use reached 3.7 million tons in 2022, a trend that has continued to rise since 1990. The most widely used pesticide class is neonicotinoids (Jeschke et al., 2011; Zhang et al., 2018), compounds that exert neurotoxic effects by binding to nicotinic acetylcholine receptors. Numerous studies have shown that neonicotinoids negatively affect a variety of physiological and behavioral parameters in honey bees, including navigation, learning, memory, immunity, lifespan, and brood development (Brandt et al., 2016; Buluş & Gösterit, 2025; Fischer et al., 2014; Whitehorn et al., 2012).

Learning and memory performance in honey bees is most commonly assessed using the Proboscis Extension Reflex (PER) paradigm (Bitterman et al., 1983; Giurfa & Sandoz, 2012). This classical conditioning technique is based on associating an odor or visual stimulus with a sucrose reward and is a reliable tool for measuring associative learning ability in bees (Wright & Smith, 2004). PER-based studies have shown that neonicotinoids impair learning acquisition and memory consolidation processes (Laurino et al., 2011; Motta et al., 2024). Chronic exposure, in particular, reflects persistent contamination scenarios experienced by forager bees under natural field conditions and reveals the sustained nature of cognitive impairments (Iwasa et al., 2004; Suchail et al., 2001).

Due to the increasing evidence of the harmful effects of neonicotinoids, their use has been severely restricted in the European Union and the United States (Li et al., 2020; Stokstad, 2013). This has led to the development of alternative compounds marketed as "bee-friendly." One such new-generation compound is Flupyradifurone (FPF), derived from the natural alkaloid stemofoline. Although chemically classified within the butenolide group, it functions similarly to neonicotinoids in terms of its mode of action (Nauen et al., 2015). Recent studies indicate that FPF also produces adverse effects on learning, memory, feeding behavior, and thermoregulation in honey bees (Hesselbach et al., 2020; Siviter & Muth, 2022; Tan et al., 2017).

In this context, the neurotoxic potential of FPF and its impacts on the cognitive performance of bees have not been fully elucidated. This study aims to experimentally investigate the effects of Flupyradifurone exposure on learning and memory behavior in honey bees, thereby contributing scientific insight into the safety profile and possible environmental risks associated with this compound.

2. MATERIALS AND METHODS

The research was conducted at the Beekeeping Research and Application Laboratory of the Department of Animal Science, Faculty of Agriculture, Isparta University of Applied Sciences. As the chemical material, an insecticide containing the active ingredient Flupyradifurone—recommended at a dose of 60 ml/100 L of water—was used. The honey bees serving as the biological material were collected from colonies.

During the process of determining the experimental groups, findings obtained from a preliminary study conducted in the planning phase of the research were evaluated together with literature reports indicating that farmers often apply agrochemicals at doses higher than the recommended levels to achieve the desired efficacy (Özkan et al., 2002). Accordingly, four experimental groups were formed to include different dose applications of Flupyradifurone (FPF; Sivanto, Bayer):

Group 1: Feeding with plain sugar syrup (control group)

Group 2: Feeding with sugar syrup containing 1/10 of the recommended dose of FPF

Group 3: Feeding with sugar syrup containing the full recommended dose (1/1) of FPF

Group 4: Feeding with sugar syrup containing twice the recommended dose (2/1; 2×) of FPF

The learning and memory capacities of worker honey bees (Apis mellifera) exposed to different proportions (0 (control), 1/10, 1/1, 2/1) of the recommended maximum application dose of Flupyradifurone were evaluated. Each group consisted of 50 individuals, making a total of 200 forager worker bees. The workers were randomly assigned to the four groups and were fed ad libitum under laboratory conditions for 24 hours with sugar syrup containing the corresponding concentration of Flupyradifurone.

After feeding, the worker bees were briefly placed in a cold chamber (2.5 °C) to immobilize them, and subsequently mounted onto specially designed bee harnesses, allowing free movement of the antennae,

forelegs, and mouthparts. To prevent starvation during this stage, the bees were fed with 50 Brix plain (pesticide-free) sugar syrup using cotton swabs. In this way, behavioral changes potentially caused by hunger were minimized. Lavender essential oil was used as the olfactory stimulus for the learning and memory tests. After these procedures, the bees were allowed to acclimate and settle before testing began.

Tests involving the proboscis extension response were conducted using a modified version of the protocol described by Bitterman et al. (1983) (Tan et al., 2015). Each individual conditioned to lavender odor via classical conditioning was placed in front of the conditioning apparatus. First, odorless air was blown toward each restrained worker bee for 15 seconds to eliminate any environmental odors that could influence the response. This was followed by exposure to lavender-scented air between seconds 16 and 22. During this time, cotton swabs dipped in plain sugar syrup were touched to the bees' antennae between seconds 19 and 22. Bees that responded to the odor stimulus by extending their proboscis were rewarded with feeding. This procedure was repeated five times at 10-minute intervals to reinforce learning, and the number of bees exhibiting proboscis extension in each trial was recorded.

After completing the learning phase, the study proceeded to the memory testing phase. Memory tests were conducted at the 1st, 2nd, 6th, and 12th hours following the completion of the conditioning process, and the number of bees responding to the lavender odor was recorded. Similar procedures to the learning tests were used during the memory tests; however, unlike the learning phase, no reward feeding was provided following the proboscis extension response during memory assessments, and only the number of responding bees was recorded.

Data obtained as the presence or absence of proboscis extension behavior were analyzed using the Chi-square independence test. Subsequently, the z-test was used for comparing the calculated proportions.

3. RESULTS AND DISCUSSION

In this study, the effects of different doses of flupyradifurone (FPF) on the proboscis extension reflex (PER) behavior of honey bees were examined. No statistically significant differences were found between the control group (76% PER) and the low-dose (1/10, 82% PER) or medium-dose (1/1, 66% PER) FPF treatments. However, while the PER rate was 76% in the control group, it decreased to 46% under the high-dose (2/1) FPF treatment, and this reduction was found to be highly significant ($p < 0.01$). Similarly, PER rates showed statistically significant decreases when transitioning from the low dose (82%) to the high dose (46%) ($p < 0.01$), and from the medium dose (66%) to the high dose (46%) ($p < 0.05$).

The findings indicate a dose-dependent effect of FPF on PER behavior in honey bees. While no significant differences were observed in PER responses at low and medium doses (1/10 and 1/1) compared to the control group, a pronounced and statistically significant decline was detected at the high dose (2/1). These results

suggest that FPF, at doses exceeding a certain threshold, may adversely affect behavioral traits associated with learning and memory in honey bees.

Table 1. Proboscis Extension Response (PER) display ratio

Groups	N	%
Control	50	76 a
FPF 1/10	50	82 a
FPF 1/1	50	66 a
FPF 2/1	50	46 b

The difference between values bearing different letters in the same column is significant; a, b: $p<0.05$

Çalışmanın bulguları, literatür bildirişleri ile önemli paralellikler göstermektedir. Hesselbach & Scheiner (2018), FPF'nin yüksek dozda bal arılarının bilişsel performansını azalttığını, ancak düşük ve orta dozların PER performansını etkilemediğini bildirmiştir. Bu çalışmada da benzer şekilde, düşük (1/10) ve orta (1/1) dozlar PER davranışını etkilemezken, yüksek dozun (2/1) belirgin bir baskılayıcı etki gösterdiği belirlenmiştir. Bu paralellik, arılar açısından FPF için bir eşik dozun varlığını desteklemektedir. Asya bal arılarında yapılan bir çalışmada (Honatel vd., 2024), FPF maruziyetinin larva ve yetişkin dönemde koku alma öğrenmesini bozduğu bildirilmiştir.

Table 2. Time-dependent memory performance of workers (%)

Groups	Time elapsed after application (hours)			
	1 st hour	**2nd hour**	**6th hour**	**12th hour**
Control	100	100 a	94,73 a	94,73 a
FPF 1/10	97,56	92,68 ab	90,24 a	82,92 a
FPF 1/1	90,90	81,81 b	66,66 b	57,57 b
FPF 2/1	91,30	82,60 b	60,96 b	60,96 ab

The difference between values bearing different letters in the same column is significant; a, b: $p<0.05$

The finding that acute FPF exposure impairs learning and memory abilities is also consistent with the high-dose (2/1) results of this study. Chen et al. (2024) reported that chronic FPF exposure negatively affects survival ability and memory, highlighting the risks associated with long-term low-dose exposure. High doses of FPF have been reported to increase oxidative stress and adversely affect gustation, learning, motor abilities, behavior, survival, and immunity (Harwood et al., 2022). The findings of this study, which are in line with the literature, further confirm the reliability of the PER test in assessing FPF toxicity. By identifying the dose–response relationship and the critical threshold dose, this study contributes valuable information to current knowledge. Despite differences in methodology, there is a broad consensus in the literature that high doses of FPF severely impair the learning and memory behaviors of honey bees.

4. CONCLUSION

The findings of this study demonstrate that flupyradifurone (FPF) exhibits a dose-dependent effect on the learning and memory behaviors (PER) of honey bees. While low and medium doses (1/10 and 1/1) did not significantly affect PER, the high dose (2/1) produced a pronounced suppressive effect. The PER response reflects the bees' capacity to learn odor–reward associations and is directly related to their ability to locate food resources. A reduction of approximately 30% in PER at the high dose indicates that the pesticide may negatively impact learning and memory functions. This effect is thought to result from the disruption of neural transmission due to FPF's interaction with nicotinic acetylcholine receptors (nAChRs). The absence of significant effects at low doses suggests that bees may tolerate exposure up to a certain threshold level.

From a pollinator-health perspective, the impairment of learning caused by high-dose FPF may negatively affect bees' foraging and navigation abilities, ultimately posing risks to colony health. In conclusion, FPF exerts dose-dependent toxic effects on the cognitive functions of honey bees. The marked decline observed at high doses underscores the need for careful and guideline-based use of this insecticide. Based on the results of this study, future research should focus on determining the long-term effects of low doses and colony-level changes associated with FPF exposure.

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Effect of Selection on Sustainability of Mass Rearing in Bumblebees

Bombus Arılarında Kitlesel Yetiştiriciliğin Sürdürülebilirliğinde Seleksiyonun Etkisi

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Özet

Bombus arıları, seralarda özellikle domates yetiştiriciliğinde etkin tozlaştırıcı olarak kullanılmaktadır. Ancak ticari üretim sürecinde tozlaşmaya uygun koloni elde etme oranı genellikle %30–40 arasında değişmekte, bu da maliyetleri artırmakta ve verim kaybına neden olmaktadır. Bu çalışma, *Bombus terrestris* arılarında tozlaşmaya uygun koloni yetiştirme başarısının seleksiyon ile artırılıp artırılamayacağının belirlenmesi amacıyla gerçekleştirilmiştir. Çalışmada indeks yönteminden yararlanılarak gerçekleştirilen seleksiyon programına ait koloniler kullanılmıştır. Kolonilerin tozlaşma performansları ile ilgili olabileceği düşünülen birinci kuluçka döneminde üretilen işçi arı sayısı, dönüşüm noktası zamanı ve toplam işçi arı sayısı gibi özelliklere ilişkin veriler değerlendirilmiştir. Elde edilen sonuçlar bombus arısı kolonilerin tozlaşma performansı ile ilgili özelliklerin takip edilecek uygun seleksiyon programı ile iyileştirilebileceğini göstermiştir.

Anahtar kelimeler: Bombus Arısı, Kitlesel Üretim, Sürdürülebilirlik, Seleksiyon

Abstract

Bumblebees are used as effective pollinators in greenhouses, particularly for tomato cultivation. However, during commercial production, the proportion of colonies suitable for pollination generally ranges between 30–40%, which increases costs and leads to yield loss. This study was conducted to determine whether the success rate of producing pollination-suitable colonies in Bombus terrestris can be improved through selection. Colonies from a selection program carried out using the index method were used in the study. Data on characteristics considered potentially related to pollination performance, such as the number of workers produced during the first brood, switch point time, and total worker number, were evaluated. The results indicated that characteristics associated with the pollination performance of bumblebee colonies can be improved through an appropriate selection program.

Keywords: Bumblebee, Mass Rearing, Sustainability, Selection

1. INTRODUCTION

When used as pollinators, bumblebees—characterized by long tongues, large body size, high pollination capacity, ability to work under low temperature and light intensity, lower tendency to leave the greenhouse,

and calm behavior—have become indispensable in greenhouse tomato production. Their use eliminates the need for plant growth regulators, known as hormones, which induce fruit formation without fertilization. Bumblebee-based pollination improves both fruit quality and yield, limits the use of hormones and chemical pesticides, increases the market value of greenhouse products, and facilitates export (Gösterit & Gürel, 2018; Velthuis & van Doorn, 2006). A healthy queen, a broad brood area with open and closed brood cells, and 60–70 workers are sufficient for colonies intended for pollination. Depending on the crop, each colony is used in approximately 1500–2000 m² of greenhouse area for only 40–45 days (Gösterit & Gürel, 2014).

In bumblebee rearing, all life stages—queen colony initiation, queen and male production, mating, control of the diapause period of mated queens, and post-diapause colony initiation—are carried out under controlled conditions to enable year-round mass production. Although losses occur at each stage of production, the most critical losses arise during the formation of colonies suitable for pollination. Some queens die during the egg-laying stage, some fail to lay eggs, and only a portion of egg-laying queens produce colonies suitable for pollination. Therefore, even under ideal conditions, a large proportion of queens do not produce quality colonies, and the proportion of pollination-suitable colonies typically ranges between 30–40%. Such colonies have shorter pollination periods and lower performance, which increases production costs and reduces yield and fruit quality due to insufficient pollination, ultimately causing economic losses for growers.

Differences observed in the colony structure of B. terrestris may originate from various factors such as queen quality, mating success, environmental conditions during rearing, nutritional status, diapause duration, diseases and pests, and the genetic structure of queens and males used as breeding stock (Amin et al., 2010; Baloğlu & Gürel, 2015; Beekman & van Stratum, 2000; Cnaani et al., 2000; Gösterit & Erkan, 2012; Gösterit, 2016). It remains unclear whether considering colony quality when selecting queens and males for the next generation affects the quality of the colonies they produce, and thus the relationship between colony quality and genetic structure has not been fully explained. It is assumed that commercial companies conduct selection programs over several generations to minimize losses during colony production, although the details of these breeding practices remain confidential.

This study was conducted to determine whether the proportion of marketable colonies and colony developmental traits of B. terrestris can be improved through selection within the scope of sustainable mass rearing.

2. MATERIALS AND METHODS

The study used Bombus terrestris queens obtained from the second-generation colonies of an ongoing laboratory selection program. Rearing procedures were carried out in a bumblebee rearing room maintained at 27–28°C and 50–60% relative humidity. Queens and colonies were fed with sugar syrup (50° Brix) and

fresh pollen (Gösterit et al., 2018).

An index value was calculated by evaluating several developmental traits (time to first egg laying, time to emergence of the first worker, number of workers produced during the first brood, switch point time, competition point time, time to first queen production, total number of workers, and time to pollination suitability) of colonies belonging to the high-quality, low-quality, and control groups in the second generation of the selection program (Table 1).

Table 1. Colony characteristics used in the calculation of the index value and scoring criteria

Characteristics |	**Scoring Criteria**
Time to first egg-laying (days) |	>20 ⇒ 1 point, 16–20 ⇒ 2 points, 11–15 ⇒ 3 points, 6–10 ⇒ 4 points, ≤5 ⇒ 5 points
Time to first worker emergence (beginning of social phase) (days) |	>50 ⇒ 1 point, 46–50 ⇒ 2 points, 41–45 ⇒ 3 points, 36–40 ⇒ 4 points, ≤35 ⇒ 5 points
Number of workers produced in the first brood	1–3 ⇒ 1 point, 4–8 ⇒ 2 points, 9–12 ⇒ 3 points, 13–15 ⇒ 4 points, t≥15 ⇒ 5 points
Switch point (days) |	<10 ⇒ 1 point, 10–20 ⇒ 2 points, 21–30 ⇒ 3 points, 31–40 ⇒ 4 points, >40 ⇒ 5 points
Competition point (days) |	≤25 ⇒ 1 point, 26–30 ⇒ 2 points, 31–35 ⇒ 3 points, 36–40 ⇒ 4 points, >40 ⇒ 5 points
Time to first queen production (days) |	≤5 ⇒ 1 point, 6–20 ⇒ 2 points, 21–30 ⇒ 3 points, 31–40 ⇒ 4 points, >40 ⇒ 5 points
Total number of workers (count) |	≤40 ⇒ 1 point, 41–80 ⇒ 2 points, 81–120 ⇒ 3 points, 121–150 ⇒ 4 points, >150 ⇒ 5 points
Time to pollination readiness (days) |	>90 ⇒ 1 point, 81–90 ⇒ 2 points, 76–80 ⇒ 3 points, 71–75 ⇒ 4 points, ≤70 ⇒ 5 points

Queens and males produced in the high-scoring colonies of the pollination-suitable group were mated to form the pollination-suitable selection group. Similarly, queens and males produced in the low-scoring colonies were mated to obtain queens for the pollination-unsuitable selection group. Queens used for the control group were selected randomly. After undergoing diapause for two months at +2.5°C and 75% RH, queens were

placed individually into rearing boxes to establish third-generation colonies. In these colonies, the number of workers produced during the first brood, switch point time, and total worker number—traits associated with pollination performance—were recorded. Mating, diapause, and colony initiation procedures were performed according to standard protocols (Kwon et al., 2006; Gösterit et al., 2018). Each breeding group consisted of 50 queens, totaling 150 diapause-completed queens. All queens were selected to have similar body size and weight.

Data were analyzed using the Minitab statistical package. Differences among groups for colony developmental characteristics were evaluated using ANOVA. In addition, third-generation data were compared with the initial generation to determine the effect of selection.

3. RESULTS AND DISCUSSION

The number of workers produced during the first brood directly influences subsequent colony development (Duchateau & Velthuis, 1988; Bogo et al., 2017). Understanding the factors influencing this trait is essential for successful rearing. Analysis of the effect of selection revealed significant differences among groups (Table 2). Statistical evaluation showed that the pollination-suitable group had a higher mean number of workers compared to the initial generation and other groups, and the difference between the initial generation and both the pollination-suitable and control groups was significant ($p<0.05$). High worker production during the early stages of colony development plays a crucial role in colony success. According to Gösterit & Gürel (2018), colonies with larger worker populations live longer, are stronger, and exhibit higher pollination efficiency. Worker number is also one of the most important indicators of colony quality, as workers directly affect colony growth and productivity through brood care and foraging (Velthuis & van Doorn, 2006).

Table 2. Effect of selection on the number of workers produced in the first brood

Generations and groups		**N**	$\bar{x}$ **± S.H**
Initial generation		82	11,171 ± 0,464 ^{b}
3. Generation	Colony group suitable for pollination	42	14,286 ± 0,743 ^{a}
	Control group	41	13,756 ± 0,741^{a}
	Colony group unsuitable for pollination	36	12,556 ± 0,917 ^{ab}

a,b: means followed by a different letter are different ($p=0.02$)

Selection also affected the switch point—the time when colonies begin producing their first males (Table 3).

This stage indicates that colonies are approaching the end of their life cycle (Amsalem et al., 2015; Goulson, 2010). No significant difference was found between the initial generation and third-generation groups. However, a significant difference was observed between the pollination-suitable and unsuitable colonies in the third generation. The later switch point observed in the pollination-suitable group indicates that these colonies continued worker production longer and delayed investment in reproduction. Conversely, Gösterit (2009) reported that selection did not significantly delay the switch point.

Table 3. Effect of selection on the switch point time

Generasyon ve gruplar		**N**	$\bar{x}$ **± S.H**
Initial generation		61	24,62 ± 1,40^{ab}
3. Generation	Colony group suitable for pollination	25	26,44 ± 1,82^{a}
	Control group	33	21.64 ± 1,38^{ab}
	Colony group unsuitable for pollination	28	19,46 ± 1,66^{b}

a,b: means followed by a different letter are different (p=0.029)

Significant differences were also observed in total worker production (Table 4). The pollination-suitable group had the highest total worker number, while the lowest values were recorded in the pollination-unsuitable group and the initial generation (p=0.000). These findings show that selection markedly increases worker production and enhances colony pollination capacity. The results indicate that selection improves not only early colony development but also colony productivity throughout the life cycle. Since colony size and reproductive output are genetically linked in bumblebees, worker production capacity is likely influenced by genetic structure. Therefore, the selection method used in this study may have strengthened genetic factors associated with colony quality.

Table 4. Effect of selection on the total number of workers produced in colonies

Generasyon ve gruplar		N	$\bar{x}$ ± S.H
Initial generation		82	94,65 ± 5,54^{b}
3. Generation	Colony group suitable for pollination	41	149,71 ± 8,46^{a}
	Control group	41	118,59 ± 7,82^{b}
	Colony group unsuitable for pollination	32	94,94 ± 9,44^{b}

a,b: means followed by a different letter are different (p=0.000)

4. CONCLUSION

This study investigated the effects of selection on colony developmental parameters in Bombus terrestris. Significant findings were obtained, particularly regarding worker production, switch point time, and total worker number. The results demonstrate that selection can markedly influence colony performance and increase the success rate of producing pollination-suitable colonies. Although colony performance is also affected by environmental conditions, nutritional quality, diapause duration, and queen quality, the uniformity

of rearing conditions in this study indicates that the observed differences were largely the result of selection. These findings support the applicability of genetic-based selection programs in bumblebee mass-rearing and represent an important step toward the sustainable production of colonies with high pollination efficiency. Overall, the data show that selection improves colony growth rate, worker production, and timing of male production in Bombus terrestris.

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Artificial Intelligence and Virtual Reality in Cultural Heritage Sites: A Study on Nature-Based Experiences

Kültürel Miras Alanlarında Yapay Zekâ ve Sanal Gerçeklik: Doğa-Temelli Deneyimler Üzerine Bir Çalışma

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Özet

Tarihsel, mimari ve toplumsal değerleri bünyesinde barındıran kültürel miras alanları, toplumların kimliğini ve kolektif hafızasını yansıtan çok katmanlı mekânlardır. UNESCO'nun 1972 Dünya Kültürel ve Doğal Mirasın Korunmasına Dair Sözleşmesi ile 2003 Somut Olmayan Kültürel Mirasın Korunması Sözleşmesi, kültürel mirasın korunmasının ve gelecek kuşaklara aktarılmasının önemini vurgulamaktadır. Günümüzde dijital teknolojiler, özellikle yapay zekâ (YZ) ve sanal gerçeklik (SG), kültürel miras alanlarının korunması, belgelenmesi ve ziyaretçi deneyiminin zenginleştirilmesi açısından etkili araçlar olarak öne çıkmaktadır.

Sanal gerçeklik üzerine yapılan çalışmalar; sanal ortamların kaybolmuş veya zarar görmüş yapıların yeniden canlandırılmasına, ziyaretçi etkileşiminin artırılmasına, tarihsel bağlamlarla duygusal bağ kurulmasına, kültürel peyzajların geleceğe aktarılmasına ve bireylerin peyzajla olan bağlarının güçlendirilmesine önemli katkılar sağladığını göstermektedir. Yapay zekâ ve sanal gerçekliğin bu yönleri, doğayla temasın kolaylaştırıldığı kültürel peyzajlarda deneyim temelli öğrenme olanakları sunmakta; iyi oluş hâlini desteklemekte ve sağlık okuryazarlığına katkı sağlamaktadır.

Öte yandan, yapay zekâ uygulamaları mimari yapıların hasar tespiti, malzeme analizi ve önleyici koruma süreçlerinde kullanılmakta; derin öğrenme algoritmalarının akademik çalışmalara önemli katkılar sunduğu görülmektedir. Bu çalışma, yapay zekâ ve sanal gerçeklik teknolojilerinin kültürel mirasın korunması, belgelenmesi ve deneyimlenmesi süreçlerindeki rolünü incelemektedir. UNESCO ve ICCROM'un tanımları doğrultusunda, teknolojik müdahalelerin etik, bağlama duyarlı ve sürdürülebilir bir biçimde uygulanmasının önemi vurgulanmaktadır.

Elde edilen bulgular, dijital teknolojilerin yalnızca teknik yenilikler değil; aynı zamanda kültürel mirasın gelecek kuşaklara aktarılması, kamusal katılımın artırılması ve koruma stratejilerinin geliştirilmesi açısından stratejik araçlar olduğunu ortaya koymaktadır. Sonuç olarak, kültürel miras alanlarında yapay zekâ ve sanal

gerçeklik uygulamaları, doğa temelli deneyimler aracılığıyla ziyaretçi iyi oluşu, erişilebilirlik ve güvenlik gibi sağlıkla ilişkili çıktıları güçlendirebilmektedir. Yapay zekâ ve sanal gerçeklik temelli yaklaşımlar, miras koruma alanında disiplinlerarası iş birliğini artırmakta, ziyaretçi deneyimini zenginleştirmekte ve sürdürülebilir koruma stratejilerine katkı sağlamaktadır. Bu teknolojilerin etik ve bağlamsal hassasiyet gözetilerek uygulanması, kültürel mirasın özgün değerlerinin korunması ve gelecek kuşaklara aktarılmasında kritik bir rol oynayacaktır.

Anahtar Kelimeler: Kültürel miras, yapay zekâ, sanal gerçeklik, doğa, koruma

Abstract

Cultural heritage sites, which embody historical, architectural and social values, are multilayered spaces that reflect the identity and collective memory of societies. The 1972 World Heritage Convention and the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage of UNESCO emphasize the importance of preserving cultural heritage and transmitting it to future generations. Today, digital technologies, particularly artificial intelligence (AI) and virtual reality (VR), stand out as effective tools in the conservation, documentation and enhancement of visitor experience in cultural heritage contexts. Studies on virtual reality show that virtual environments make significant contributions to the reconstruction of lost or damaged structures, to the enhancement of visitor interaction, to the establishment of emotional bonds with historical contexts, to the transmission of cultural landscapes to the future and to the strengthening of individuals' connection with the landscape. These aspects of AI/VR generate experience-based learning opportunities in cultural landscapes, where contact with nature is facilitated, that support well-being and contribute to health literacy.

On the other hand, AI applications are used in damage assessment, material analysis and preventive conservation of architectural structures; deep learning algorithms have been shown to contribute to academia. This paper examines the role of AI and VR technologies in the processes of conserving, documenting and experiencing cultural heritage. In line with the definitions of UNESCO and ICCROM, it emphasizes the importance of implementing technological interventions in an ethical, context-sensitive and sustainable manner. The findings reveal that digital technologies are not only technical innovations but also strategic tools for transmitting cultural heritage to future generations, increasing public participation and improving conservation strategies. In conclusion, AI and VR applications in cultural heritage sites can strengthen health-related outcomes such as visitor well-being, accessibility and safety through nature-based experiences. AI- and VR-based approaches enhance interdisciplinary collaboration in heritage conservation, enrich visitor experience and contribute to sustainable conservation strategies. The ethical and contextually sensitive

implementation of these technologies will play a critical role in safeguarding the authentic values of cultural heritage and transmitting them to future generations.

Keywords: Cultural heritage, artificial intelligence, virtual reality, nature, conservation

1.INTRODUCTION

Cultural heritage is not limited to physical structures or artefacts transmitted from the past to the present; it is also the totality of values that represent the identity, memory and continuity of societies. As stated in UNESCO's 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage, cultural heritage "includes monuments, architectural works, sites and cultural landscapes of outstanding universal value" (UNESCO, 1972). Cultural landscapes and open-green spaces, which constitute an important component of cultural heritage, are places where contact with nature is easily established. Nature-based solutions in the conservation and management of cultural heritage help to overcome the challenges of preservation. The concept of nature-based solutions emerged in conservation and nature enhancement sectors following the recognition of both positive and negative relationships between people and nature (Cohen-Shacham et al., 2016).

In recent years, green infrastructure concepts have started to occupy an important place in planning practice in urban design, in the conservation of heritage sites and in the provision of high-level visitor experiences (Tzoulas et al., 2007). Green infrastructure is a significant urban network system that encompasses natural, semi-natural and artificial networks composed of multifunctional ecological systems at all spatial scales within and around urban areas. All networks that are part of this green infrastructure system, or that connect heritage sites to each other and to other spaces, have important effects on individuals' well-being.

If green infrastructure is proactively planned, developed and maintained, it can guide urban development by providing a framework for economic growth and nature conservation (Walmsley, 2006). Such a planned approach can offer many opportunities for integrating urban development, nature conservation and public health promotion. One way to strengthen the conservation of cultural and natural elements in cities is to focus on what connects them. All heritage consists of natural and cultural elements and, although the balance between them may vary greatly, there can be opportunities for mutual benefit.

In cultural heritage sites, VR-supported narratives and AI-based decision support tools make it possible to design accessible and inclusive experiences that support visitor well-being, reduce stress and enhance learning motivation. In addition, UNESCO's 2003 Convention for the Safeguarding of the Intangible Cultural Heritage defines cultural heritage as a multilayered phenomenon extending from oral traditions to social practices, from rituals to craftsmanship (UNESCO, 2003). This approach frames cultural heritage conservation not only as

the restoration of physical assets but also as a process that requires the sustainability of knowledge, skills and social meanings.

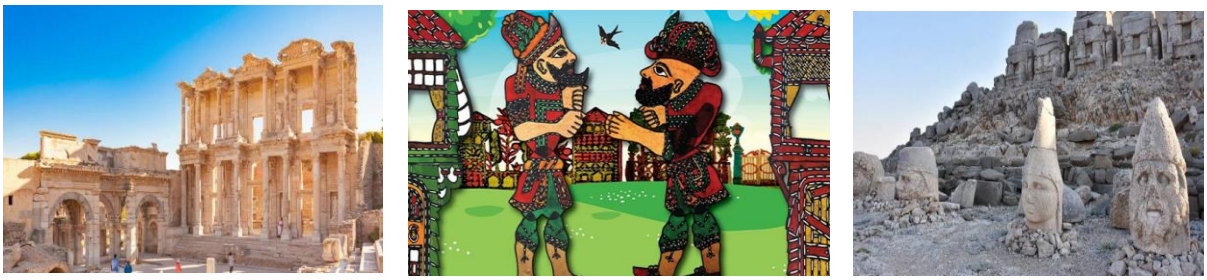

Figure 1. Examples of Tangible and Intangible Cultural Heritage

Cultural heritage conservation and transmission are strongly supported by ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), one of the most important institutions in this field, which emphasizes the effective use of technological developments. According to ICCROM (2020), tools such as digitization, artificial intelligence and virtual/augmented reality provide contemporary methods for "documentation of cultural heritage, risk assessment, development of conservation strategies and engagement with communities."

In recent years, academic studies at the intersection of digital technologies and cultural heritage have gained considerable importance. The study titled *A Systematic Review of Virtual 3D Reconstructions of Cultural Heritage in Immersive Virtual Reality* notes that VR-based three-dimensional reconstructions have become a common tool in the reconstruction of lost or damaged cultural assets (Garcia et al., 2024). Similarly, *Virtual Reality with 360-Video Storytelling in Cultural Heritage* shows that VR technology enriches user experience in cultural spaces and facilitates the establishment of emotional bonds with historical contexts (Skola et al., 2020).

The inclusion of AI in conservation practices provides critical contributions in terms of restoration, damage detection and preventive conservation. In the study *Cross-Material Damage Detection and Analysis for Architectural Heritage Images* (Xu et al., 2025), AI-based object recognition algorithms were developed to detect damage in architectural structures and achieved high accuracy rates, especially in complex deterioration types. Moreover, in the research titled *Towards AI-Assisted Preventive Conservation in Libraries*, deep learning methods were used to enable early detection of biological deterioration caused by fungi and insects in old manuscripts (Schirrmeister et al., 2025).

On the other hand, VR and digital storytelling offer important opportunities in the interaction between cultural heritage and visitors. The study *Digital Storytelling in Cultural Heritage: Audience Engagement in the Interactive Documentary New Life* enabled audiences to establish an active relationship with historical narratives (Nisi et al., 2021); *Digital Storytelling and Audience Engagement in Cultural Heritage*

Management: A Collaborative Model demonstrated that it is possible to increase cultural participation through digital city applications (Economou & Meintani, 2011).

All these studies show that AI- and VR-based applications are not only technical innovations for the conservation, reconstruction and experiencing of cultural heritage but also strategic tools in terms of sustainability, public participation and the safeguarding of cultural authenticity. As UNESCO also emphasizes, the ethical, inclusive and contextually sensitive use of digital technologies will be decisive in the transmission of cultural heritage to future generations (UNESCO, 2021).

2.MATERIALS and METHOD

2.1 Aim

The aim of this study is to present, from the perspective of existing academic research, the opportunities and challenges related to artificial intelligence and virtual reality applications in cultural heritage sites. The objectives of the research can be listed under four headings:

1. To reveal the conceptual foundations of artificial intelligence and virtual reality technologies in the context of cultural heritage conservation.
2. To evaluate the compatibility of these technologies with UNESCO and other international heritage principles.
3. To examine application models through selected examples from the literature (e.g., Design and Evaluation of a Real-World Virtual Environment for Architecture and Urban Planning, Digital Storytelling and Narratives in Cultural Heritage Sites, A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage).
4. To discuss advantages, limitations and recommendations derived from the applications and to contribute to future directions.

2.2 Method

This research offers a perspective on studies conducted to ensure the sustainability of cultural heritage sites through virtual reality and artificial intelligence applications. It employs a qualitative literature review to examine academic studies on the challenges and potential of cultural heritage, artificial intelligence and virtual reality applications. The following steps were followed in the research method:

1. Academic databases (Scopus, Web of Science, Google Scholar) were searched using the predefined keywords “cultural heritage + virtual reality”, “augmented reality + cultural heritage”, “digital storytelling heritage”, “heritage + artificial intelligence”.

2. Influential studies in the literature, such as Design and Evaluation of a Real-World Virtual Environment for Architecture and Urban Planning (Drettakis et al., 2007) **and** *Digital Storytelling and Narratives in Cultural Heritage Sites*, were taken as a basis, and key references cited in these papers were identified and examined.
3. The obtained articles were selected based on scientific quality, contribution to the field and application dimension, and were subjected to systematic reading.
4. The texts were analyzed thematically, and common concepts, example applications, advantages and constraints were classified.
5. Finally, the findings were synthesized and a conclusion and recommendations section was developed.

3. CONCEPTUAL FOUNDATIONS and TECHNOLOGICAL APPROACHES

3.1 Artificial Intelligence (AI) and Cultural Heritage

Artificial intelligence includes approaches such as machine learning, deep learning, computer vision and natural language processing (NLP). In the field of cultural heritage, AI can be used for the following purposes:

- Automatic recognition of structures/cubic elements and material classification through image processing.
- Detection of damage or deterioration: analysis of data such as cracks, moisture effects and surface degradation.
- Suggestions for virtual restoration: predictive completion of missing parts of lost decorative motifs.
- Analysis of user behaviour: developing personalized experiences through the analysis of interaction data from museums/visitors.

Although AI applications in the field of cultural heritage are currently limited, they have increased in recent years, particularly in the areas of image processing and modelling. In this context, providing information layers such as shade, resting areas, access to water and barrier-free routes via AI in open-air museums and cultural landscape routes is a low-cost approach that strengthens both accessibility and visitor health. Especially in cultural landscapes, VR is well suited to producing scenarios that support health-related experiences such as relaxation and attention restoration through the multisensory presentation of green spaces and water elements.

3.2 Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR)

VR (Virtual Reality): A technology that transports the user into a fully computer-generated environment. In cultural heritage sites, it is used for virtual tours, reconstructions and simulations.

Figure 2. A View from a VR (Virtual Reality) Application

AR (Augmented Reality): A technology that enriches the real world by overlaying computer-generated layers. For example, projecting graphics of an historic façade's former appearance onto its current image.

Figure 3. A View from an AR (Augmented Reality) Application

MR (Mixed Reality): Environments in which VR and AR components are combined and in which both virtual objects and the real environment interact.

Figure 4. A View from an MR (Mixed Reality) Application

In the study by Boboc and colleagues, an overview is provided of AR applications in the field of cultural heritage over the last decade, and modes of intervention and dimensions of user experience are examined (Boboc et al., 2022). For instance, AR technology offers enriched information to users by superimposing an information layer onto the real environment. Particularly when producing nature-based scenarios, VR content can balance multisensory elements such as vegetation, the sound of water and wind.

Figure 5. Example of a Mobile AR Application Designed to Enhance Tourist Experience, by Boboc et al. (2022)

3.3 Digital Storytelling and Interaction

Digital storytelling is a method of presenting historical narratives in digital environments using text, visuals, sound and animation tools. In cultural heritage sites, it aims to provide storytelling to visitors and to convey the history of the place experientially. Interactive digital storytelling allows the user to influence the course of the story through their choices, thereby positioning the visitor as a more active and meaningful participant. The “Narralive” project by Vrettakis et al. offered visitors the opportunity to create and experience stories in a mobile environment (Vrettakis et al., 2019).

4. FİNDİNGS

4.1 Virtual Environment Design – Findings from the Study “Design and Evaluation of a Real-World Virtual Environment for Architecture and Urban Planning” by Drettakis et al.

The study titled *Design and Evaluation of a Real-World Virtual Environment for Architecture and Urban Planning* presents a methodology for the design and evaluation of VR environments in the context of architecture and urban planning. Based on a user-centred design approach, the study emphasizes the integration of feedback from architects, engineers and decision-makers at early stages. Narratives enriched with natural elements can be prepared to strengthen visitors’ awareness of emotional attachment by linking them to biophilic design principles.

Some of the main findings identified in the study are as follows:

- The audiovisual realism of the environment (e.g., shadows, plant details, three-dimensional sound) significantly enhances users' sense of space and perception of scale.
- The involvement of users in the design process from the beginning enables the VR environment to be tailored to user expectations.
- Experimental evaluations were conducted both in laboratory settings and real usage environments, and both settings were reported to yield complementary results.

This study shows that VR in architectural projects has potential not only as a visualization tool but also as a decision-support and design communication tool.

4.2 AR/VR Applications in Cultural Heritage

Boboc et al. (2022) reviewed AR applications in the context of cultural heritage and identified both the aspects of AR that enhance visitor interaction and those that can assist conservation processes. For example, digital information overlays, reconstruction layers and user-interactive guidance become possible with AR.

In the study conducted by Ariya and colleagues, the impact of VR, VR360 and MR technologies on visitor experience was examined; panoramic video and VR-based historic city tour applications were found to strengthen visitors' perception of the city's history (Ariya et al., 2025).

The article *Virtual Reality Simulation in Urban Design Processes* by Ali et al. (2025) addressed the impact of VR simulations on decision-making processes in the context of urban design and highlighted the advantages of VR in terms of spatial understanding, interactive visualization and stakeholder participation. The positive effects of VR technology on decision-making processes and the flexibility it provides in urban design workflows are among the findings of the study (Ali et al., 2025).

In addition, interactive digital storytelling approaches for integrating narrative methods with VR environments in cultural heritage have attracted attention. For example, the study *Interactive Digital Storytelling in Cultural Heritage* proposes systems in which visitors can determine the flow of the story through their choices, and discusses the effect of user agency on experience (Katifori et al.).

Furthermore, in the work *A Reference Architecture for Gamified Cultural Heritage Applications Leveraging Generative AI and Augmented Reality* by Martusciello and colleagues, the integration of generative AI with gamification approaches and AR is proposed, emphasizing the importance of making user interaction with content adaptive and personalized (Martusciello et al., 2025).

5. RESULTS and DISCUSSION

Recent research demonstrates that virtual reality (VR) and artificial intelligence (AI) applications enhance user interaction and support the sustainable memorability of cultural heritage. This paper has addressed the use of AI and VR technologies in cultural heritage sites from both theoretical and applied perspectives. According to the findings obtained:

Kültürel Miras Alanlarında Yapa…

- VR/AR technologies offer multiple benefits for the documentation and simulation of cultural heritage, visitor interaction and restoration support systems. In particular, the realism of VR environments and user participation deepen spatial perception.
- Artificial intelligence can provide automatic analytical and recommendation systems through image processing and generative models. This offers contributions such as reducing restoration costs and optimizing conservation strategies.
- Digital storytelling and interactive narratives tend to transform the visitor from a passive viewer into an active participant; this approach increases both educational and experiential value.
- However, high costs, challenges in data acquisition, hardware requirements and copyright/ethical issues emerge as significant constraints in the implementation of these technologies.
- Considering UNESCO's cultural heritage principles, it is important that these technologies be structured in line with the principles of "priority of conservation", "transparency of intervention" and "sustainable access".

6.CONCLUSION

- A phased implementation model (pilot scale → upscaling) should be adopted in projects, with tests initially carried out in small areas.
- High-resolution cameras/drones and LIDAR technologies should be used in data collection processes, and accuracy should be ensured with ground control points (GCP).
- A user-centred design approach (cultural heritage experts + users + community participation) should be adopted from the beginning of the process.
- AI models should be carefully selected in terms of "transparency" and "interpretability", and black-box models should be avoided.

- Copyrights, data use permissions and digital ethics should be planned from the outset; open-source alternatives should be preferred over platforms such as Google Earth wherever possible.
- Collaboration should be established with UNESCO and relevant heritage institutions, and strategies compatible with conservation principles should be developed before technological interventions.

In conclusion, artificial intelligence and virtual reality technologies offer strong opportunities in the field of cultural heritage; however, their successful implementation requires multidisciplinary approaches, careful planning and close attention to ethical responsibilities.

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Ecosystem-Based Microlandscape Interventions in Urban Children's Playgrounds

Kentsel Çocuk Oyun Alanlarında Ekosistem Temelli Mikro Peyzaj Müdahaleleri

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Abstract

The lack of green spaces and recreational spaces in urban areas is increasingly felt. Children are the most disadvantaged group affected by these deficiencies. The study addresses not only the design of recreational spaces for children but also ecosystem-based approaches to children's playgrounds in urban areas. The study aims to develop solutions to problems such as dense urban development, lack of green spaces, and microclimate disruptions, thereby increasing children's interaction with nature and developing sustainable spatial strategies.This study will examine open green spaces (urban voids) and children's playgrounds in Rize's city center to identify existing spatial and ecological problems. Solutions will be proposed for the most urgent and solvable problems identified, and these proposed solutions will be shared with the local government. Analyses of the study areas will include on-site observations and user profile assessments, as well as landscape elements. Based on the data obtained, ecosystem-based microlandscape interventions for recreational spaces (children's playgrounds) will be developed, and design approaches that will enhance children's interaction with nature will be proposed. Sustainable design proposals will be developed at a spatial scale. The study will utilize methods based on qualitative analysis and local ecological assessment.

Microlandscape interventions developed for open green spaces (urban voids) and children's playgrounds in the Rize city center, the subject of this study, have been identified as playing a significant role in both urban landscape planning approaches and the physical and psychological development of children. Observations and user profile assessments revealed that children's opportunities to interact with nature in playgrounds were quite limited. Furthermore, microclimatic disturbances in the areas (lack of shade, overheating, and inadequate air circulation) were also found to negatively impact children's play experience. The findings demonstrate the necessity of ecosystem-based microlandscape interventions and the critical role these interventions will play in children's healthy development and sustainable urban living. The study revealed that the current spatial and ecological conditions of children's playgrounds in Rize's city center are inadequate to meet children's developmental needs. In particular, the lack of green space, the predominance of impermeable surfaces, and microclimatic disruptions limit children's interaction with nature and negatively impact their play experiences. This poses a risk to children's physical, cognitive, and emotional development. In this context, the design

proposals developed within the study not only offer spatial improvements for children but also emphasize the importance of nature-based approaches in urban landscape planning. Reconsidering children's playgrounds through ecosystem-based micro-interventions is a strategic necessity for both children's healthy development and the climatic and environmental resilience of cities. Local governments' consideration of these recommendations will be a crucial step in building a sustainable and inclusive urban life.

Keywords: Micro-landscape interventions, Ecological design, Landscape design, Children, Children's playground.

1. INTRODUCTION

A portion of public spaces allocated for the purpose of enabling children to play are defined as playgrounds. Throughout the twentieth century, the creation of public playgrounds in parks, residential areas, and various urban environments has become a common practice. The primary purpose of these spaces is not only to provide children with opportunities for fun and development but also to protect them from risky environments such as heavy traffic and from negative social influences such as juvenile delinquency (Frost, 1986; Hart, 2002).

The design of a playground should be structured to offer children multifaceted experiences. In this context, playgrounds should provide spaces and opportunities for children to come together and socialize. It is also important that they offer opportunities to develop physical skills such as climbing, balancing, and testing themselves and others. The playground should encourage exploration and controlled risk-taking behaviors, strengthen the sense of solidarity, and include elements of movement, color, and excitement. In addition, it should contain equipment or landscape arrangements that support imagination and creativity and allow for children’s need to make noise, be energetic, and play joyful games. The use of different textures, materials, heights, levels, and surfaces creates diversity that supports children’s sensory and motor development (Jansson, 2010).

The landscape design of open spaces plays a significant and effective role in children’s development and well-being. Therefore, to ensure that the design of these spaces is compatible with children’s needs and functional, appropriate landscape design principles and standards must be reviewed and applied. The aesthetic and functional value of a landscape largely depends on how the designer utilizes its elements and components. A competent landscape architect can enhance the harmony, appeal, and usability of open spaces by integrating the natural processes of change and growth of plant elements with the design of hardscape components (Farooq and Kamal, 2021).

Landscape components are generally examined in three main groups: plant elements, structural elements, and water features (Booth, 2011). The stability, portability, and openness of these elements, with which

children can interact, should be evaluated in terms of design and function. Environmentally, the water element contributes to climate regulation, temperature control, and the reduction of acoustic pollution (Dagher and etc., 2022). Mårtensson (2004), Fjørtoft & Sageie (2000), and Boldemann et al. (2006) emphasize that play is significantly influenced by the landscape structure in which it takes place, and argue that diversity and richness in landscape (vegetation, topography, and variety in landscape elements) are important for encouraging play and increasing children's social interaction.

In playground design, these spaces should not be considered as isolated areas but should be evaluated in interaction with the social and environmental context. In environments where people live, spend time, and where natural elements are present, play opportunities can continuously emerge and be developed. This approach contributes to the creation of playgrounds that are more frequently visited and sustainable over time (Noschis, 1992; Herrington, 1999). The character and overall design of a space play a decisive role in the success of frequently visited playgrounds. Diversity, natural elements, enclosure, and topography are important factors that increase the attractiveness of these areas. Content holds secondary importance in terms of the balanced use of natural materials and play equipment. In addition, factors such as opportunities for social interaction and the proximity of playgrounds to residences and schools also affect visitation frequency. Children's participation and their impact on the environment strengthen the dynamism of the space, while the opportunity for free play enhances the value of these spaces. On the other hand, while new or different equipment may create short-term interest, it is not considered sufficient on its own for continuous visits (Jansson, 2010).

Furthermore, due to the increasingly evident impacts of climate change today, the lack of green spaces and microclimatic disturbances in urban areas directly affect the use of children's playgrounds and their play experiences (Bekci, 2021). The ability of cities to develop resilience against climate change, prevent it, and adapt to it is associated with the existence of flexible and high-quality urban public spaces designed in accordance with sustainable design principles (Bekci et al., 2013; Matos Silva & Costa, 2016; Sanei, Khodadad & Khodadad, 2018). In this context, it can be said that sustainable urban planning against climate change in the built environment involves the integration of passive design strategies and nature-based solutions (Bekci et al., 2012; Ali & Dinçer, 2025).

In addressing the spatial and ecological problems faced by contemporary cities, designing children's playgrounds through ecosystem-based micro-landscape interventions emerges as a significant approach. Rapid urbanization and dense construction processes lead to a reduction in green spaces, which in turn restricts the spaces where children can interact with nature. This situation brings about various problems that negatively affect children's physical, cognitive, and emotional development. Therefore, in the planning and design processes of children's playgrounds, it is increasingly important to adopt ecosystem-based approaches

integrated with nature, in addition to focusing on safety and functionality. In this context, this study examines the current state of children's playgrounds located in the city center of Rize, where dense construction and housing pressure are high, and proposes ecosystem-based micro-landscape interventions.

2. MATERYAL and METHOD

2.1. Study Area

Within the scope of the study, open green spaces located in the city center of Rize were identified as research areas. These areas were selected primarily from among public spaces that are heavily preferred first by children and then by parents. In selecting the sites, open green spaces that children use voluntarily or compulsorily were taken into consideration, with particular attention given to identifying the places where children enjoy spending time and feel happy while using them. As a result of the observations, efforts were made to identify one space each where children play football, ride bicycles, and play in playgrounds. In this process, three main types of spaces were brought to the forefront and included in the study: (1) children's playgrounds, (2) schoolyards, and (3) streets/neighborhood gaps (urban voids). Each of the selected areas is a place where children play, and they are all highly valuable. Accordingly, three sample areas were chosen for the study: (1) the Renovated Fetih Park (as it has been redesigned as a children's playground), (2) Reşadiye Middle School (due to its large garden area), and (3) Eminettin Neighborhood (for its safe location at the neighborhood scale). Although each of these areas has different physical and administrative characteristics, they serve similar functions in terms of addressing the play needs of children.

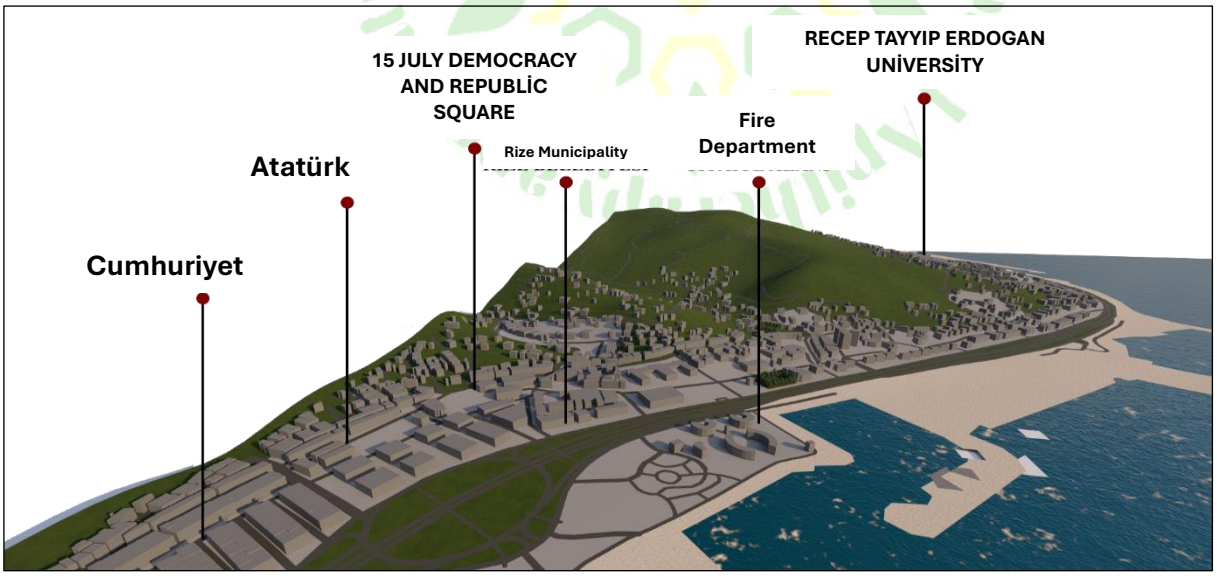

Figure 1. Study Area (Examination of the Proximity of the Selected Children's Playgrounds to the City Center)

Fetih Park, selected as one of the study areas, is located near the city center of Rize, within the boundaries of the Eminettin Neighborhood, adjacent to the Governor's Office building. The park was named in reference to Rize's conquest date, August 28, 1461, and holds symbolic value in the urban memory within

this historical context. It has been defined as a landmark point from past to present. The park's long-term use as a resting area led to its deterioration over time, causing it to become neglected and lose its functionality. For these reasons, the recently renewed Fetih Park design project has transformed the park into a more modern and functional structure.

The main goal of the Fetih Park design project was to provide urban residents with high-quality spaces for outdoor recreation, relaxation, and social interaction. Conceptually, playgrounds with different characteristics were designed at various points throughout the park. With its new concept, Fetih Park has become the first public park in the city to feature a concept approach centered on children's playgrounds. Within the scope of this study, Fetih Park is evaluated in terms of children's playground use, and its transformation over the years and proximity to the city center are illustrated in Figure 2.

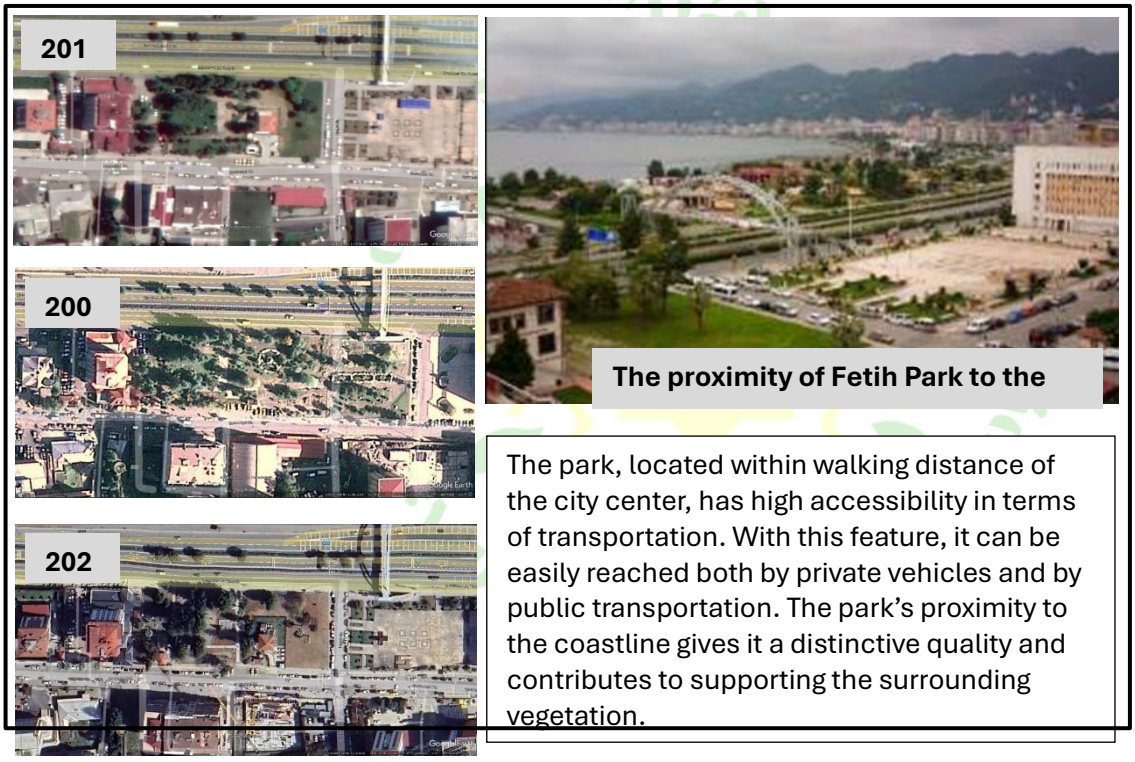

Figure 2. Recreational Area Change of Fetih Park Selected as the Study Area Over the Years

2.2. Data collection and examination of ethical principles

In this study, the data collection process was planned and conducted based on qualitative methods. The data were obtained from three main sources: (1) field observations, (2) semi-structured participant interviews, and (3) examination of existing physical-spatial documentation. Within the scope of the fieldwork, Fetih Park, Eminettin Street, and Reşadiye Middle School garden, located in the city center of Rize, were examined on-site, and the physical conditions were recorded with photographic documentation.

Semi-structured interviews were conducted with individuals using children's playgrounds, focusing on their expectations, usage habits, and the level of interaction between the playgrounds and their surroundings. To ensure full compliance with ethical principles, participants were provided with clear information regarding the purpose, methodology, and use of the research, and all participants were informed. Participation was based on voluntariness, and attention was paid to maintaining anonymity and confidentiality during the interviews. The research was carried out with the approval of the Ethics Committee of Recep Tayyip Erdoğan University (05.11.2025).

2.3.Analysis of the research problem

This research focuses on the spatial and ecological deficiencies of children's playgrounds and open green spaces located in city centers in Turkey. Within the scope of the study, three main types of spaces that are heavily used by children—playgrounds, schoolyards, and neighborhood gaps—were examined, and their physical characteristics, user profiles, and environmental conditions were evaluated using qualitative methods. In this context, the study thoroughly explores the question: "How can children's interaction with nature be enhanced through ecosystem-based micro-landscape interventions in playgrounds located in city centers?" The research problem addresses the impact of both the physical environment and user needs on spatial design through a holistic approach, emphasizing the significance of data-driven and nature-oriented design decisions for children's healthy development and sustainable urban life.

2.4.Model of the Research

In the selection of study areas, criteria such as the density of child users, physical accessibility, diversity of vegetative and structural elements, surface permeability, and levels of shading were taken into consideration. Each selected study area was included in the sample because they represent different spatial characteristics while also exhibiting comparable ecological features. The main data collection tools used in the research consisted of field observations, photographic documentation, and user surveys.

Through the surveys conducted with children, parents, and local residents, the safety, comfort, level of interaction with natural elements, and design adequacy of the playgrounds were evaluated. The surveys were administered during fieldwork in November 2025, and all participants responded on a voluntary basis. The data obtained were later subjected to statistical analysis. The survey results were transferred to the SPSS (Statistical Package for the Social Sciences) program and evaluated using two main statistical analysis methods.

- **T-test:** Applied to determine significant differences between participant groups (e.g., gender, age, frequency of use).
- **Correlation Analysis:** Used to reveal the relationship between the physical characteristics of the areas and the levels of user satisfaction.

The purpose of conducting these analyses is to enable a statistical comparison between the existing ecological adequacy of children's playgrounds and user perceptions. This research focuses on identifying the deficiencies and improving the most frequently used children's playgrounds through surveys and observations. Three playgrounds with different characteristics, frequently used by children, were included in the study, emphasizing the formation of user (parent/child) profiles.

Following data collection, the findings were transformed into spatial design proposals using artificial intelligence algorithms. During this process, multiple AI-based design and analysis tools were used simultaneously. In this context, the study consists of three stages:

1. Survey- and Observation-Based Data Collection: Documentation of the current state of children's playgrounds and identification of users' (parents and children) expectations regarding ecologically based playgrounds.
2. Data Analysis and Digital Modeling: Transfer of collected data into digital format and analysis through the SPSS program. Spatial modeling in the CAD environment and analyses conducted according to user demands (unreal design approaches—desired—expected).
3. AI-Supported Scenario Development: Generation of design alternatives using genetic algorithms and decision support systems, followed by their comparative evaluation.

Through these research models, a participatory and technology-assisted design process will be evaluated within a holistic framework that takes into account pedagogical, ecological, and technological parameters, with a focus on user needs.

In the proposed designs for children's playgrounds, artificial intelligence algorithms were employed as follows: Midjourney was used to ensure harmony between color combinations and playground equipment in the designs; DALL·E 3 was utilized to visualize color contrasts of playground equipment and user interaction scenarios; Runway ML was applied to transform design presentations into dynamic visuals; and Interior AI was used to test spatial layout decisions and design seating units integrated with the landscape.

3. RESULTS and DISCUSSION

Children's playgrounds located in urban open green spaces contribute to the diversity of recreational activities within cities and serve as a factor that positively influences the standard of urban life. The use of various alternative solutions that positively affect the city's image also enhances the quality and diversity of urban spaces. It should be noted that, in addition to the quantitative and qualitative value of each defined and interpreted urban area, the originality and usability of the proposed playgrounds for the study area are also of great importance.

As the main framework of the study, the concept of the "children's playground" was examined in accordance with functional and ecological values and evaluated within the scope of sustainable landscape

planning and design practices. Figure 3 presents the locations of the study areas: (1) the Renovated Fetih Park (redesigned as a children's playground), (2) Reşadiye Middle School (featuring a large garden area), and (3) Eminettin Neighborhood (located in a safe position at the neighborhood scale).

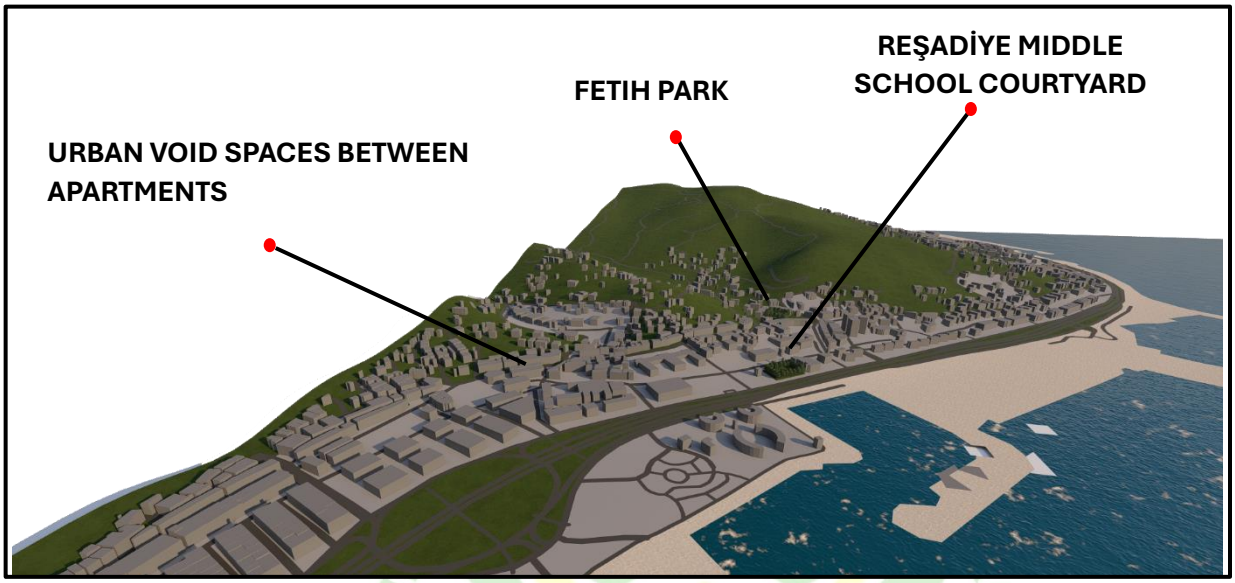

Figure 3. Locations of the Study Areas within the City Center of Rize

The data obtained from the surveys conducted with users of open green spaces—particularly those used as children's playgrounds throughout Rize—were evaluated using the correlation analysis method, and the results are presented in Table 1. Among the respondents, 63% were female and 37% were male. It was determined that even though some female participants did not have children of their own, they were involved in the care of a relative's child (r = .570**). It was also found that married participants had at least one child (r = -.748**) and lived in a residential complex (r = .325**). In addition, individuals who were involved with at least one child in playgrounds were observed to have a positive view of local governments' policies on "maintaining sustainability and ecological balance in park and green space planning" (r = .402*). It was also found that individuals living in residential complexes had their children's playground needs met (r = .388*). Furthermore, it was emphasized by participants that while parks in the city center of Rize meet children's physical and social needs, the inclusion of parks and green space planning by local governments contributes to maintaining sustainability and ecological balance (r = .397*). Participants also noted that park areas provide spaces where individuals of all age groups can spend time together (r = .392*; r = .320*), that activities in parks and green areas contribute to the social integration of the community (r = .363*), and that parks in Rize's city center possess design features that support interaction with the natural environment (r = .407*; r = .660**). On the other hand, participants also emphasized that as individuals of all ages spend time together in park spaces, these areas contribute to socialization within the community (r = .418**).

Table 1. Analysis of Open Green Spaces in the City Center of Rize within the Scope of Children's Playgrounds

	b	c	d	e	f	g	h	ı	j	k
a. What is your gender? (1: Female; 2: Male)	-,027	**,570****	,157	-,123	-,301	-,235	,162	,097	,103	,037
b. Are you married? (1: Yes; 2: No)		,158	**-,748****	**,325****	,032	-,012	,007	-,225	-,044	-,006
c. Are you accompanying or caring for a child in the playground? (1: Yes; 2: No)			-,142	,274	-,239	-,122	**,402***	-,096	,003	,180
d. If you have children, how many do you have? (1: 1; 2: 2; 3: 3; 4: 4 or more)				-,280	-,109	-,064	-,219	,209	,137	-,143
e. Do you live in a residential complex (gated community)? (1: Yes; 2: No)					**,388***	,009	,058	-,073	,173	,025
f. Does your residential area meet your need for open green spaces? (Rate on a scale from 1 to 5)						,208	,050	,169	,142	,210
g. Do the parks in Rize city center meet children's physical and social needs? (Rate on a scale from 1 to 5)							**,397***	**,392***	**,363***	**,407***
h. Do the local government's park and green space arrangements protect sustainability and ecological balance? (Rate on a scale from 1 to 5)								**,320***	,220	**,660****
ı. Do the parks include spaces where individuals of all age groups can spend time together? (Rate on a scale from 1 to 5)									**,418****	,273
j. Do the activities in parks and green spaces contribute to the social cohesion of the community? (Rate on a scale from 1 to 5)										,270
k. Do the parks in Rize city center have design features that support interaction with the natural environment? (Rate on a scale from 1 to 5)										-

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)

In this study, the presence of meaningful relationships between certain questions was examined using three comparative queries. The obtained data were then analyzed through the t-Test method.

- When evaluating the question, *"Is there a significant relationship between the contribution of parks and green spaces in Rize city center to the physical and social development of the child you are accompanying or a relative's child in the playground?"*, it was found that the participants' level of direct engagement with a child did not have a statistically significant effect on this perception. In other

words, there is no significant relationship between the participants' involvement with a child and their perception of the contribution of parks and green spaces to child development (sig = 0.470; Mean Difference = 0.340). The obtained significance level (sig = 0.470) indicates that the relationship is not statistically meaningful. Although the mean difference (Mean Difference = 0.34) suggests a slight variation in the perception of children's physical and social development, this difference is not statistically reliable.

- When examining the question, *"Is there a significant relationship between participants' marital status and the perception that park areas provide inclusive spaces where individuals of all age groups can spend time together?"*, the results revealed a significant relationship between these two variables (sig = 0.029; Mean Difference = 0.600). The obtained significance level (sig = 0.029) indicates a statistically meaningful relationship. This finding shows that marital status significantly influences the perception of inclusivity in park spaces, suggesting that married and unmarried participants differ in their views on whether parks provide inclusive environments for all age groups.
- When evaluating the question, *"Is there a significant relationship between living in a residential complex and the perception that activities in parks and green spaces contribute to social cohesion?"*, it was found that there is no significant relationship between these variables (sig = 0.146; Mean Difference = -0.476). The obtained significance level (sig = 0.146) indicates that the relationship is not statistically meaningful. This finding demonstrates that the nature of the living environment does not significantly affect perceptions of the social contribution of park activities. Whether participants live inside or outside a residential complex does not create a meaningful difference in their views regarding the role of parks and green spaces in fostering social cohesion.

Findings obtained from the SPSS analyses indicate that:

- For **Reşadiye Middle School Garden**, increasing **plant diversity** is necessary (Figure 5),
- For the **playground located between apartment buildings**, the use of **natural materials** and the promotion of **permeable surfaces** are recommended (Figure 4),
- For **Fetih Park**, the development of **shading structures** and **microclimate-regulating elements** is needed (Figure 6).

These recommendations are highly significant in addressing the discrepancies between the current conditions of the sites and user expectations, as well as in enhancing children's interaction with nature.

Figure 4. Eminettin Neighborhood Street Area Selected as a Study Site

Figure 5. Reşadiye Middle School Garden Selected as a Study Site

Completed and opened to the public in 2025, Fetih Park has become the most frequently used open green space by the local residents in the city center of Rize. Although the construction of the park was completed relatively recently, it stands out with its large and safe playgrounds that appeal to both children and parents. According to the survey results conducted within the scope of this study, 54% of participants reported that they had used this open green space before the renovation of Fetih Park. Among these users, 41% used the area mainly for walking, 35% for shade and resting purposes, and 24% for children's playground activities. However, before its renovation, the park was not widely preferred by users due to several factors, including lack of safety, poor maintenance, absence of diverse activity opportunities, and low public awareness of the

park's existence. In contrast, following the renovation, Fetih Park is now used by 38.5% of visitors for sports and walking, 33.3% for resting in shaded seating areas, and 25.6% for children's play activities.

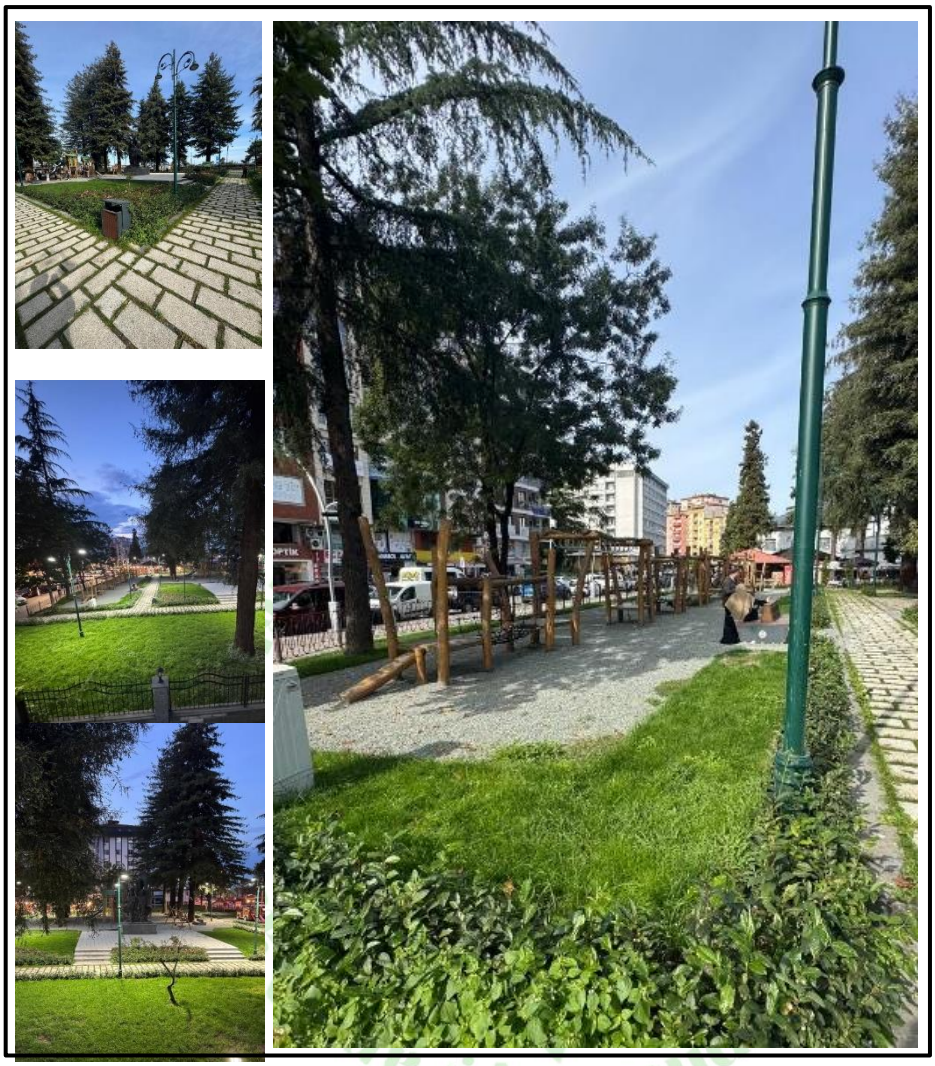

Figure 6. Visuals of the Renovated Fetih Park

According to the survey findings on the renovated Fetih Park, participants rated several aspects of the park at a moderate level: 41% evaluated the park's recreational and ecological requirements as moderate, 30.8% assessed the vegetated resting and shaded areas as adequate, 43.6% considered the ground permeability and drainage of the park as sufficient, 41% stated that the park's design does not reflect Rize's cultural identity, 35.9% found the selection of materials and plants insufficient in terms of aesthetics and sustainability, 41% highlighted concerns regarding the continuity of maintenance, cleanliness, and safety, and 41% indicated that local authorities do not adequately carry out information sharing and maintenance activities related to the park.

In this context, questions focusing on the design of the children's playground within the renovated Fetih Park were directed to users, and the responses obtained are summarized in Table 2 below.

Table 2. Users' Expectations from the Renovated Fetih Park

•More flowers and well-maintained spaces
• Lighting should be increased, play equipment should be made entirely of natural materials, and seating areas for adults should be made more comfortable
• There could be more greenery and social spaces
• We feel the lack of safety, seating elements, and areas sheltered from rain and sun; we would also like to see more trees and flowers
• Its proximity to residential areas, safety, and appeal to all age groups are important
• Equipment, accessibility, and safety should be improved
• Grass and natural stones could be used instead of concrete surfaces. Additionally, shaded seating areas around the playgrounds could be increased. Activities such as flower planting and litter collection could both encourage social interaction among children and raise awareness about environmental cleanliness and protection.
• Play areas for younger and older children should be separated, and restrooms should be available
• Plant fruit trees and ensure their maintenance
• More planting is needed
• The equipment used in the park should be made from materials reflecting the city's identity, and maintenance and safety should be carried out regularly
• Green areas should be increased, and planting should be done properly
• Attention should be paid to the implementation of boundary elements
• In the city center of our province, once known for its greenery, green spaces have almost disappeared. Parks have become concrete; compared to the past, paved surfaces have increased
• The lack of gazebos could be addressed; more green areas for seating could be added
• Plants suitable for our city's climate and character should be used
• It should be designed according to purpose and age group while preserving the natural texture
• It gives quite an artificial appearance. Instead, I would prefer the previously existing natural green areas along Rize's coastline, with trees and small hills
• We would like to have swings for adults as well
• More innovative, functional, and modern activity areas should be created under an environmental recycling campaign
• The number of green areas in Rize city center should be increased, and existing parks should be

regularly maintained. Safety and diversity should be prioritized in children's playgrounds, with play equipment suitable for all age groups added

According to the results of this research, it has been determined that the renovated Fetih Park provides an environment that supports the physical and social development of children. When participants' expectations for playgrounds, usage habits, and levels of interaction with the environment are examined, it is observed that Fetih Park largely meets these needs. The park's design—particularly the inclusion of age-appropriate play equipment, the balanced distribution of open and green spaces, and the consideration of safety elements—has been evaluated positively. In addition, the physical conditions of the park, supported by photographic documentation, align with the goal of creating a child-friendly environment. In this context, the planning of Fetih Park as a public space specifically for children is commendable, as it prioritizes children's needs within urban spatial arrangements. However, based on the findings, Fetih Park in Rize can be considered an open green space that moderately meets users' basic recreational needs but remains open to improvement in terms of accessibility, maintenance, aesthetics, and representation of cultural identity. It should be noted that participants emphasized the need for improvements related to climatic adaptation, drainage systems, and maintenance services. On the other hand, the park's shaded areas, walking paths, and children's playgrounds were identified as the most preferred sections. In conclusion, to enhance user satisfaction, it is recommended to strengthen accessibility, renew the planting and aesthetic arrangements to reflect local identity, and increase the frequency and quality of maintenance and public information activities.

4. CONCLUSION

In today's digitalized world, children are increasingly exposed to technological devices, leading to a lack of physical activity and a more sedentary pattern of growth. Unfortunately, many children are able to fulfill their physical activity needs only during physical education classes or recess periods, which are quite limited in duration.

This situation, commonly observed in schoolyards, also manifests itself in public open green spaces, where similar issues frequently arise and children's opportunities for movement are further restricted.

In this context, considering the limited capacity of existing open green spaces, it is necessary to redesign

or rehabilitate these areas to make them more functional and spacious. Increasing the number of shared-use spaces, implementing flexible recreational designs, and developing alternative usage scenarios stand out as sustainable strategies to support children's physical development and enhance their interaction with outdoor environments (Figure 7).

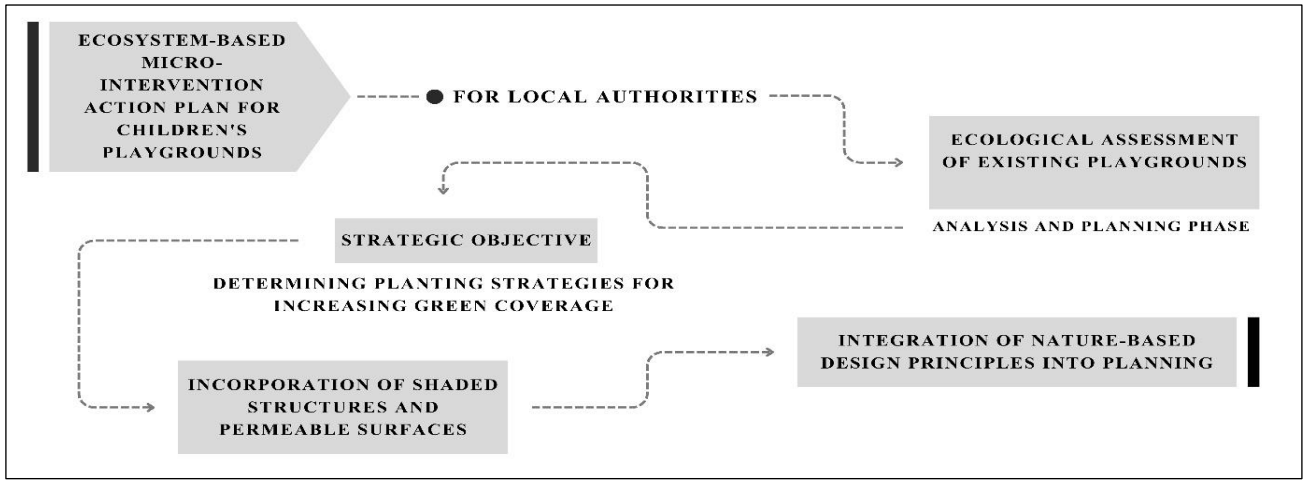

Figure 7. Project Workflow Diagram

The existing spatial and ecological conditions of children's playgrounds in the city center of Rize do not adequately meet the physical, cognitive, and emotional development needs of children. The lack of green texture, the abundance of impermeable surfaces, the insufficiency of shaded areas, and microclimatic degradation limit children's interaction with nature and negatively affect their play experiences. This study reveals that children's playgrounds should be regarded not only as spaces for entertainment but also as ecosystem-based environments for learning and development (Figure 8). Micro-landscape interventions such as the use of natural materials, planting, shaded structures, and permeable surfaces strengthen children's connection with nature while also supporting microclimatic balance in urban areas.

In conclusion, the redesign of children's playgrounds through ecosystem-based micro-interventions is a strategic necessity for both the healthy development of children and the climatic and ecological resilience of urban environments. The implementation of these proposed strategies by local authorities would represent a significant step toward building a sustainable and inclusive urban life.

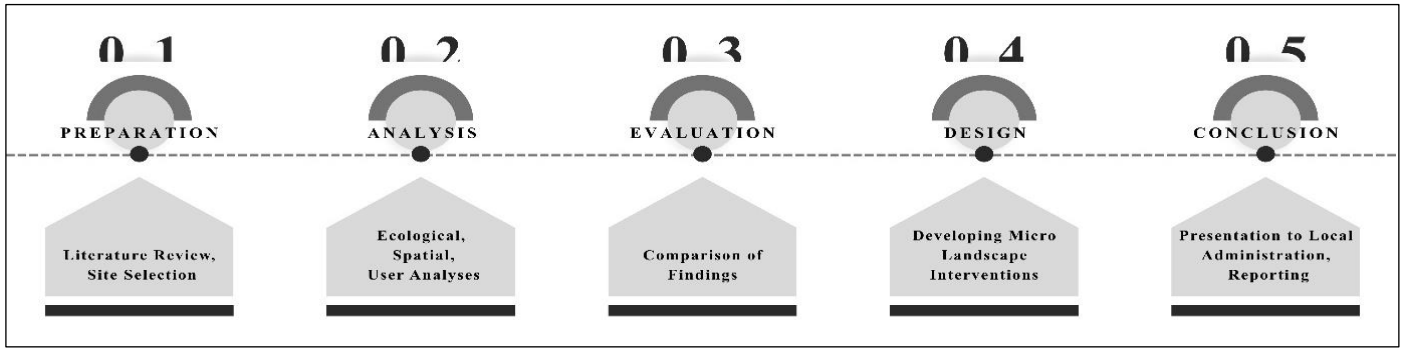

Figure 8. Management Model

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Farklı Azot Dozları ve Biçim Zamanlarının Tritikalenin Ot Verimi ve Kalitesi Üzerine Etkileri

Effects Of Different Nitrogen Doses And Harvesting Times On The Forage Yield And Quality Of Triticale

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Özet

Bu çalışma, farklı azot dozu ve biçim zamanı uygulamalarının tritikale bitkisinin ot verimi ve kalitesi üzerine etkilerini belirlemek amacıyla 2023-2024 vejetasyon döneminde Isparta Uygulamalı Bilimler Üniversitesi Ziraat Fakültesi, Eğitim, Araştırma ve Uygulama Çiftliğinde, tesadüf bloklarında bölünmüş parseller deneme desenine göre üç tekrarlamalı olarak yürütülmüştür. Deneme azot dozları (0, 5, 10, 15 ve 20 kg/da) ana parsellerde, biçim zamanları (başaklanma dönemi, çiçeklenme dönemi ve süt olum dönemi) ise alt parsellerde olacak şekilde kurulmuştur. Çalışmada kuru ot verimi, ham protein oranı, ham protein verimi, NDF ve ADF oranları belirlenmiştir. Araştırma sonuçlarına göre, tritikalede kuru ot verimi 593.7-1483.5 kg/da, ham protein oranı %5.93-9.47, ham protein verimi 43.71-118.35 kg/da, NDF %56.56-70.57 ve ADF %42.18-54.10 arasında değişmiştir. Azot dozları arttıkça kuru ot verimi, ham protein oranı, ham protein verimi artmış, ADF ve NDF oranı ise azalmıştır. Biçim zamanları ilerledikçe, kuru ot verimi, ham protein verimi, NDF ve ADF oranları artmış, ham protein oranı azalmıştır. Sonuçlar bir bütün olarak değerlendirildiğinde, hem verim hem de kalite açısından dekara 20 kg azot uygulaması, tritikalenin süt olum döneminde hasat edilmesi verim açısından, başaklanma döneminde hasat edilmesi ise kalite açısından en yüksek değerleri vermiştir. Yüksek verim ve kalite için dekara en az 15 kg azot uygulanması ve biçimin en geç çiçeklenme döneminde yapılması daha uygun olacaktır.

Anahtar Kelimeler: Tritikale, Azot dozu, Biçim zamanı, Ot verimi, Ot kalitesi.

Abstract

This study was conducted during the 2023-2024 growing season at the Education, Research, and Application Farm of the Faculty of Agriculture, Isparta University of Applied Sciences, using a randomized block design with split plots and three replications, to determine the effects of different nitrogen doses and harvest times on the forage yield and quality of triticale. The nitrogen doses (0, 5, 10, 15, and 20 kg da^{-1}) were set up in the main plots, while the harvest times (heading stage, flowering stage and milk stage) were set up in the subplots.

Hay yield, crude protein content, crude protein yield, NDF and ADF, were determined in the study. According to the research results, the in triticale were hay yield 593.7-1483.5 kg da^{-1}, crude protein content 5.93-9. 47, crude protein yield 43.71-118.35 kg da^{-1}, NDF 56.56-70.57%, ADF 42.18-54.10%. As nitrogen doses increased, hay yield, crude protein content and crude protein yield increased, while ADF and NDF decreased. As the cutting times progressed, hay yield, crude protein yield, NDF and ADF ratios increased, while crude protein ratio decreased. When the results were evaluated as a whole, applying 20 kg of nitrogen per decare yielded the highest values in terms of both yield and quality, while harvesting triticale during the milk stage yielded the highest values in terms of yield, and harvesting during the heading stage yielded the highest values in terms of quality. For high yield and quality, applying at least 15 kg of nitrogen per decare and harvesting at the latest flowering stage would be more appropriate.

Key Words: Triticale, Nitrogen dose, Harvesting time, Forage yield, Forage quality.

GİRİŞ

Ülkemizde üreticilerin alternatif yem kaynaklarına yönelmesinin temel nedeni, mevcut kaba yem açığının yeterli düzeyde karşılanamamasıdır. Bu durum, özellikle kurak koşullara dayanıklı yapısı ve buğdaya yakın verim potansiyeli nedeniyle tritikalenin önemini artırmıştır. Triticale, hayvan beslenmesinde hem tane hem de kaba yem olarak değerlendirilmektedir. Tane formu, özellikle büyükbaş ve kanatlı hayvanların rasyonlarında kullanılmakta olup, besin değeri açısından arpa, buğday ve mısırla benzer düzeyde olduğu bildirilmektedir (Lorenz, 2003). Dünyada tritikale en fazla Fransa, Almanya ve Belarus'da üretilmektedir (FAO, 2020). Dünyada 3,81 milyon ha alanda 15,36 milyon ton (FAO, 2020) üretimi yapılan tritikalenin, ülkemizde 110 bin ha alanda 370 bin ton üretimi yapılmaktadır (FAO, 2023). Türkiye'de en çok ekimi yapılan iller başta Tokat, Balıkesir, Kırklareli, Kahramanmaraş, Çanakkale, Edirne, Kütahya ve Denizli olmak üzere 52 ilde tritikalenin üretimi yapılmaktadır (Alp, 2009).

Bitkisel üretimde verimi artırmak için gübre kullanımı uzun bir geçmişe sahiptir. Kimyasal gübreler, özellikle azotlu gübreler, hem dünya genelinde hem de Türkiye'de bitkisel üretimde özel bir öneme sahiptir (Polat, 2022). Azot, bitkilerin büyüme ve gelişiminde en önemli besin maddelerinden biri olup tahıllarda kullanım etkinliği yaklaşık %33 olarak bildirilmiştir (Raun ve Johnson, 1999). Son yıllarda yavaş salınımlı azotlu gübreler, etkinliği artırmak ve kayıpları azaltmak amacıyla farklı bitkilerde araştırılmaktadır (Mukherjee vd., 2015). Azotun yetersiz kullanımı ekonomik kayıplara yol açarken, aşırı kullanımı çevresel sorunlara sebep olabilmektedir. Bu nedenle doğru azot yönetimi hem ekonomik hem de çevresel açıdan önem taşımaktadır (Baethgen, 2000).

Tahılların kaba yem olarak kullanımı açısından, bitkilerin gelişme evreleri ot verimi ve kalitesi bakımından belirleyicidir. Bitkiler olgunlaştıkça genellikle ot verimi artmakta, ancak ham protein ve sindirilebilirlik oranları azalmaktadır. Geç biçim yapmak kuru ot veriminde artış sağlasa da besin değeri açısından kayıplar meydana gelebilmektedir. Bu nedenle ot üretimi amacıyla yetiştirilen tahılların süt olum evresine kadar değerlendirilmesi önerilmektedir (Bishnoi ve ark., 1978; Hasar ve Tükel, 1993; Tan, 1995).

Bu çalışmada, Isparta ili ekolojik koşullarında, üç farklı biçim zamanı (başaklanma, çiçeklenme ve süt olum) ve beş farklı azot dozu (0, 5, 10, 15 ve 20 kg N/da) uygulamalarının, tritikalenin ot verimi ve kalitesi üzerine etkilerinin incelenmesi amaçlanmıştır.

MATERYAL VE YÖNTEM

Bu çalışma, Isparta Uygulamalı Bilimler Üniversitesi, Ziraat Fakültesi, Tarımsal Eğitim, Araştırma ve Uygulama Çiftliği'nde 2023-2024 yıllarında yürütülmüştür. Denemede bitki materyali olarak Tacettin bey tritikale çeşidi kullanılmıştır.

Denemenin yürütüldüğü bölgeye ait uzun yıllar iklim verilerine göre, ekim-mayıs ayları arasında toplam yağış miktarı 486.4 mm, ortalama sıcaklık değeri 7.7°C ve ortalama nispi nem miktarı %67.7 olarak hesaplanmıştır. Arazi denemesinin yürütüldüğü Ekim 2023 ve Mayıs 2024 tarihleri arasında yağış miktarının 354.8 mm ile uzun yıllar ortalamasından daha düşük, ortalama sıcaklık değeri 11.7°C ile uzun yıllar sıcaklık ortalamasından daha yüksek ve nispi nem değeri %65.1 ile uzun yıllar ortalamasından daha düşük olduğu tespit edilmiştir. Analizi sonucuna göre; deneme alanı tekstür bakımından killi-tınlı, kireç bakımından zengin (%20.9), organik maddece fakir (%1.56), pH'sı 7.99, fosfor bakımından fakir (5 mg/kg) ve potasyum bakımından zengin olduğu (1.94 mg/kg) belirlenmiştir.

Deneme, tesadüf bloklarında bölünmüş parseller deneme desenine göre 3 tekerrürlü yürütülmüştür. Çalışmada 5 farklı azot dozu (0, 5, 10, 15 ve 20 kg/da N) ve 3 farklı biçim zamanı (başaklanma, çiçeklenme ve süt olum dönemi) uygulanmıştır. Azot dozları ana parsellere, biçim zamanları ise alt parsellere yerleştirilmiştir.

Denemede sıra arası 20 cm, her parselde 10 sıra, parsel eni 2 m, parsel boyu 10 m olarak planlanmıştır. Bloklar arası 2 m, parseller arası 1 m olarak ayarlanmıştır. Parsel alanı 20 m² (2 m x 10 m), parsel sayısı 15, toplam deneme alanı 476 m^2 olarak hesaplanmıştır.

Denemenin yürütüldüğü arazi, ekimden önce pulluk yardımıyla sürülmüş ardından diskaro ile ikileme işlemi yapılmış ve ekimden hemen önce rotovatör yardımıyla toprak ekime hazır hale getirilmiştir. Denemede ekim işlemi 10.10.2023 tarihinde, dekara 25 kg tohum gelecek şekilde tahıl mibzeriyle yapılmıştır. Ekimle birlikte

fosforlu gübre olarak triple süper fosfat (TSP %42) gübresi kullanılmış ve toprak analizleri dikkate alınarak, dekara 8 kg fosfor (P_2O_5) olacak şekilde uygulanmıştır. Azotlu gübre olarak üre amonyum sülfat (Nitropower %33) kullanılmış ve dozlara uygun şekilde 1/3'ü ekimle, 2/3'ü ise kardeşlenme döneminde olacak şekilde iki seferde uygulanmıştır

Denemenin hasat işlemleri, başaklanma dönemi için 25.04.2024 tarihinde, çiçeklenme dönemi için 03.05.2024 tarihinde ve süt olum dönemi için 29.05.2024 tarihinde gerçekleştirilmiştir. Biçim dönemlerinde her parselde kenar tesirleri dikkate alınarak, 1 m²'lik kuadrat yardımı ile 2'şer adet biçim yapılmıştır.

Araştırmada kuru ot verimi, ham protein oranı, ham protein verimi, NDF ve ADF oranları belirlenmiştir. Biçim dönemlerinde her parselden, 1 m²'lik kuadrat yardımı ile 2'şer adet biçim yapılarak arazide tartılmıştır. Yeşil ot verimleri bulunan bitkilerden alınan 500 g'lık örnekler kurutma dolabında 70°C'de 48 saat süre ile kurutularak tartımları yapılmıştır. Kurutulan örnekler yardımıyla % kuru madde oranları hesaplanmış ve yeşil ot verimleri ile çarpılarak dekara kuru ot verimleri hesaplanmıştır. Parsellerden alınan kuru ot örnekleri öğütülmüş ve yakma yöntemiyle toplam azot miktarları tespit edilmiştir. Bulunan değerler 6.25 ile çarpılarak ham protein oranı hesaplanmıştır (Kacar, 1972). Ham protein oranı ile kuru ot verimi çarpılarak ham protein verimleri hesaplanmıştır (Ankom, 2020). Her dönem elde edilen kuru ot örneklerinde ANKOM teknolojinin bildirdiği esaslara göre NDF ve ADF oranları tespit edilmiştir (Türk vd., 2009).

Çalışmada elde edilen bütün veriler, tesadüf bloklarında bölünmüş parseller deneme desenine'ne göre SAS (1998) bilgisayar programından yararlanılarak varyans analizine tabi tutulmuştur. Analiz sonucunda ortaya çıkan önemli farklılıklar %5 önemlilik düzeyinde Asgari Önemli Fark (LSD) testi yapılarak karşılaştırılmıştır.

BULGULAR VE TARTIŞMA

Farklı azot dozu ve biçim zamanı uygulamalarının yulafın ot verimi ve kalitesi üzerine etkilerine ilişkin varyans analiz sonuçlarına göre azot dozları ve biçim zamanları incelenen tüm özellikler üzerine %1 düzeyinde önemli etki yapmıştır.

Çizelge 1'de verilen kuru ot verimi değerleri incelendiğinde, azot dozu uygulamalarının kuru ot verimini arttırdığı ve kontrol parsellerinde dekardan 940.5 kg olarak elde edilen kuru ot veriminin, dekara 20 kg azot uygulanan parsellerde dekardan 1029.5 kg'a kadar yükseldiği tespit edilmiştir. Biçim zamanlarına ait ortalama kuru ot verimleri incelendiğinde ise bitkinin olgunluk seviyesinin artması ile kuru ot verimi değerlerinde artış gözlenmiştir. Başaklanma döneminden süt olum dönemine kadar hasat edilen tritikale bitkilerinde kuru ot verimi 637.5 kg/da'dan 1381.9 kg/da'a kadar yükseldiği görülmektedir. En düşük kuru ot verimi başaklanma döneminde belirlenirken, en yüksek kuru ot verimi süt olum döneminde elde edilmiştir.

Azot dozu uygulamalarının tritikalede kuru ot verimi üzerine etkilerinin incelendiği benzer çalışmalarda, artan azot dozuna paralel olarak verimin yükseldiği bildirilmiştir (Çil ,2000; Kökten vd., 2005; Güneş, 2013 ve Açıkbaş vd., 2024). Biçim zamanlarının kuru ot verimi üzerine etkilerinin incelediği diğer çalışmalarda ise biçim dönemlerinin ilerlemesiyle kuru ot veriminin yükseldiği belirtilirken, Royo vd. (1998), 1097.6'dan 2059.9 kg/da'a, Kaplan vd. (2011), 836.37'den 1364.70 kg/da'a, Seydoşoğlu vd. (2020), 1452.00'den 2231.60 kg/da'a, Kılınç (2022), 452.1'den 2063.4 kg/da'a, Bulut ve Başaran (2023), 801'den 1337 kg/da'a ve Günay (2024), 440'dan 1140 kg/da'ya kadar arttığını belirlemişlerdir. Denemede elde edilen kuru ot verimi literatürlerle de belirtildiği gibi hem azot dozunun artmasıyla hem de biçim zamanının geciktirilmesiyle artış göstermiştir. Bulgularımız araştırmacıların sonuçlarıyla yüksek oranda benzerlikler göstermektedir.

Çizelge 1. Tritikalede farklı azot dozları ve biçim zamanlarında elde edilen ortalama kuru ot verimi, ham protein oranı, ham protein verimi, NDF ve ADF oranları.

Uygulamalar	Kuru Ot Verimi	Ham Protein Oranı	Ham Protein Verimi	NDF	ADF
Azot dozları					
N_0	940.5 C	6.88 C	62.84 D	65.38 A	50.03 A
N_5	967.2 C	7.11 C	66.25 CD	64.76 A	49.83 A
N_{10}	959.4 C	7.18 C	67.40 C	63.24 B	48.20 B
N_{15}	998.6 B	8.19 B	79.71 B	62.07 C	48.00 B
N_{20}	1029.5 A	8.77 A	88.20 A	61.15 C	46.98 B
LSD (%5)	27.1	0.43	4.36	1.14	1.33
Biçim Zamanları					
Başaklanma	637.5 C	8.25 A	52.73 C	58.54 C	44.19 C
Çiçeklenme	917.6 B	7.95 B	73.00 B	63.87 B	49.31 B
Süt Olum	1381.9 A	6.69 C	92.91 A	67.55 A	52.32 A
LSD (%5)	19.0	0.28	3.16	0.73	0.61
N	**	**	**	**	**
BZ	**	**	**	**	**
N x BZ	**	n.s.	**	n.s.	n.s.

Ham protein oranı, uygulanan azot miktarları arttıkça, N_0 konusundan N_{20} konusuna kadar artış göstermiş olup, N_0, N_5 ve N_{10} konuları arasında istatistiksel olarak bir farklılık görülmemiştir. Analizler sonucu, azot uygulamalarına göre en düşük ham protein oranları %6.88, %7.11 ve %7.18 ile sırasıyla N_0, N_5 ve N_{10} uygulamalarından, en yüksek ham protein oranı ise %8.77 ile N_{20} uygulamasından tespit edilmiştir. Her bir hasat döneminde elde edilen bitki örneklerinde belirlenen ham protein oranlarının biçimin geciktirilmesiyle

azaldığı gözlemlenmiştir. Tritikale bitkisinde üçüncü biçim dönemi olan süt olum döneminde ham protein oranı %6.69 ile en düşük değere, başaklanma döneminde %8.25 ile en yüksek değere sahip olmuştur.

Deneme sonucunda elde edilen ham protein oranları %5.93 ile %9.47 arasında değişim göstermiştir. Farklı araştırıcılar tarafından tritikalede azot dozu uygulamalarının ham protein oranı üzerine etkilerine baktıkları çalışmalarda, Güneş (2013), %11.64-14.28 arasında değiştiğini bildirirken, Çerit (2021), %9.50-12.28 arasında belirlemiştir. Takıl ve Olgun (2020) ve Li vd. (2016) azot uygulamaları sonucu tanelerde de protein oranının arttığını tespit etmişlerdir. Farklı biçim zamanı dönemlerinin ham protein oranları üzerine etkilerini incelediği çalışmalarda ise Kılınç (2022), başaklanma döneminden, süt olum dönemine kadar %15.29'dan %9.67'ye, Bulut ve Başaran (2023), başaklanma öncesi dönemden, döllenme sonrası dönenine kadar %16.24'den %13.33'e, Günay (2024), gebeleşme döneminden, erken hamur olum dönemine kadar %15.63'den %9.66'a düştüğünü bildirmişlerdir. Denemede elde edilen sonuçlara göre azot dozu uygulamalarının ham protein oranını arttırdığı, biçim zamanının geciktirilmesiyle ham protein oranının azaldığı literatürlerle uyumluluk gösterirken, araştırıcıların belirttiği ham protein değerleri bizim değerlerimizden yüksek çıktığı gözlemlenmiştir. Bu farklılıklarında bölge, iklim, çeşit ve yetiştirme koşulları gibi sebeplerden olabileceği düşünülmektedir.

Denemeden elde edilen ortalama ham protein verimleri incelendiğinde, azot dozlarının ham protein verimini üzerine pozitif etkide bulunduğu belirlenmiştir (Çizelge 1). Azot uygulaması yapılmayan parsellerden 62.84 kg/da ile en düşük ham protein verimi elde edilirken, dozlardaki artışa paralel olarak ham protein veriminde artmış göstermiş ve N_{20} uygulamasının yapıldığı parsellerden 88.20 kg/da ile en yüksek ham protein verimi tespit edilmiştir. Biçim dönemlerine ait ortalama değerlere bakıldığında ise en düşük ham protein verimi başaklanma evresinde 53.73 kg/da olarak belirlenirken, en yüksek ham protein verimi süt olum evresinde 92.91 kg/da olarak tespit edilmiştir. Biçim zamanının ilerlemesiyle ham protein oranın düşmesine karşılık birim alandan elde edilen kuru ot veriminin yükselmesinin ham protein veriminin artışında etkili olduğu gözlemlenmiştir.

Ham protein verimi üzerine azot dozu uygulamalarının etkisinin incelendiği çalışmalarda, Dubey vd. (2013), 0, 4, 8 ve 12 kg/da azot uygulamalarından ortalama 51-94 kg/da arasında, Yalçin (2019), 0, 5, 10 ve 15 kg/da azot uygulamalarından ortalama 79.2-85.2 kg/da arasında olduğunu bildirmişlerdir. Farklı biçim dönemlerinde ortalama ham protein verimlerini, Kaplan vd. (2011), 67.59-114.15 kg/da arasında, Kılınç (2022), 67.71-195.51 kg/da arasında ve Günay (2024), 68.72-110.65 kg/da arasında değişim gösterdiğini belirlemişlerdir. Türk ve Albayrak (2012), hasat döneminin ilerlemesiyle kuru madde ve ham protein veriminin arttığını fakat yem kalitesinin azaldığını bildirerek çalışmamızdan elde edilen sonuçlara katkıda

bulunmuşlardır. Yapılan çalışmalarda da belirtildiği üzere hem azot hem de biçim zamanlarının ham protein verimleri üzerine önemli etkide bulunmuş, uygulamalar sonucu verim değerlerinin arttığı elde edilen sonuçlarla uyumluluk göstermiştir. Çalışmadan elde edilen ham protein verimleri bazı araştırıcıların bulgularıyla benzerlik gösterirken, bazı araştırıcıların bulgularından düşük olduğu görülmüş, bu farklılıklarında bölge, iklim, çeşit ve yetiştirme koşulları gibi sebeplerden olabileceği düşünülmektedir.

Tritikale bitkisinde uygulanan azot dozlarının miktarı arttıkça, NDF oranlarının azaldığı görülmektedir (Çizelge 1). Azot dozu uygulamaları sonucu en düşük NDF oranları %61.15 ve %62.07 ile N_{15} ve N_{20} uygulamalarından, en yüksek NDF oranları ise %65.38 ve %64.76 ile N_0 ve N_5 uygulamalarından elde edilmiştir. Biçim zamanlarına ait ortalama değerlere bakıldığında ise biçimin geciktirilmesi tritikale bitkisinde NDF oranının artmasına sebep olmuş, başaklanma döneminde %58.54 olarak belirlenen NDF oranı süt olum döneminde %67.55'e kadar artmıştır.

Ortalama ADF oranları incelendiğinde, azot uygulamaları sonucu artan dozlara bağlı olarak ADF oranını azalma gözlemlenmiştir. En yüksek ADF oranları N_0 ve N_5 uygulamalarından sırasıyla %50.03 ve %49.63, en düşük ADF oranları ise $N_{10,}$ N_{15} ve N_{20} uygulamalarından sırasıyla %48.20, %48.00 ve %46.98 olarak belirlenmiştir. Biçim dönemlerine ait ortalama ADF oranlarına bakıldığında ise geciken biçim zamanlarına paralel olarak ADF oranlarının arttığı görülmektedir. Deneme sonucunda en düşük ADF oranını %44.19 ile başaklanma döneminde, en yüksek ADF oranı %52.32 ile süt olum döneminde hasat edilen bitki örneklerinde belirlenmiştir.

Kaba yemlerdeki karbonhidratlar, hayvanların sindirim sistemlerinde kısmen sindirilebilirken, geri kalan kısım ise sindirilemeyen bileşiklerden oluşur. Bu bileşikler genellikle selüloz, hemiselüloz ve lignin gibi yapısal bileşenleri içerir (Mertens, 1987; Moon vd., 2002; Zhao vd., 2011). ADF ve NDF oranları, yemin lifli yapısının belirlenmesinde önemli göstergedir. Bu oranların yüksek olması, yemdeki lif miktarının arttığını ve dolayısıyla yemden yararlanma düzeyinin azaldığını gösterir. Bu nedenle, düşük ADF ve NDF oranları besleme açısından daha arzu edilir niteliktedir (Bowman vd., 2003).

Çalışmada tespit edilen NDF değerleri %56.56 ile %70.57 arasında değişim göstermiştir. Çerit (2021), farklı azot dozu (0, 4, 8 ve 12 kg/da) uygulamaları sonucu tritikalede NDF oranının %56.42'den %44.17'e düştüğünü belirlemiştir. Benzer konu üzerine yapılan diğer çalışmalarda ise Kumari vd. (2014) %57.1'den %55.1'e, Bayram ve Ayan (2017) %53.9'dan %51.7'a ve Yalçin (2019) %61.77'den %59.12'ye kadar azaldığını bildirmişlerdir. Farklı biçim zamanlarının NDF oranı üzerine etkisinin incelendiği çalışmalarda, Kaplan vd. (2011), %40.07-49.27 arasında, Günay (2024), %54.65-58.56 arasında, Kılınç (2022) %55.99-

59.78 arasında değişim göstermiş olup biçim döneminin geciktirilmesi ile NDF oranlarının arttığı sonucu vurgulanmıştır. Bu sonuçlar araştırmamızdan elde edilen sonuçlarla benzerlikler göstermektedir.

SONUÇ

Çalışma sonucunda elde edilen veriler bir bütün olarak değerlendirildiğinde Isparta ekolojik koşullarında, yüksek verim bakımından 20 kg/da azot uygulaması ve süt olum döneminde hasat edilmesi uygun görülürken, kalite bakımından 20 kg/da azot uygulaması yapılan ve başaklanma ve çiçeklenme dönemlerinde hasat edilmesi gerekmektedir. Tritikale bitkisinin yeşil ot amaçlı üretiminde çalışmada incelenen özellikler bakımından ve artan gübre maliyetleri göz önüne alınarak dekara en az 15 kg azot uygulanması ve biçimin ise en geç çiçeklenme döneminde yapılmasının daha uygun olacağı değerlendirilmiştir.

TEŞEKKÜR

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Analysis of Biochemical and Ethnomedicinal Studies on Species of the Genus *Myosotis* L.

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Abstract

This study is devoted to the analysis of works focused on the phytochemical composition, applications in traditional medicine, and molecular-phylogenetic features of plants of the genus *Myosotis* L. It has been established that representatives of the genus *Myosotis* contain significant amounts of fatty acids, alkaloids, flavonoids, and saponins. In traditional medicine, their oils are widely used as anti-inflammatory, antibacterial, antidepressant, and for other therapeutic purposes. The results of the analysis showed that, to date, the biochemical composition and beneficial properties of *Myosotis* species remain insufficiently studied, and modern scientific data in this field are limited.

Keywords: *Myosotis*, biochemistry, alkaloids, flavonoids, saponins, ethnomedicine, fatty acids, taxonomy, therapeutic application

1. Introduction

The study of the biochemical composition and beneficial properties of *Myosotis* L. species began in the 1960s. According to scientific sources, several species of *Myosotis* contain high levels of fatty acids, alkaloids, and saponins. Early investigations by G.R. Jamieson and E.H. Reid on marsh and aquatic plants revealed that the lipids of *Myosotis scorpioides* leaves contained relatively high amounts of γ-linolenic (18:3ω6) and octadecatetraenoic (18:4ω3) acids. Both acids were also found in the seed oils of Boraginaceae family members. Subsequent studies noted significant similarities in the lipid composition of different tissues of *M. scorpioides*, as well as seasonal variations in polyunsaturated acid ratios during the growing season. In addition, high percentages of γ-linolenic and octadecatetraenoic acids were identified in the leaf lipids of five Boraginaceae species (*M. scorpioides, M. arvensis, M. alpestris, Symphytum officinale, Pulmonaria officinalis*).

2. Materials and Methods

This study is based on a systematic review of published literature regarding the phytochemistry, ethnomedicinal applications, and biochemical properties of *Myosotis* species. Sources included biochemical assays, phytochemical screenings, and records of traditional medicinal uses, analyzed to identify general trends and gaps in current knowledge.

3. Results and Discussion

3.1. Biochemical composition

Lyon et al. (1971) analyzed the content of calcium (Ca), magnesium (Mg), chromium (Cr), nickel (Ni), cobalt (Co), and copper (Cu) in the ash of leaves from six plant species on serpentine soils in New Zealand, including *Myosotis monroi*. Results showed that *M. monroi* largely excreted Mg, while *Notothlaspi australe* accumulated more Ca. Other taxa displayed resistance or intermediate accumulation of heavy metals, indicating that no universal mechanism exists for vegetation survival on serpentine soils.

Shinkarenko (2008) studied flavonoid content in 15 species of *Myosotis* from different sections. The values ranged from 1.0–4.0%, with high variability depending on region. Species of section *Alpestris*, especially *M. asiatica*, showed the highest flavonoid content (up to 7.4%). Samples collected during peak flowering were identified as promising sources of flavonoids.

Znajdek-Awiżeń et al. (2014) reported that oil from *M. arvensis* seeds had historically been used as antibacterial, antifungal, and anti-inflammatory, though scientific validation of acaricidal activity was lacking. Later, Park et al. (2017) demonstrated the activity of 3-methylbenzaldehyde isolated from *M. arvensis* oil against *T. putrescentiae*.

In 2018, Zakari et al. investigated *M. scorpioides*, confirming the presence of alkaloids, terpenes, tannins, flavonoids, saponins, and anthraquinones. These metabolites were traditionally used by healers in Adamawa State (Nigeria) against malaria, and laboratory data supported its antimalarial effectiveness.

3.2. Ethnomedicinal applications

In folk medicine, oil from *M. arvensis* seeds was used as an anti-inflammatory agent. Shinkarenko and co-authors recommended *M. arvensis* for treating malignant tumors of the oral cavity and reproductive organs, as well as tuberculosis. Studies by Polomeev et al. (2011) showed that aqueous extracts of aerial parts of *M. arvensis* had anxiolytic and antidepressant effects in mice, while oil extracts inhibited bacterial growth.

Radulović et al. (2006) noted that despite the low essential oil content in *M. arvensis*, these oils still contributed to antibacterial, antifungal, and anti-inflammatory effects. In Mongolia, *M. latifolia* was used for treating rashes and ulcers, though its high alkaloid content (~0.2%) presents health risks. In northern Pakistan, decoctions from *M. alpestris* were used to treat asthma, bronchitis, fever, and skin diseases.

In medieval Azerbaijan, *M. arvensis* was documented in a phytopharmacological corpus of 724 plants, valued for antiseptic and sedative properties and applied against infectious diseases of external tissues.

Despite this ethnomedicinal evidence, studies in Central Asia, and especially Uzbekistan, remain scarce. This gap highlights the importance of targeted research on the phytochemistry and pharmacological potential of *Myosotis* in the region.

4. Conclusion

Species of the genus *Myosotis* are well studied morphologically but insufficiently investigated in terms of phytochemistry, pharmacology, and molecular-phylogenetic relationships. Existing data suggest valuable therapeutic potential, but current knowledge remains fragmentary, particularly in Central Asia. Further comprehensive studies are required to clarify taxonomic boundaries, evaluate pharmacological properties, and integrate traditional uses with modern science.

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A Review of the Impacts of Climate Change on Vegetation Dynamics and Driving Factors

İklim Değişikliğinin Bitki Örtüsü Dinamiklerine Etkileri ve Belirleyici Faktörler Üzerine Bir Derleme

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Abstract

Climate zones play a critical role in shaping the structure, and diversity of vegetation. Each climate zone presents unique temperature patterns, precipitation levels, and seasonal variations that directly influence plant growth. Vegetation adapts to these climatic conditions through structural traits, resulting in distinct biomes such as tropical rainforests, deserts, grasslands, and tundras. Understanding the dependency of vegetation on climate zones is essential for predicting ecological responses to climate change, managing natural resources, and developing sustainable land-use strategies. Climate change has a significant impact on vegetation growth. Changes in climate conditions will alter the air and soil properties, thereby affecting nutrient transfer to vegetation and disrupting the original growth structure. The impact of climate change on vegetation varies across regions. Vegetation change driven by climate change is a complex process. The Normalized Difference Vegetation Index (NDVI) serves as an indicator of vegetation productivity and is widely used to monitor vegetation growth. There are studies that investigate the relationship between climate zones and vegetation cover by utilizing NDVI data and climate reanalysis data from ERA5. Key findings indicate that precipitation and humidity are the primary positive drivers of vegetation growth, while temperature has a slightly higher positive than negative impact. Wind speed generally exerts a negative influence on vegetation, albeit with a relatively minor effect. During the growing season, vegetation becomes more sensitive to temperature, precipitation, and humidity, highlighting the complex interplay of climatic factors in shaping vegetation dynamics. In addition to regional differences, the effect of any single climate factor on vegetation becomes part of a complex mechanism influenced by natural factors such as slope aspect and elevation. Moreover, it is important to consider the presence of human-induced effects on vegetation alongside climate factors. Therefore, there are many driving factors affecting vegetation. For example, the impact of wind speed on vegetation varies depending on the region and the type of vegetation. For this reason, it is important to conduct studies that investigate the effects of multiple driving factors on vegetation. This study has been prepared to review the findings of numerous studies in the literature that investigate the impact of climate zones on vegetation, and to examine the most influential climatic parameter affecting vegetation as well as other non-climatic driving factors.

Keywords: Climate Zones, Climate Changes, Vegetation, Seasonal Variations, Soil Properties

1.INTRODUCTION

Climate zones are fundamental determinants of the structure, distribution, and diversity of global vegetation. Variations in temperature regimes, precipitation patterns, humidity levels, and seasonal dynamics shape plant physiological processes and drive the formation of distinct biomes. Classic ecological frameworks such as Holdridge's Life Zone system (Holdridge, 1967) and Whittaker's biome conceptualization (Whittaker, 1975) shows how vegetation communities align closely with climatic gradients, which explains the sensitivity of plant systems to environmental conditions. For example, tropical rainforests flourish in warm conditions, such as humid climates with abundant precipitation, whereas desert regions contain limited vegetation that is highly tolerant of drought and adapted to severe arid conditions. These early models established the foundation for understanding how climate helps regulate ecosystem structure and function.

Recent studies Lu et al., (2025); Li et al., (2025); Dastour & Quazi, (2024); Huang et al., (2021); Hossain & Li, (2021); Wang et al., (2021); Zhang et al., (2020) have increasingly aimed to quantify these relationships through the use of remote sensing data and climate reanalysis products. The Normalized Difference Vegetation Index (NDVI), widely accepted as an indicator of vegetation productivity, has been extensively employed to monitor ecological responses to climate variability across both spatial and temporal scales. Numerous studies have revealed that precipitation and humidity typically act as strong positive drivers of vegetation greenness, while temperature exerts both facilitative and inhibitory effects depending on regional conditions and phenological phases. For example, research using NDVI and ERA5 climate data has shown that vegetation becomes particularly sensitive to fluctuations in temperature, precipitation, and humidity during the growing season, underscoring the dynamic interplay of multiple climatic controls.

However, the influence of climate on vegetation cannot be fully understood without considering additional geographic factors such as elevation and slope and soil moisture availability (e.g., Körner, 2007). This study aims to review the literature of climate classification methods and to explore the impact of climate zones on vegetation, with particular attention to identifying the most influential climatic parameters.

2. CLIMATE ZONE CLASSIFICATIONS and VEGETATION

Climate is generally defined as the long-term average of weather conditions and can be described either by quantitative values or by the classification of these values. There are several key factors that influence a region's climate, including latitude, elevation, proximity to large bodies of water and mountains, ocean circulation patterns, and long-term atmospheric circulation. These factors determine temperature ranges and precipitation patterns throughout the year. Climate, in turn, shapes ecology by influencing the types of plants for region. Climate zones are regions defined by distinct climatic conditions shaped by weather patterns,

latitude, and ecological conditions. Each zone exhibits characteristic temperature ranges, precipitation levels, and seasonal variations which directly influence vegetation structure. As a climate change, changes in the weather patterns and the extreme weather events are considered as important indicators of changes in climate zones. These climatic factors play a crucial role in determining the structure, distribution, and diversity of vegetation across the Earth. Determining climate classifications is essential for understanding how climate influences vegetation patterns and ecosystem dynamics. By categorizing regions based on temperature, precipitation, and seasonal variations, researchers can predict the types of plant communities likely to thrive in different areas. Climate classifications provide a scientific framework for linking environmental conditions to vegetation distribution, growth, and productivity. This knowledge is crucial for conservation planning, sustainable land management, and assessing the potential impacts of climate change on ecosystems.

Identifying the climate regions of a country is very important because climate knowledge has a wide range of uses, including monitoring changes in vegetation cover and understanding its impacts on e.g. beekeeping activities. The most common used methods for classifying climate regions in literature depends on weather patterns, environmental indicators, and lifezone classification. Weather pattern based classification systems commonly use geographic descriptors such as polar, tropical, continental, and marine. These primary terms are further refined by qualifiers that indicate temperature, moisture levels, or seasonal weather severity. Examples of such descriptors include moist or dry, warm or cold, and temperate or severe. The combination of these elements yields specific climate classifications, such as "polar marine" or "temperate continental," facilitating precise characterization of regional climates.

2.1. Climate Classification Methods

In determining the climate zones, different methods and variables have been used in the literature. Early climate classifications were based on single variables, but later systems became more complex by incorporating multiple climatic elements. Climate classifications are used to identify regional and seasonal climate types and have been widely applied in various scientific fields (De Castro et al., 2007; Jacobeit, 2010; Bieniek et al., 2012; Gallardo et al., 2013). Numerous classification systems have been developed, including those by De Martonne (1926), Köppen and Geiger (1928), Thornthwaite (1948), and Holdridge (1967), among which the Köppen and Thornthwaite methods are the most commonly used (Spinoni et al., 2014). These methods play an important role in climate change and modeling studies, as well as in watershed management (Mahlstein et al., 2013; Jylhä et al., 2014; Şensoy and Ateşoğlu, 2018).

- **Köppen-Geiger Climate Classification:** Originally proposed by Köppen in 1900, the Köppen climate classification system was later refined and standardized into its modern form through the revisions made by Geiger in 1961. Köppen classification is widely applied at the global scale due to its simplicity and

effectiveness (Peel et al., 2007; Alvares et al., 2014). (Köppen 1900; Geiger 1961). Köppen climate classification groups climates into five main types: tropical (A), arid (B), temperate (C), cold (D), and polar (E), based on temperature and moisture characteristics. Climate subtypes are further defined by a second letter indicating precipitation patterns and a third letter indicating temperature thresholds, classifying climates as hot, cold, dry, or humid.

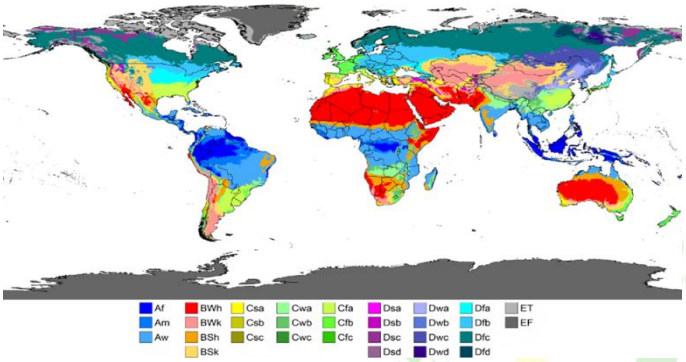


Figure 1. Distribution of Köppen climate zones around the world (Beck et al, 2018).

- **De Martonne index** evaluates regional drought conditions based on precipitation and temperature distributions (De Martonne, 1926; Dursun and Babalık, 2021).

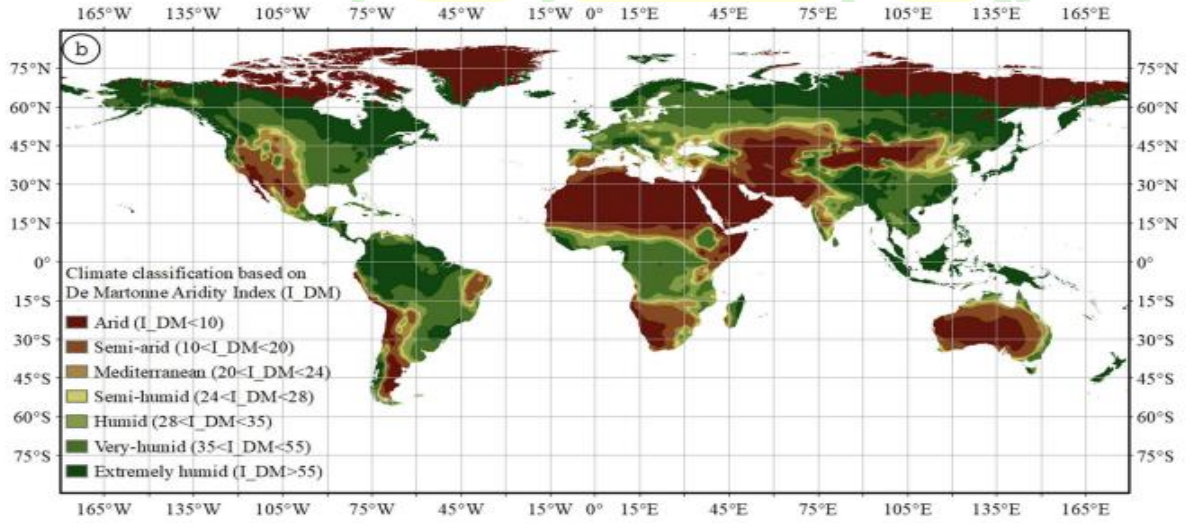


Figure 2. Global climate classification De Martonne aridity index (Clement et al 2022)

De Martonne aridity index is primarily temperature-based (Eq. 2), and when temperatures fall below −10 °C, index values become negative and indicate an arid climate regardless of precipitation. These negative values account for the lack of intermediate climate classes (Figure 2).

- **Thornthwaite system** is more complex and focuses on water balance, evapotranspiration, and plant water requirements, making it particularly suitable for hydrological and agricultural studies (Feddema et al.,

2005; Rolim et al., 2007; Yılmaz and Çiçek, 2016). Although the Köppen climate classification remains the most widely used system today, the Thornthwaite classification developed in 1948 is often regarded as a more advanced approach due to its rational and process-based structure. Thornthwaite classified climates using moisture and heat as the two primary factors, while seasonal variations were considered as secondary components.

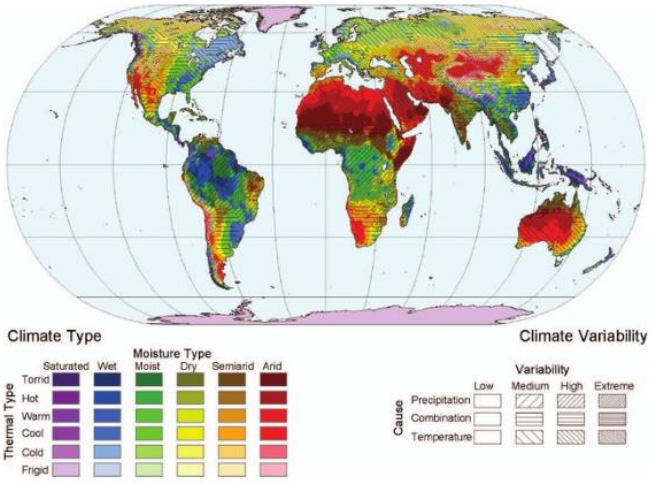


Figure 3. Global climate classification De Martonne aridity index (Feddema, 2005)

While Köppen classification is effective at the macro scale, Thornthwaite provides more reliable results at the meso scale and in agricultural regions (Rolim et al., 2007). Köppen-Geiger system mainly uses temperature and precipitation thresholds, while the Thornthwaite classification is based on evapotranspiration, humidity, and water balance, making it especially useful in hydrological studies.

2.2. Climate Zones of Türkiye

Turkey, located between 36°–42° north latitudes and 26°–45° east longitudes, covers an area of approximately 783,000 km, serves as a bridge between Europe, Asia, and Africa. It lies in a transitional zone influenced by the temperate westerlies of Western and Central Europe, the continental climate of Eastern Europe, and the subtropical high-pressure system to the south, with diverse air masses affecting the region. Consequently, Türkiye experiences a wide range of climate types, including arid, semi-arid, continental, humid, and semi-humid conditions. The country exhibits diverse climatic conditions, with average annual temperatures and precipitation patterns varying widely across regions due to topography and latitude (Çiçek, 1996; Dursun and Yazıcı, 2022). Vegetation shows clear zonation, ranging from Mediterranean shrublands and forests along the coasts to temperate deciduous forests, steppe, and alpine meadows in the interior and high-altitude regions.

Türkiye experiences diverse climate regimes dominated by a Mediterranean-type macroclimate due to its complex topography. Studies indicate that Türkiye is highly vulnerable to climate change, with increasing

annual and seasonal surface and nighttime temperatures. Long-term precipitation records, particularly for winter and annual totals, show a notable drying trend beginning in the early 1970s, with the strongest decreases in Eastern Anatolia, the Marmara region, and the Mediterranean coast. Additionally, climate changes are not random but period-dependent, and urbanization has been shown to contribute to rising temperatures and altered precipitation patterns (İyigün et al, 2013; Baş and Şahin 2024; Türkeş and Yurtseven 2025).

- **Köppen-Geiger climate classification of Türkiye:** According to the Köppen-Geiger climate classification, humid tropical (A) and polar (E) climate types do not occur in Türkiye. Based on the main climate types map, arid (B) climate conditions are dominant in the interior regions of the country. The most widespread climate type in Turkey is the temperate humid mid-latitude climate (C), covering approximately 43% of the country. This climate type dominates all coastal regions as well as large parts of Southeastern Anatolia. In areas where mountain ranges run parallel to the coast, such as the Black Sea Region and the Central Taurus Mountains, it appears as a narrow belt, while it expands over wider areas where orographic conditions are more favorable, including the Marmara, Aegean, Central Black Sea, and Southeastern Anatolia regions. Its widest distribution is observed in the western parts of Anatolia. The cold, humid mid-latitude climate (D), also known as the continental climate, is the second most extensive climate type worldwide. It is also the second most widespread climate type in Türkiye, covering approximately 39% of the country (Öztürk et al. 2017).

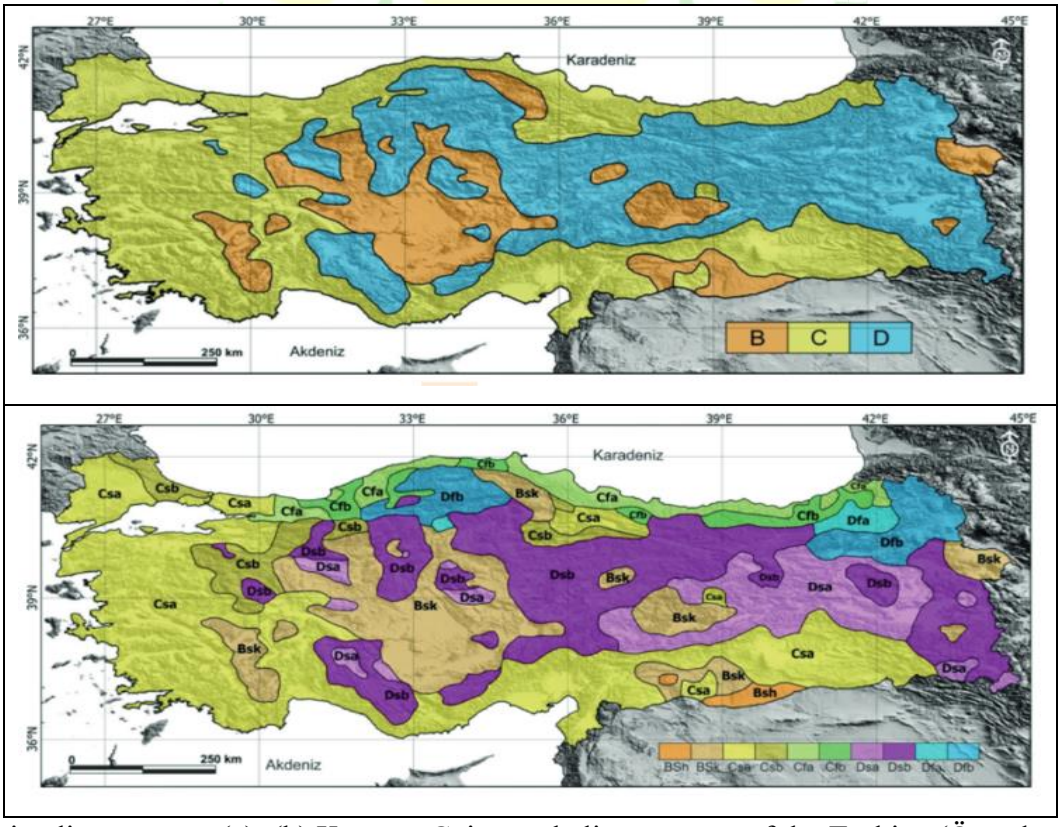
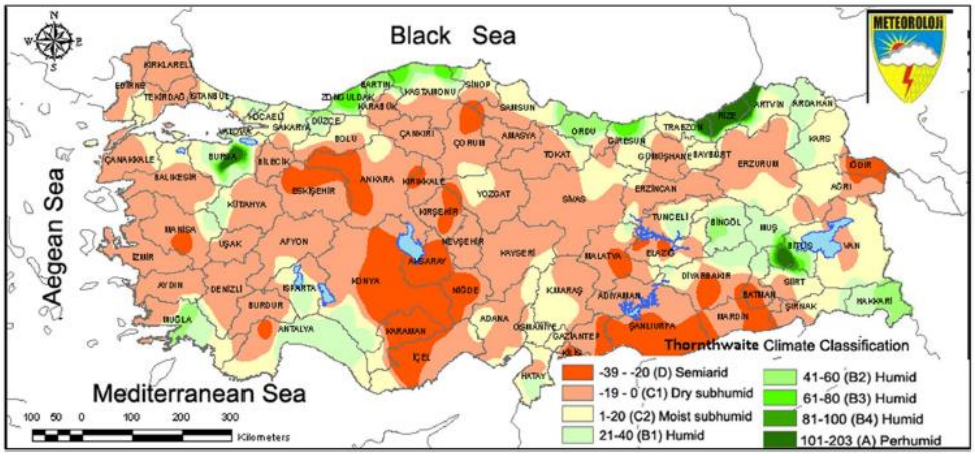


Figure 4. Main climate types (a), (b) Köppen-Geiger subclimate types of the Türkiye (Öztürk et al, 2017)

The first letters (A, B, C, D, E) of Köppen-Geiger climate classification denote the main climate types, which are defined based on temperature for four groups and precipitation for one group (Figure 4a). The second letters (S, W, s, w, f) indicate precipitation characteristics, while the third letters (h, k, a, b, c, d) represent thermal conditions. For climate types in which precipitation is the determining factor, subtypes are identified using aridity threshold values (Figure 4b) (Öztürk et al 2017).

Thornthwaite Classification of Türkiye; studies on Thornthwaite climate classification in Turkey began in the mid-20th century (Yüksel ve Karan 2024). In the Thornthwaite climate classification, a location's climate is determined using monthly average temperature, precipitation, and evapotranspiration data. These values are used to calculate annual soil water storage, monthly changes in soil moisture, annual actual evapotranspiration, water deficit and surplus, as well as runoff and humidity levels. Based on these calculated parameters, the climate of the area is then classified. he Thornthwaite method is based on the concept of Potential Evapotranspiration (PET), which estimates plant water use assuming unlimited water availability. Potential Evapotranspiration is a theoretical value that increases with rising temperature and decreases with higher humidity (Erinç 1949; Çikek 1996; Bölük et al 2023).



Şekil 3. Integrated Thornthwaite Climate Classification Map of Türkiye (Şensoy et al 2008)

2.3. Vegetation Response to Climate Change

Vegetation growth and response are influenced by short- to seasonal changes in local conditions, including soil moisture, precipitation, temperature, and solar radiation. Scientific models are crucial for analyzing climate-vegetation interactions and helping predict vegetation responses to climate variability. Dynamic global vegetation models are widely used to assess crop yields and evaluate climate impacts on agriculture. Extreme climate events, including droughts, heatwaves, floods, and wildfires, increasingly affect vegetation growth and stability across continents. Understanding these responses is essential for guiding management, adaptation, and mitigation strategies, especially in rangelands and vulnerable ecosystems (Afuye et al 2021).

Advances in satellite technology have enabled the use of indicators like the normalized difference vegetation index (NDVI) to monitor vegetation dynamics from regional to global scales. NDVI reflects vegetation growth and is widely used to track seasonal and inter-annual changes, phenology, land-use changes, and vegetation responses to climate variability. Coarse-resolution satellite imagery, such as MODIS, has been widely used to monitor spatial and temporal variations in vegetation due to their high temporal frequency. Recent studies on this topic fall into two main categories; analyses of temporal correlations between NDVI and climate variations and analyses of spatial correlations using corresponding spatial datasets. Both approaches provide insights into how vegetation responds to climate variability over time and space (Li and Shi, 2000; Wang et al 2015; Schultz and Halpert, 1995; Fang et al., 2001; Wen et al 2019; Basit et al 2024).

NDVI, derived from red and near-infrared reflectance, is sensitive to vegetation presence, density, and dynamics, and is commonly applied to quantify LAI (leaf area index), productivity, and biomass. Multi-temporal NDVI analyses over the past two decades have revealed inter-annual variations in vegetation cover at regional, continental, and global scales (Wang et al., 2015; Tucker et al., 2001; Paruelo et al., 2004; Xin et al., 2008; Li et al., 2011).

The interactions between climate zones and vegetation dynamics at multiple spatial and temporal scales have investigated by integrating NDVI and ERA5 reanalysis data (Kilpys et al 2025; Afuye et al. 2022). ERA5-Land ,fifth-generation global reanalysis product provided by European Centre for Medium-Range Weather Forecasts (ECMWF) provides updated and improved climate data compared to its predecessors.

3.RESULTS and DISCUSSION

The review analysis revealed that vegetation dynamics are strongly influenced by climate zones, with precipitation and humidity identified as the primary positive drivers of vegetation growth, while temperature showed mixed effects depending on the region and season. Vegetation responses were more pronounced in regions with complex topography, where elevation and slope modulated climatic effects. Integration of NDVI and ERA5 data allowed for a spatiotemporal evaluation of vegetation-climate interactions, capturing both inter-annual trends and regional differences. Overall, results underscore the complex interplay of multiple climatic and non-climatic drivers in shaping vegetation dynamics across Türkiye.

4.CONCLUSION

Climate zones are fundamental in determining vegetation structure, distribution, and productivity, with precipitation and humidity being the dominant positive drivers. Temperature effects vary by region and season, highlighting the need to consider phenological responses in vegetation studies. NDVI serves as a robust tool for monitoring vegetation dynamics, especially when combined with climate reanalysis data like ERA5-Land. Vegetation growth is highly sensitive to seasonal and inter-annual climatic variations, particularly during the growing season. Integrated analyses of vegetation and climate data provide critical

guidance for sustainable land-use planning and ecosystem management. Understanding these complex interactions is essential for predicting future vegetation responses under changing climate conditions.

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Determination of Important Plants for Beekeeping and Their Potential Uses in the Flora of Aksu Plateau, Ardanuç District, Artvin Province

Artvin İli Ardanuç İlçesi Aksu Yaylası Florasında Arıcılık Açısından Önemli Bitkilerin Belirlenmesi ve Potansiyel Kullanım Alanları

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Özet

Bu çalışmada, Artvin ili Ardanuç ilçesi Zekeriya köyü Aksu Yaylası'nda, 2024 yılı Mayıs–Eylül ayları arasında gerçekleştirilen flora araştırması verilerini kullanarak, bölgedeki arıcılık faaliyetleri açısından önem taşıyan ballı ve tıbbi-aromatik bitki türleri belirlenmiştir. Araştırma sonucunda, 34 familyaya ait toplam 105 bitki türü tespit edilmiştir. Bu türlerden 87'sinin ballı, 72'sinin Tıbbi-Aromatik, 50'si ise hem ballı hem de Tıbbi-Aromatik özellik gösterdiği belirlenmiştir. Elde edilen bulgular, yaylanın zengin bir bitki çeşitliliğine sahip olduğunu ve özellikle arıcılık potansiyeli yüksek türlerin yoğunlukla bulunduğunu ortaya koymaktadır. Çalışmada, belirlenen bitkilerin arıcılık açısından nektar ve polen kaynağı olarak önemi ile literatürde yer alan geleneksel ve bilimsel tıbbi-aromatik kullanım alanları detaylı şekilde incelenmiştir. Sonuçlar, Aksu Yaylası'nın arıcılık için değerli bir ekosistem sunduğunu ve burada üretilen balların, tıbbi-aromatik bitkilerin katkısıyla katma değeri yüksek ürünler olarak pazarlanabileceğini göstermektedir. Bu bulgular, bölgedeki arıcılığın sürdürülebilirliği ve yerel ekonomiye katkısı açısından önemli veriler sunmaktadır.

Anahtar Kelimeler: Aksu Yaylası, flora, ballı bitkiler, tıbbi-aromatik bitkiler.

Abstract

In this study, honey and medicinal-aromatic plant species important for beekeeping activities in the region were determined using data from flora research conducted in Aksu Plateau, Zekeriya Village, Ardanuç District of Artvin Province, between May and September 2024. As a result of the research, a total of 105 plant species belonging to 34 families were identified. Among these species, 87 were determined to be honey plants, 72 were Medicinal-Aromatic, and 50 were determined to exhibit both honey and Medicinal-Aromatic characteristics. The findings reveal that the plateau has a rich plant diversity and that species with high beekeeping potential are densely found. In the study, the importance of the determined plants as nectar and pollen sources for beekeeping and their traditional and scientific medicinal-aromatic usage areas in the

literature were examined in detail. The results show that Aksu Plateau offers a valuable ecosystem for beekeeping and that the honey produced here can be marketed as high value-added products with the contribution of medicinal-aromatic plants. These findings provide important data for the sustainability of beekeeping in the region and its contribution to the local economy.

Keywords: Aksu Plateau, flora, honey plants, medicinal-aromatic plants.

1. INTRODUCTION

Beekeeping has stood out as an significant agricultural activity throughout human history; honey bees (*Apis mellifera* L.) produce products with high nutritional and economic value such as honey, pollen, propolis, and royal jelly by collecting nectar and pollen. The quality and quantity of these products are directly related to the diversity of the plant flora visited by the bees (Potts et al., 2010; Klein et al., 2007; Gallai et al., 2009). Especially, honeys obtained from regions where plants with medicinal and aromatic properties are dense are evaluated as functional foods thanks to the phenolic compounds and flavonoids they contain (Kartal et al., 2020).

Thanks to its geographical location and different climate types, Türkiye has a rich biodiversity hosting approximately 75% of the world's honey plant flora, and this situation offers great potential for beekeeping on a global scale (Sancak et al., 2013). Numerous honey and medicinal-aromatic plant species in the country's flora enable the production of unique honey varieties with regional characteristics (Cengiz, 2018).

The Eastern Black Sea Region, one of the most important regions of Türkiye in terms of biodiversity, stands out with its rich vegetation and high endemism rate. Artvin, one of the most characteristic provinces of this region, exhibits extraordinary floral richness. This richness of the province is a result of numerous ecological factors such as altitude differences of approximately 4,000 meters, the intersection of three different climate types (Mediterranean, Continental, and Euxine), rich water presence, and complex geomorphological structure. Floristic studies have revealed that Artvin is the richest province in Türkiye with 2,727 natural plant taxa belonging to 137 families and 761 genera. 500 of these taxa (198 endemic and 302 rare species) are evaluated as threatened, which emphasizes the ecological importance of protecting the region (Eminağaoğlu et al., 2015).

Artvin's biodiversity offers significant contributions to both ecosystem health and the regional economy. In this context, the province being the gene center of the Caucasian honey bee race, one of the most important honey bee races in the world, not only makes high-quality honey production possible but also stands out as a key factor carrying the region to the first rank in queen bee production in Türkiye. Considering the ecological

function of bees in pollination, beekeeping is a strategic activity not only economically but also in terms of ecosystem services (Demirci & İnci, 2022).

Medicinal and aromatic plants, which have widespread use in traditional and modern medicine, show many biological effects such as antioxidant, antimicrobial, and anti-inflammatory thanks to the bioactive compounds in their contents and are among the important raw materials of the pharmacology and cosmetics industry today (Düvenci, 2024).

The main aim of this study is to reveal the flora diversity detected as a result of field studies conducted in Aksu Plateau, Zekeriya Village, Ardanuç District of Artvin Province between May and September 2024. In addition, it is aimed to determine the species showing honey and medicinal-aromatic properties among these plants and to examine the usage areas of these species in traditional and scientific literature. In the light of the data obtained, suggestions for sustainable use will be presented by evaluating the beekeeping and medicinal potential of the region's flora.

2. MATERIALS AND METHODS

2.1. Study Area This research was carried out between May and September 2024 in Aksu Plateau (around coordinates 40°58'26.8"N 42°08'18.6"E), located within the borders of Zekeriya Village, Ardanuç district of Artvin province (Figure 1). The study area has altitudes ranging from 2100 to 2650 m and forms a border with the Olur district of Erzurum. Due to this location, the field has the characteristics of an ecological transition zone reflecting both the continental climate features of the Eastern Anatolia Region and the humid and cool climate features of the Eastern Black Sea Region. Aksu Plateau has a remarkable position in terms of representing the characteristic mountainous and plateau ecosystems of the Eastern Black Sea Region and stands out with its high biological diversity, rich vegetation, and traditional beekeeping activities.

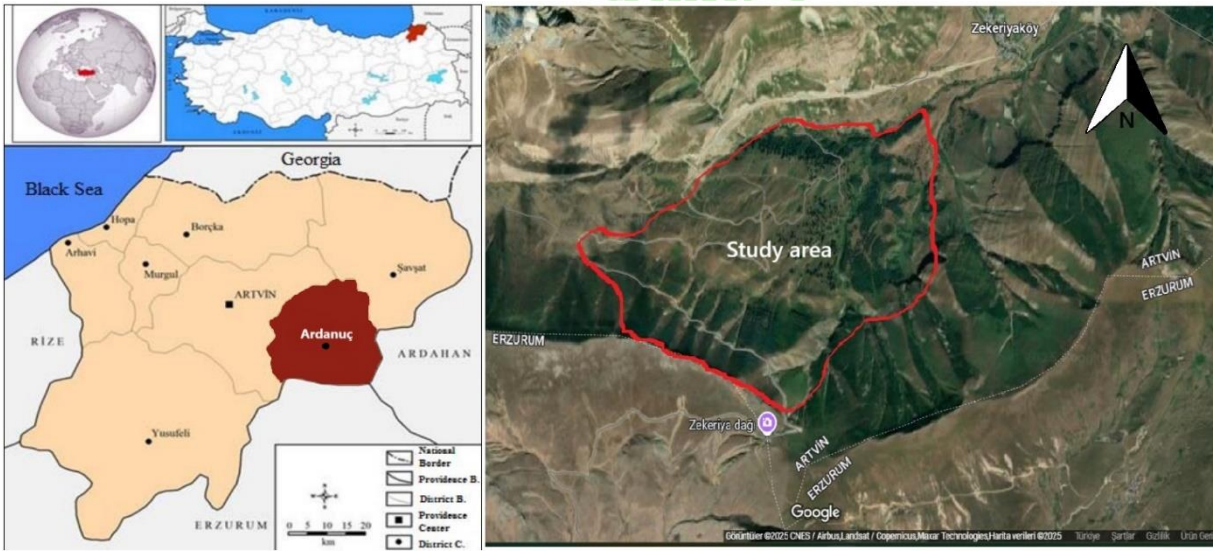

Figure 1. Map of the study area

2.2. Material In the field studies carried out during the vegetation period between May and September 2024, sampling was performed to reveal the diversity of plant species. Care was taken to collect underground organs such as flowers, fruits, leaves, rhizomes, tubers, and bulbs, as well as buds completely, to contribute to morphological identification. Ecological and geographical data such as location, altitude, and collection date were recorded in detail for each of the samples.

2.3. Method The materials collected in field studies were dried according to herbarium standards and made ready for identification. The examination of morphological characters of the samples (seed, fruit, flower, leaf, hair, etc.) was carried out under a Nikon SMZ 1000 brand binocular stereo zoom microscope. In the process of identifying plants, "Flora of Turkey and the East Aegean Islands" (Davis, 1965-1985; Davis et al., 1988; Güner et al., 2000), which is the main reference work for the flora of Türkiye, was used as the main source. In addition to this main work, floras of neighboring regions such as "Flora USSR" (Komarov, 1934-1978) and "Flora Kavkaza" (Grossheim, 1939-1967), as well as current national sources such as Akkemik (2014) and Eminağaoğlu (2012, 2015) and various illustrated flower atlases were utilized. The preliminary identifications made as a result of these examinations were finalized by comparing them with the current nomenclatures in the work titled "List of Turkey's Plants (Vascular Plants)" (Güner et al., 2012), and the identification process was completed.

3. RESULTS AND DISCUSSIONS

3.1. General Floristic Findings

In this research conducted to determine the honey and medicinal-aromatic plant species in Aksu Plateau of Zekeriya Village, Ardanuç District of Artvin Province, floristic data obtained from field studies between May and September 2024 were evaluated. As a result of the identification of plant samples collected from the area, a total of 105 plant species belonging to 34 families were detected.

When the usage areas of these species were examined; it was determined that 87 of them are honey plants, 72 of them are medicinal and aromatic plants, and 50 of them exhibit both honey and medicinal-aromatic characteristics. These results reveal that the plateau possesses a rich biodiversity and a high carrying capacity for apiculture.

3.2. Evaluation of Honey and Medicinal Plants

The distribution of the identified species according to families shows that Lamiaceae, Asteraceae, and Rosaceae families are dominant in the region.

Asteraceae Family: This family is represented by important species in the region. For example, *Achillea millefolium* (Yarrow) draws attention as both a honey and medicinal plant used in the treatment of asthma, gynecological diseases, and wounds. *Helichrysum arenarium* (Immortelle) is used for kidney stones and stomach pain. *Centaurea macrocephala* (Yellow cornflower) is recorded as a medicinal plant used in the treatment of diabetes and hypertension.

Lamiaceae Family: This family contains plants with high nectar value. *Thymus praecox* (Creeping thyme) is a strong antioxidant honey plant used in the treatment of shortness of breath and spasm. *Salvia sclarea* (Clary sage) is used for nervous tension and insomnia, while *Origanum vulgare* (Oregano) is noted for its antimicrobial and anti-viral effects as well as being used for digestive problems.

Rosaceae Family: *Rosa canina* (Rosehip) is a significant medicinal plant used for cold, cholesterol, and diabetes. *Rubus idaeus* (Raspberry) is identified as a strengthening and germ-killing species.

Other Significant Species: *Urtica dioica* (Stinging nettle) is a honey plant with a wide range of uses from rheumatism to diabetes. *Hypericum perforatum* (St. John's wort) is known for its use in depression and wound treatment. Echium vulgare (Viper's bugloss) is a honey plant used as an anti-depressant and for respiratory tract diseases.

The presence of these species directly affects the quality of the honey produced in the region. Specifically, the coexistence of plants with both honey and medicinal properties (such as Achillea millefolium, Thymus praecox, Trifolium repens) adds high added value to the bee products.

	Familya	Tür	Yerel Adı	Tıbbi	Ballı	Tıbbi-Aromatik Kullanımları
1	Amaranthaceae	*Chenopodium foliosum* (Moench) Asch.	cülek	**x**		Bitkinin toprak üstü kısımlarından hazırlanan dekoksiyonun, radikal temizleme aktivitesi olan flavonoidlerin potansiyel bir kaynağı olabileceğini önermektedir.
2	Amaranthaceae	*Chenopodium album* L.	ak sirken	**x**		Geleneksel olarak bağırsak kurtlarına karşı (solucan düşürücü), kalp güçlendirici, gaz giderici, sindirimi kolaylaştırıcı, idrar söktürücü ve müshil olarak kullanılmıştır.
3	Apiaceae	*Pimpinella major* (L.) Huds.	pembe anason	**X**		Etkili bir idrar söktürücü olarak, kökü, iç organlardaki tıkanıklıklardan kaynaklanan rahatsızlıkların tedavisinde kullanılır.

4	Asteraceae	*Achillea millefolium* L.	civanperçemi	**X**	**X**	Astım, Kadın hastalıkları, Yara ve iltihaplarda
5	Asteraceae	*Arctium platylepis* (Boiss. & Balansa) Sosn. ex Grossh.	baldikeni	**X**	**X**	Antioksidant özelliği gösterir, cilt rahatsızlıklarının tedavisinde kullanılır.
6	Asteraceae	*Bellis perennis* L.	çayırpapatyası, koyungözü	**x**		Hemartroz, çürükler, baş ağrısı, soğuk algınlığı, egzama, deri çıbanları, gastrit, ishal, kanama,romatizma, iltihaplanma, üst solunum yolu enfeksiyonları.
7	Asteraceae	*Carduus nutans* L.	eşekdikeni		**X**	Yaprak ve çiçeklerinden hazırlanır, sindirim ve karaciğer destekleyici
8	Asteraceae	*Centaurea macrocephala* Puschk. ex Willd.	sarıbaş	**X**		diyabet, hipertansiyon, ishal ve sıtmanın tedavisi
9	Asteraceae	*Cirsium arvense* (L.) Scop.	köygöçüren		**x**	Karaciğer fonksiyonlarını destekler, safra akışını artırabilir.
10	Asteraceae	*Cirsium echinus* (M.Bieb.) Hand.-Mazz.	kirpikangalı		**x**	İltihaplı durumların hafifletilmesinde
11	Asteraceae	*Cota tinctoria* (L.) J.Gay.	boyacı papatyası, çayır papatyası	X		Soğuk algınlığı önleyici, uyarıcı, idrar söktürücü, öksürük kesici, cildi sıkılaştırıcı, saçı sarıya boyama samaçlı, yapraklar böcek sokmasına karşı kullanılır.
12	Asteraceae	*Doronicum orientale* Hoffm.	kaplanotu		**x**	İltihap ve ödem durumlarında
13	Asteraceae	*Echinops orientalis* Trautv.	dağşekeri		**x**	Eklem ve kas ağrıları ile iltihaplı durumlarda, karaciğer fonksiyonlarını destekleyici ve sindirimi kolaylaştırıcı
14	Asteraceae	*Helichrysum arenarium* (L.) Moench	ölmezçiçek, altınotu, nego	**X**	**x**	Böbrek taşı tedavisi, üro-genital rahatsızlıklar, mide ağrısı.
15	Asteraceae	*Inula orientalis* Lam.	şark andızotu	**X**	**x**	Sindirim, hazmi kolaylaştırıcı, idrar arttirici, safra söktürücü, balgam söktürücü, öksürük, üst solunum yolu rahatsızlıklarını giderici, damar büzücü, anti-kanser.

16	Asteraceae	*Petasites hybridus* (L.) G.Gaertn., B.Mey. & Scherb.	kabalak		x	Bronş ve solunum yollarındaki spazmları azaltır
17	Asteraceae	*Senecio othonnae* M.Bieb.	tek kanaryaotu		x	Stres ve sinirsel rahatsızlıklara karşı çay veya infüzyon şeklinde kullanılır.
18	Asteraceae	*Solidago virgaurea* L.	altınbaşakç içeği		x	Böbrek ve idrar yolu sağlığını destekler; geleneksel olarak böbrek taşları ve idrar yolu enfeksiyonlarında kullanılır.
19	Asteraceae	*Tanacetum macrophyllum* (Waldst. & Kit.) Sch.Bip.	koca pireotu	x	x	Hazımsızlık, gaz ve mide problemlerinde çay veya infüzyon şeklinde kullanılır.
20	Asteraceae	*Tanacetum parthenium* (L.) Sch.Bip.	beyazpapatya	x	x	Romatizma ağrılarını önleyici, uyarıcı, kuvvet verici, baş ağrısı kesici, depresyon önleyici.
21	Asteraceae	*Tussilago farfara* L.	öksürükotu		x	Boğaz ağrısı ve hafif ağrılar için çay veya infüzyon şeklinde kullanılmıştır
22	Boraginac	*Cerinthe minor* L.	cücegözü		x	Hafif anti-inflamatuvar, sindirim destekleyici ve antioksidan özelliklere sahiptir.
23	Boraginac	*Echium vulgare* L.	engerekotu	x	x	Böbrek, solunum yolu hastalıkları, dokuları iyileştirici, anti-depresan, idrar söktürücü, soğuk algınlığı, öksürük, idrar yolu enfeksiyonu, ateş, iltihaplanma tedavisi.
24	Boraginac	*Onosma* sp.	şincar	X	x	Cilt iltihapları ve yaraların iyileştirilmesinde
25	Campanul	*Campanula alliariifolia* Willd.	akçan	X	x	antioxidant activity
26	Campanulaceae	*Campanula lactiflora* M.Bieb.	kuspida	x		Bazı Çin patentli bitkisel ilaçlar, tavuklardan bulaşan bronşit için 8; Gut hastalığında, yak banyo tozu için kabızlık, migren ve hipertansiyon, anti-inflamatuar, erkek ve kadın hastalıklarını, kozmetik, endokrin, guatr, tiroit, osteoporoz, diyabet, yüksek kolesterol ve obezite tedavisi.

27	Campanul	*Campanula stevenii* M.Bieb.	Yan çançiçeği	**X**		Hafif hazımsızlık ve mide rahatsızlıklarında kullanımı geleneksel olarak kaydedilmiştir.
28	Caprifoliac	*Knautia montana* (M.Bieb.) DC.	dağ eşekkulağı		**x**	
29	Caprifoliac	*Lonicera* sp.	Hanımeli	**x**	**x**	Anti-oksidan.
30	Caprifoliacea	*Valeriana alliariifolia* Vahl	kediotu	**x**	**x**	Ateş düşürücü, mikrop öldürücü, yaraların iyileşmesini kolaylaştırıcı, yatıştırıcı, sinirsel baş ağrısı, çarpıntı, uykusuzluğa, sara, nevrasteni, histeri gibi rahatsızlıklarda, rahatlatıcı, baş dönmesi, araba tutması, epilepsi.
31	Caryophyl	*Dianthus cretaceus* Adam	kabuk karanfil		**x**	
32	Caryophyl	*Silene vulgaris* (Moench) Garcke	ecibücü		**x**	
33	Caryophyl	*Stellaria media* (L.) Vill.	kuşotu		**x**	
34	Caryophyll	*Silene vulgaris* (Moench) Garcke	ecibücü	**x**	**x**	Bakterisidal, virüsidal, fungisidal, anti-paraziter, insektisidal.
35	Colchicace	*Colchicum szovitsii* Fisch. & C.A.Mey.	katırçiğdemi	**x**	**x**	Gut hastalığı tedavisi, gastroenterolojik, muskülo-skeletal, deri hastalıklarını tedavisi.
36	Convolvul	*Convolvulus arvensis* L.	tarlasarmaşığı		**x**	
37	Ericaceae	*Vaccinium myrtillus* L.	ayıüzümü	**x**	**x**	Göz rahatsızlıkları, şeker, tansiyon, kolesterol, bacak ağrıları.

38	Ericaceae	*Rhododendron caucasicum* Pall.	dağ kumarı	**x**	**x**	yaprakları, romatizma ile kalp ve damar hastalıklarını iyileştirmek için kullanılır.
39	Euphorbia	*Euphorbia* sp.	Sütleğen	**x**	**x**	Siğil, nasır veya deri lezyonlarını kurutmak/temizlemek için lateks uygulanmıştır.
40	Fabaceae	*Coronilla coronata* L.	burçak		**x**	
41	Fabaceae	*Trifolium medium* L.	köse yonca		**x**	
42	Fabaceae	*Trifolium repens* L.	ak üçgül	**x**	**x**	Kuvvet verici, romatizma ağrılarını dindirici, anti-bakteriyal, anti-fungal.
43	Fabaceae	*Astragalus* sp.	*Geven*	**x**	**x**	Çay, tentür veya decoction şeklinde, bağışıklık güçlendirici ve dayanıklılık artırıcı
44	Fabaceae	*Lathyrus nissolia* L.	çimenburçak		**x**	
45	Fabaceae	*Vicia cracca* L.	kuş fiği		**x**	
46	Gentianace	*Gentiana septemfida* Pall.	yedi gentiyan	**x**		Karaciğer hastalıkları, sıtma, ateş, ishal ve iltihaplı hastalıkların tedavisinde kullanılır.
47	Gentianace	*Gentianella caucasea* (Lodd. ex Sims) Holub	kaf boduranı	**x**		antioxidant activity.
48	Geraniacea	*Geranium ibericum* Cav.	kırmızı ıtır		**x**	
49	Geraniacea	*Geranium psilostemon* Ledeb.	zarif ıtır		**x**	

50	Hypericac	*Hypericum elongatum* Ledeb. ex Rchb.	Tülserotu	**x**	**x**	Anti-depresan, yara iyileştirici, anti-fungal, anti-viral.
51	Hypericac	*Hypericum perforatum* L.	Kantaron	**x**	**x**	Depresyon, hafif anksiyete, uykusuzluk, yara, yanık ve cilt iltihaplarının tedavisinde kullanılmıştır.
52	Juglandac	*Juglans regia* L.	ceviz	**x**		İştah açıcı, kabızlık, kan şekerini düşürücü, kuvvet verici, dermatolojik hastalıklarda anti-septik, kan şekeri ayarlanması.
53	Lamiaceae	*Prunella vulgaris* L.	gelinciklem e otu		**x**	
54	Lamiaceae	*Ajuga reptans* L.	dağ mayasılotu	**x**		Kabız, ateş düşürücü, kuvvet verici, idrar çoğaltıcı
55	Lamiaceae	*Ajuga orientalis* L.	dağmayasıl ı	**x**		Antibakteriyel, antitümör ve yara iyileştirici romatizma, gut, astım, diyabet, sıtma, ülser ve ishal tedavisi
56	Lamiaceae	*Clinopodium grandiflorum* (L.) Kuntze	kabafesleğe n		**x**	
57	Lamiaceae	*Leonurus quinquelobatus* Gilib.	beş aslankuyru ğu	x	**x**	Kalp çarpıntılarını, sinirsel kökenli kalp rahatsızlıklarını ve hipertansiyonu yatıştırmak
58	Lamiaceae	*Mentha longifolia* (L.) L.	pünk	**x**	**x**	çeşitli bakterilere, mayalara, böceklere vb. karşı geniş bir antibiyotik aktivite yelpazesi gösterir.
59	Lamiaceae	*Nepeta nuda* L.	mor küncü	**x**	**x**	tentürü, ağız patojenlerine karşı etkilidir) (Smiljković ve ark., 2018)
60	Lamiaceae	*Nepeta racemosa* Lam.	pisikotu	**x**	**x**	antiseptic and astringent properties
61	Lamiaceae	*Origanum acutidens* (Hand.-Mazz.) Ietsw.	zemul	**x**	**x**	Anti-fungal, fitotoksik, insektisidal.

62	Lamiaceae	*Origanum vulgare* L.	karakınık	**X**	**x**	Sindirim problemleri, baş ağrısı, kas ağrıları, ishal, romatizma, astım gibi hastalıkların tedavisi, anti-oksidan etki, anti-ülserojenik etki, anti-mikrobiyal etki, anti-viral etki, anti-septik, anti-tümör, anti-fungal.
63	Lamiaceae	*Phlomis pungens* Willd.	silvanok		**x**	
64	Lamiaceae	*Salvia sclarea* L.		**X**	**x**	Sinirsel gerginlik, uykusuzluk, baş ağrısı ve adet sancılarında.
65	Lamiaceae	*Salvia verticillata* L.	dadırak	**X**	**x**	a potential source of drug candidates for the treatment of neurodegenerative diseases such as Alzheimer's
66	Lamiaceae	*Sideritis montana* L.	karaçay	X	**x**	Sindirim problemleri, soğuk algınlığı ve öksürük.
67	Lamiaceae	*Stachys macrantha* (K.Koch) Stearn	kocasoğulcan	**x**	**x**	treatment of stress, skin inflammations, gastrointestinal disorders, asthma and genital tumors
68	Lamiaceae	*Teucrium chamaedrys* L.	kısa Bodur Mahmut, dalak Otu	**x**	**x**	Hemoroit, mide rahatsızlıkları, mide ülseri, bağırsak rahatsızlıkları, şeker
69	Lamiaceae	*Thymus transcaucasicus* Ronniger	Kır Kekiği		**x**	
70	Lamiaceae	*Thymus praecox* Opiz	yaylakekiği	**X**	**x**	treatment of spasm, sore throat and shortness of breath , also having strong antioxidant
71	Liliaceae	*Lilium kesselringianum* Miscz.	kaf zambağı	**X**	**x**	treat coughs, lung diseases, burns and swellings.
72	Onagraceae	*Epilobium angustifolium* L.	yakıotu	**x**	**x**	Anti-spasmodik (böbrek, mide gibi düz kasların büzülmesi, sıkışması), astringent (daha çok tanenlerden kaynaklanan, dokuların büzülme durumu), demulsent (yaraların yumuşaması hali), emolyen (cildin yumuşaması, düzelmesi hali), hipnotik, laksatif (bağırsakların temizlenmesi, kabızlığın giderilmesi) ve tonik etkisi.

73	Onagracea	*Epilobium anatolicum* Hausskn.	anayakısı		x	
74	Orchidace	*Orchis* sp.	orkide	X		Geleneksel olarak ishal, öksürük ve mide rahatsızlıklarında kullanılmıştır.
75	Orobancha	*Euphrasia petiolaris* Wettst.	mercan gözotu	x	x	Konjunktivit, göz yorgunluğu, kaşıntı ve hafif göz irritasyonlarında.
76	Orobancha	*Pedicularis wilhelmsiana* Fisch. ex M.Bieb.	telekli bitotu	x	x	treatment of leucorrhoea, fevers, sterility, rheumatism, general debility, collapse, and urinary problems
77	Papaverac	*Papaver setiferum* Goldblatt	gelinalı	X		Tıbbi olarak ağrı kesici, öksürük bastırıcı veya sedatif amaçlı kullanılmıştır
78	Papaverac	*Papaver armeniacum* Lam.	gelinkuşağı	x	x	Hafif ağrı kesici, sakinleştirici ve öksürük şurubu gibi amaçlarla
79	Plantaginacea	*Digitalis ferruginea* L.	arıkovanı	X	x	Toz, infusion, sıvı ekstre, tentür halinde kullanılır, çok kuvvetli idrar söktürücü, Balgam söktürücü, kalp kuvvetlendirici, ayrıca uyuz, cüzam gibi çeşitli cilt hastalıklarında, yaraların kabuklarını iyileştirici, insan, hayvanlar için zehirli etkilere sahiptir.
80	Polygalace	*Polygala alpestris* Rchb.	yayla sütotu		x	
81	Polygonac	*Polygonum cognatum* Meissn.	madımak	x		Yaraların iyileştirilmesi, sindirim sorunları ve idrar yolu rahatsızlıkları
82	Polygonac	*Bistorta officinalis* Delarbre	çimenevelei	x	x	İçsel kanamalar, topikal anti- inflamatuar, anti-diyareik ajan.
83	Polygonac	*Rumex alpinus* L.	şortah	x	x	astringent and laxative

84	Primulacea	*Primula elatior* (L.) L.	yayla tutyası		x	
85	Ranuncula	*Aconitum anthora* L.	kaplanboğan	x		Ağrı kesici etkiye sahiptir. Bütün bitki zehirlidir
86	Ranuncula	*Delphinium formosum* Boiss. & A.Huet	gür hezaren	X		Dioscorides mentioned their use against lice and scorpions.
87	Ranuncula	*Ranunculus repens* L.	tiktakdana		x	
88	Rosaceae	*Rosa canina* L.	kuşburnu		x	
89	Rosaceae	*Alchemilla caucasica* Buser	kafşebnemlisi	x	x	Boğaz ağrısı semptomlarını azaltma, yara iyileştirme, kanamayı durdurma, jinekolojik hastalıkları hafifletme, bulantı ile kusmayı hafifletme.
90	Rosaceae	*Cotoneaster melanocarpus* Lodd	kara muşmula		x	
91	Rosaceae	*Fragaria vesca* L.	dağ çileği	x		İştah açıcı, idrar arttırıcı, Üre, şeker hastalıklarına karşı, kabız yapıcı, egzama.
92	Rosaceae	*Rosa canina* L.	kuşburnu	x		Afrodizyak, şeker hastalığı, kolesterol, soğuk algınlığı, hemoroit, öksürük, mide ağrısı, antihelmintik, kilo kaybı, soğuk, astım, immünostimülan.
93	Rosaceae	*Rosa boissieri Crép.*	has gül	X		Antioksidan, idrar söktürücü ve sindirim sistemi destekleyici
94	Rosaceae	*Rosa spinosissima* L.	karakuşburnu	X		C vitamini kaynağının bebek gıdaları, meyve suyu, reçel, çay, şarap, pastacılık, şekerleme endüstrisinde katkı maddesi, anti-oksidan aktivite.

95	Rosaceae	*Rubus idaeus* L.	ahududu	**x**	**x**	Kuvvet verici, yara iyileştirici, spazm çözücü, mide ağrısı, sivilce, kanser, epilepsi önleyici, mikrop öldürücü, safra salgısını arttırıcı, terletici, uyarıcı, bademcik iltihaplanması, ağız içi yaralarını önleyici.
96	Rubiaceae	*Galium verum* L.	boyalık		**x**	
97	Sapindace	*Acer hyrcanum* Fisch. & C.A.Mey.	taraklıkağacı		**x**	
98	Saxifragac	*Saxifraga* sp.	Taş kıranı	X	**x**	İdrar söktürücü, böbrek ve safra sorunlarına yardımcı, öksürük ve boğaz rahatsızlıklarında
99	Scrophular	*Verbascum thapsus* L.	burunca	**X**	**x**	Ağrı kesici, karaciğer koruyucu, dalak hastalıkları önleyici, kulak ağrılarını dindirici, tümör önleyici.
100	Scrophular	*Scrophularia nodosa* L.	*düğmeotu*	X	**x**	Böbrek ve idrar yolu sorunları için çay olarak tüketilir. Yara ve iltihaplı bölgelere bitkinin ezilmiş yaprakları veya kökünden yapılan macun uygulanır.
101	Scrophular	*Verbascum speciosum*	*Keklikotu, yünlü ispirtotu*	**x**	**x**	Öksürük, bronşit ve solunum yolu rahatsızlıkları
102	Thymelace	*Daphne glomerata* Lam.	ezentere	**x**	**x**	Diüretik, terletici, romatizma ağrılarını dindirici, abortif, pürgatif, ekspektoran, nematisidal etkiler, topal hayvanların tedavisi, diş ağrıları, sıtma, lösemi, ülser tedavisi, deri hastalıkları.
103	Urticaceae	*Urtica dioica* L.	ısırgan	**X**	**x**	Kanser, romatizma, hemoroit, diyabet, jinekolojik hastalıklar, iltihap giderici, tonik, idrar söktürücü, böbrek taşları, saç dökülmesi, yeni annelerde süt salgısını teşvik etmek, sedatif, soğuk, ağrı, afrodizyak, kanı temizler, sedef hastalığı, verem, emboli.
104	Viburnacea	*Sambucus ebulus* L.	mürverotu	**x**	**x**	Kabızlık, iltihaplanma, müshil etkisi, idrar söktürücü, balgam söktürücü, terletici, grip, kusturucu, üşütme, nezle, soğuk algınlığı, göğüs yumuşatıcı, bağırsak parazitlerini düşürücü.
105	Viburnace	*Viburnum lantana* L.	germeşe	**X**	**x**	Besin takviyesi, İltihabı azaltma, sindirimi iyileştirme, bağışıklık sistemini güçlendirme.

4. CONCLUSION

This study demonstrated that Aksu Plateau in Artvin/Ardanuç possesses a rich floristic structure with 105 identified taxa. The coexistence of a high number of honey plants (87 taxa) and medicinal-aromatic plants (72 taxa) suggests that the region is not only suitable for conventional honey production but also for the production of high value-added, functional bee products.

The presence of species such as *Achillea millefolium*, *Thymus praecox*, *Origanum vulgare*, and *Echium vulgare* directly influences the quality of the honey produced in the region. These honeys bear the characteristics of functional foods due to the bioactive components transferred from medicinal plants. Therefore, a significant opportunity exists for increasing the economic value and sustainability of beekeeping activities in the region.

To effectively evaluate this potential and ensure its long-term sustainability, the following are recommended:

- **Deepening Phytochemical Research:** The bioactive compounds of the identified plants should be defined through detailed laboratory studies.
- **Strengthening Beekeeping:** Beekeepers should be trained on modern techniques and honey plant management.
- **Branding:** Marketing honeys obtained from medicinal-aromatic plants under brands emphasizing health benefits will contribute to the regional economy.
- **Conservation:** Protection areas should be created for the unique biodiversity of the region, and sustainable harvest techniques should be encouraged.

In conclusion, the conservation and sustainable evaluation of the natural riches of Aksu Plateau will provide significant contributions to both the strengthening of the regional economy and scientific knowledge.

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Palestinian Honeys and Natural Products as Emerging Multitarget Therapeutics: Antibacterial, Antioxidant, and Wound Healing Activities

Filistin Balları ve Doğal Ürünleri: Antibakteriyel, Antioksidan ve Yara İyileştirici Etkileriyle Ortaya Çıkan Çok Hedefli Terapötikler

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Abstract

Honey has long been recognized for its healing properties, and recent investigations have highlighted the therapeutic potential of Palestinian honey varieties derived from diverse botanical origins. This study synthesizes findings on *Medicago sativa* (alfalfa) honey, *Persea americana* (avocado) honey, and additional Palestinian honeys to evaluate their physicochemical characteristics, polyphenolic composition, antioxidant capacity, anti-inflammatory effects, antibacterial activities, and wound-healing potential. Alfalfa honey and avocado honey were rich in ellagic acid and displayed strong antioxidant, anti-inflammatory, and broad-spectrum antibacterial activities while promoting keratinocyte proliferation and migration in a dose-dependent manner. Avocado honey and alfalfa honey showed high protein content, substantial phenolic levels, strong antioxidant capacity, and potent antibacterial activity, along with the ability to enhance wound healing and suppress inflammatory nitric oxide production. In silico docking supported these bioactivities by revealing strong interactions of key phenolics with molecular targets involved in oxidative stress, and microbial inhibition. Overall, Palestinian honeys emerge as multifunctional natural therapeutics with promising applications in wound management, infection control, and inflammation modulation.

Keywords: Antioxidant Activity, HaCaT Cells, Honey, Polyphenols, Wound Healing

1.INTRODUCTİON

Honey has long been used for wound treatment due to its complex chemical composition and biological activities that support tissue regeneration, prevent infection, and modulate inflammation (Almasaudi et al., 2021; Majtan, 2014). Recent interest has focused on monofloral honeys, whose distinct chemical profiles may offer enhanced therapeutic benefits (Ranneh et al., 2021). Wound healing is a dynamic process involving hemostasis, inflammation, proliferation, and remodeling, all requiring coordinated cellular and molecular responses (Eteraf-Oskouei and Najafi, 2013). Clinical wound management seeks to maintain moisture, control

infection, reduce inflammation, and protect tissue, yet conventional therapies may be limited, particularly in chronic wounds and in cases of antibiotic resistance (Scepankova et al., 2021; Ahmed et al., 2018).

Honey has re-emerged as an important complementary treatment due to its physicochemical properties—low pH, high osmolarity, hydrogen peroxide production, and electrical conductivity—providing broad-spectrum antibacterial activity (Majtan, 2014; Gharzouli et al., 2020). It is effective against pathogens such as *S. aureus*, *P. aeruginosa*, *E. coli*, and *K. pneumoniae*, including multidrug-resistant strains, with resistance to honey considered unlikely due to its multiple synergistic mechanisms (Navaei-Alipour et al., 2021; Almasaudi et al., 2021; Jenkins et al., 2011; Nolan et al., 2019; Kunat-Budzyńska et al., 2023). Honey's antioxidant components—phenolic acids, flavonoids, and phytochemicals—mitigate oxidative stress (Ranneh et al., 2021), while its anti-inflammatory activity, including inhibition of nitric oxide, promotes resolution of inflammation and tissue repair (Mărgăoan et al., 2021). Honey also stimulates keratinocyte proliferation and migration, re-epithelialization, and angiogenesis, enhancing skin regeneration (Bezerra et al., 2023). Bee products more broadly exert immunomodulatory and anti-inflammatory effects through cytokine regulation and antioxidant activity (Saad, 2025).

Evidence from clinical studies supports honey's efficacy in burns, surgical wounds, diabetic ulcers, and pressure sores (Scepankova et al., 2021; Tashkandi, 2021). However, the therapeutic effects of Palestinian monofloral honeys from less-studied botanical sources such as *Persea americana* remain largely unexplored. While avocado honey is recognized elsewhere for strong antioxidant capacity, its biological activity in Palestine has not been investigated. Other Palestinian honeys—from *Ziziphus spina-christi*, *Citrus* spp., and *Hyphaene thebaica*—have shown potent antimicrobial, antioxidant, anti-inflammatory, and anticancer effects (Iftikhar et al., 2023; Abu-Farich et al., 2024a; Abu-Farich et al., 2024b; Abu-Farich et al., 2025), suggesting alfalfa and avocado honey may also possess therapeutic potential.

This study provides the first comprehensive in vitro evaluation of Palestinian avocado honey and alfalfa honey, assessing its physicochemical characteristics, polyphenolic content, antioxidant and antibacterial activity, nitric oxide inhibitory effects, and its impact on keratinocyte viability, proliferation, and migration.

2.MATERİALS AND METHODS

The phytochemical composition of alfalfa and avocado honeys was examined using high-performance liquid chromatography to identify and quantify major polyphenolic compounds. Antioxidant capacity was assessed through total phenolic content analysis, DPPH radical scavenging assays, and total antioxidant capacity measurements. Anti-inflammatory activity was evaluated in LPS-activated THP-1 macrophages by quantifying nitric oxide production.

Wound-healing potential was assessed using HaCaT human keratinocytes through proliferation assays and scratch migration experiments to determine the influence of different honey concentrations on cell growth and migration. Antibacterial effects were tested against selected Gram-positive and Gram-negative bacterial strains by determining minimum inhibitory and bactericidal concentrations.

To complement experimental findings, in silico molecular docking was performed using AutoDock Vina with the Lamarckian Genetic Algorithm. Docking assessed the interactions of key honey constituents—including quercetin, catechin, chlorogenic acid, galangin, caffeic acid, and pinocembrin—with targets related to antioxidant regulation, inflammation, microbial survival, and cancer progression. Toxicity predictions were generated to evaluate the safety of selected phenolics.

3.RESULTS AND DISCUSSİON

Palestinian honeys derived from alfalfa, avocado, and other botanical sources exhibit strong antioxidant, antibacterial, anti-inflammatory, cytostatic, and wound-healing activities that can be attributed to their rich and diverse polyphenolic profiles. Compounds such as ellagic acid, gallic acid, catechin, quercetin, chlorogenic acid, and pinocembrin play central roles in modulating oxidative stress, inflammatory responses, microbial survival, tissue regeneration, and cancer-related pathways (Jarar et al., 2025a; 2025b)

Alfalfa honey and avocado honey demonstrated a rich polyphenolic composition, with ellagic acid as the dominant constituent (Jarar et al., 2025a; 2025b). This honey showed high total phenolic content and strong DPPH radical scavenging activity, confirming its potent antioxidant properties. In inflammatory models, Both honey types significantly reduced nitric oxide production in macrophages (Figure 1), indicating suppression of inflammatory pathways.

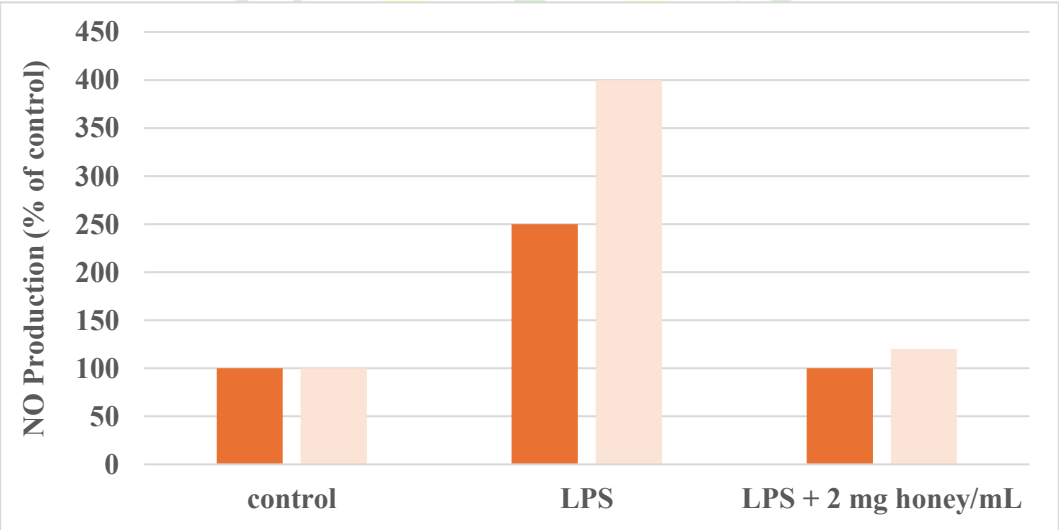

Figure 1. *Avocado honey (left column) and alfalfa honey (right column) attenuates LPS-induced inflammation in THP-1-derived macrophages. Cells were co-treated with lipopolysaccharide (LPS) and honey (2 mg/mL)*

for 72 hours. Inflammatory response was quantified and expressed as a percentage relative to the untreated control (set at 100%). Data represent the mean of three independent experiments.

Wound-healing assays revealed concentration-dependent effects in which low concentrations enhanced keratinocyte proliferation (Figure 2 and Figure 3) and migration (Figure 4), supporting accelerated wound closure, while higher doses exhibited mild cytostatic behavior.

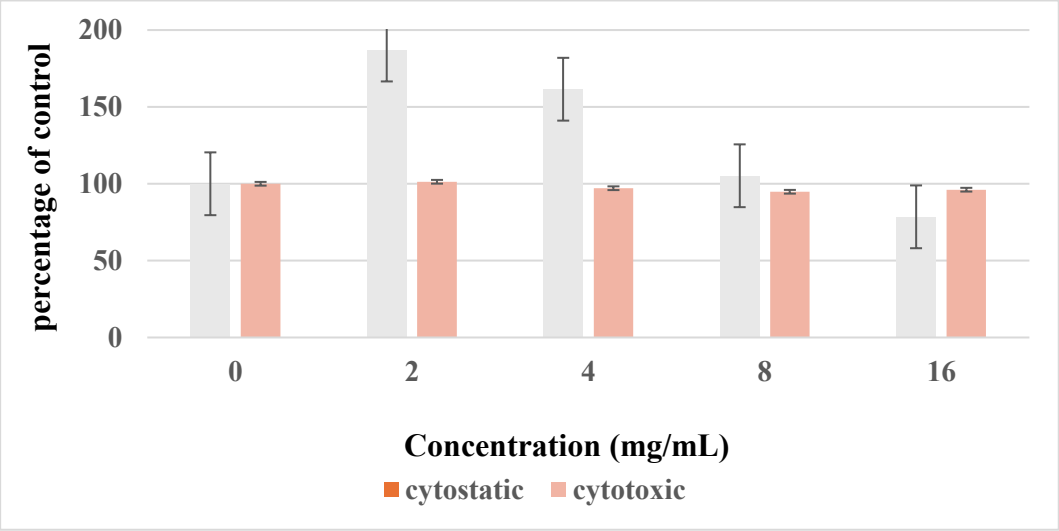

Figure 2. *Cytostatic and cytotoxic responses of HaCaT cells to increasing concentrations of alfalfa honey. Cells were exposed to increasing concentrations of honey and changes in proliferation (cytostasis) and viability (cytotoxicity) were quantified relative to untreated controls. Results are expressed as percentages of the control (mean ± SD, n = 3).*

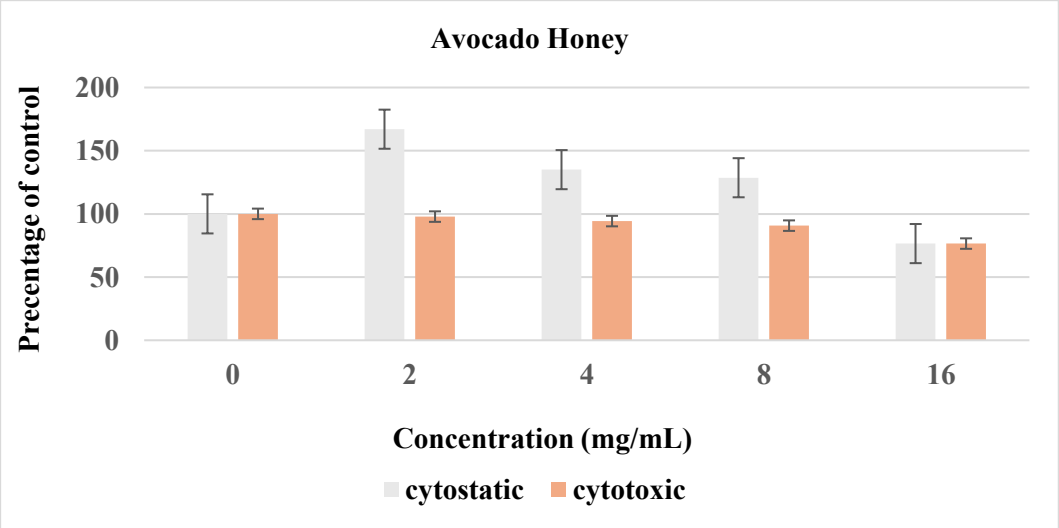

Figure 3. *Cytostatic and cytotoxic responses of HaCaT cells to increasing concentrations of avocado honey. Cells were exposed to increasing concentrations of honey. Cell proliferation (cytostasis) and viability*

(cytotoxicity) were evaluated relative to untreated controls. Values are presented as percentages of the control (mean ± SD, n = 3).

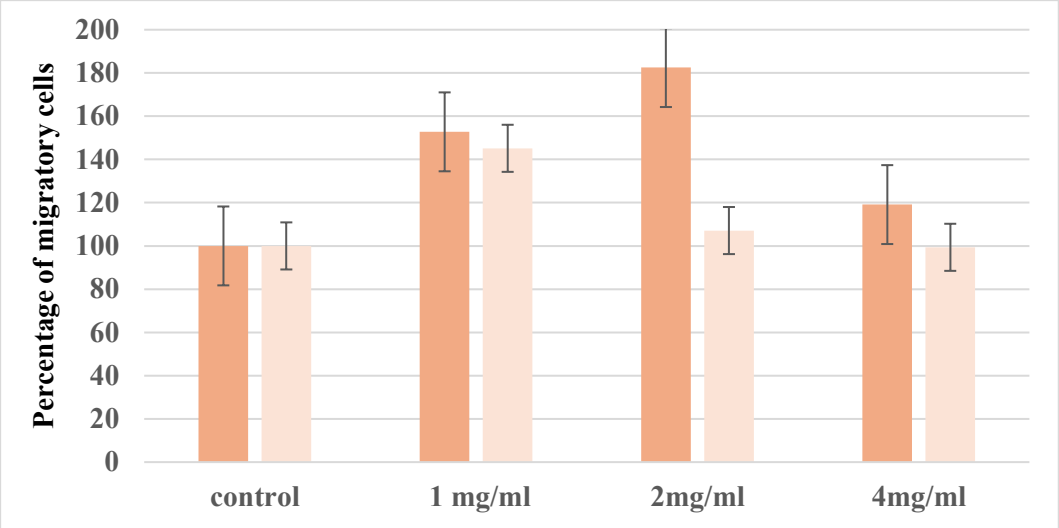

Figure 4. *Avocado honey (left column) and alfalfa honey (right column) promote HaCaT cell migration. Wound closure (%) was measured at 48 h post-treatment, normalized to untreated controls (100%). Data are mean ± SD of three independent experiments in triplicate.*

Complementary studies on Palestinian honeys from *Ziziphus spina-christi*, *Silybum marianum*, *Centaurea dumulosa*, and *Hyphaene thebaica* demonstrated strong antioxidant activity, consistent with their diverse phenolic compositions. These honeys exhibited potent antibacterial activity against multidrug-resistant strains, with some samples achieving extremely low MIC values. Several honeys also displayed cytostatic and anti-migratory effects against breast cancer cell lines, reducing cell viability and suppressing migration. Bioactive phenolics such as caffeic acid, quercetin, and chrysin were implicated in these effects, with docking studies showing strong interactions with cancer-related molecular targets including EGFR and PI3K. Together, these results indicate that Palestinian honeys possess significant anticancer potential in addition to their wound-healing and antimicrobial effects (Jarar et al., 2025a; 2025b).

Antibacterial analysis showed broad-spectrum inhibition, particularly against Bacillus subtilis and Klebsiella pneumoniae (Jarar et al., 2025a; 2025b).

Alfalfa honey and avocado honey exhibited distinct physicochemical characteristics, including high water-soluble protein content, moderate pH, and elevated electrical conductivity. Its phenolic and flavonoid levels corresponded with strong antioxidant capacity. HPLC analysis identified gallic acid, p-hydroxybenzoic acid, chlorogenic acid, quercetin, catechin, and galangin as key components. This honey significantly reduced macrophage nitric oxide production, enhanced HaCaT proliferation, and accelerated wound closure. Its

antibacterial activity was notable, with low MIC and MBC values against Bacillus subtilis and Streptococcus pneumoniae. Docking studies supported its biological activities by revealing strong binding affinities of catechin, galangin, and quercetin to antioxidant, anti-inflammatory, and antimicrobial targets, while toxicity prediction confirmed the safety of most phenolics at physiologically relevant levels (Jarar et al., 2025a; 2025b).

4.CONCLUSİONS

Overall, the findings show that Palestinian alfalfa and avocado honeys exert therapeutic effects through a network of complementary mechanisms, including polyphenol-driven antioxidant activity, downregulation of inflammatory mediators, antibacterial action against wound-associated pathogens, and enhancement of keratinocyte repair. The alignment between in vitro results and in silico modeling strengthens the mechanistic basis of these effects. Evidence from cellular assays, further validated by molecular docking, highlights the potential of these honeys as natural multi-target therapeutic agents. Collectively, the results emphasize the biomedical value of Palestinian honeys and offer a solid platform for future preclinical investigations and the isolation of key bioactive molecules for targeted pharmacological development (Jarar et al., 2025a; 2025b).

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Advancing Bee-Based Bioactive Therapeutics: A Comprehensive Evaluation of Apitherapy for Global Health and Sustainable Medical Innovation

Arı Bazlı Biyoaktif Tedavilerin Geliştirilmesi: Küresel Sağlık ve Sürdürülebilir Tıbbi İnovasyon için Arı Terapisinin Kapsamlı Bir Değerlendirmesi

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Abstract

As an alternative therapeutic intervention, apitherapy, which is the use of honeybee substances, has received growing scientific attention in reaction to the worldwide need of natural, safe, and sustainable biomedical treatment. There is a wide range of bioactive constituents in honey, propolis, bee venom, royal jelly, beeswax, and bee pollen such as flavonoids, phenolic acids, peptides, enzymes, and fatty acids that have multifunctional pharmacological activity in infectious diseases, chronic inflammatory disorders, neurological, metabolic and cancer. The current advancements in the chemical characterization, pharmacological profiling, molecular mechanisms, and therapeutic use of bee-derived products are summarized in this article. The study uses a systematic methodology approach, evaluates in vitro, in vivo, and clinical research data, analyzes the situation in the global market, and determines the most important regulatory and translational issues. The findings show that bee-compounds that are produced by bees engage with the important biological pathways like NF-kB, MAPK, PI3K/Akt, and oxidative stress-related signaling. Manuka honey is shown to have a strong antimicrobial activity against drug-resistant pathogenic microorganisms; propolis containing CAPE inhibits inflammatory and oncogenic pathways; bee venom with melittin induces cancer cell apoptosis; and royal jelly with 10HDA has neurotrophic, antioxidant and anti-aging activity. Although this has such a wide potential of therapeutic use, apitherapeutic products are facing considerable challenges such as variation in chemical compositions, lack of standardized extraction procedures, shortage of clinical trials, and disjointed regulatory systems. The current research argues that with normal scientific validation and proper regulation apitherapy may become an important part of integrative and sustainable healthcare around the world.

Keywords: Apitherapy; Bee Products; Propolis; Royal Jelly; Bioactive Compounds; Sustainable Medicine.

Özet

Alternatif bir tedavi yöntemi olarak, arı maddelerinin kullanımını içeren apiterapi, doğal, güvenli ve sürdürülebilir biyomedikal tedaviye yönelik dünya çapındaki ihtiyaca yanıt olarak giderek artan bilimsel ilgi görmektedir. Bal, propolis, arı zehiri, arı sütü, balmumu ve arı poleninde flavonoidler, fenolik asitler, peptitler,

enzimler ve yağ asitleri gibi enfeksiyon hastalıkları, kronik inflamatuar bozukluklar, nörolojik, metabolik ve kanser hastalıklarında çok fonksiyonlu farmakolojik aktiviteye sahip çok çeşitli biyoaktif bileşenler bulunmaktadır. Bu makalede, arı kaynaklı ürünlerin kimyasal karakterizasyonu, farmakolojik profillemesi, moleküler mekanizmaları ve terapötik kullanımındaki güncel gelişmeler özetlenmiştir. Çalışma, sistematik bir metodoloji yaklaşımı kullanarak, in vitro, in vivo ve klinik araştırma verilerini değerlendirmiş, küresel pazardaki durumu analiz etmiş ve en önemli düzenleyici ve translasyonel sorunları belirlemiştir. Araştırma bulguları, arılar tarafından üretilen arı bileşiklerinin NF-kB, MAPK, PI3K/Akt ve oksidatif stresle ilgili sinyalizasyon gibi önemli biyolojik yollarla etkileşime girdiğini göstermektedir. Manuka balının ilaca dirençli patojenik mikroorganizmalara karşı güçlü bir antimikrobiyal aktiviteye sahip olduğu; CAPE içeren propolisin inflamatuar ve onkojenik yolları inhibe ettiği; melittin içeren arı zehirinin kanser hücrelerinde apoptozu indüklediği; ve 10HDA içeren arı sütünün nörotrofik, antioksidan ve yaşlanma karşıtı aktiviteye sahip olduğu gösterilmiştir. Bu kadar geniş bir terapötik kullanım potansiyeline sahip olmasına rağmen, apiterapi ürünleri kimyasal bileşimlerdeki farklılıklar, standartlaştırılmış ekstraksiyon prosedürlerinin eksikliği, klinik çalışmaların yetersizliği ve birbirinden kopuk düzenleyici sistemler gibi önemli zorluklarla karşı karşıyadır. Mevcut araştırma, normal bilimsel doğrulama ve uygun düzenleme ile apiterapinin dünya çapında bütünleyici ve sürdürülebilir sağlık hizmetlerinin önemli bir parçası haline gelebileceğini savunmaktadır.

Anahtar Kelimeler: Arı Terapisi; Arı Ürünleri; Propolis; Arı Sütü; Biyoaktif Bileşikler; Sürdürülebilir Tıp.

1. INTRODUCTION

Apitherapy, which is the therapeutic use of natural products derived of bees, is one of the oldest and, at the same time, scientifically most dynamic fields in natural medicine (Szabat et al., 2019). Bee products are ancient in their origin as they were known in ancient societies, specifically, the Egyptians, Greeks, Chinese, and the Persians, as having healing, nutritional, and rejuvenating effects (Fratellone et al., 2016). However, modern enthusiasm about apitherapy goes beyond traditional knowledge due to the developments in the field of analytical chemistry, molecular biology, biotechnology, and pharmacology. These scientific breakthroughs have helped clarify an elaborate biochemical profile in bee products thus demonstrating their potential as natural therapeutic agents with intricate multi-targeted mechanisms of action (Basa et al., 2016).

Apis mellifera secret a great number of substances, such as honey, propolis, royal jelly, bee venom, bee pollen, and beeswax, with each having a distinct composition of phytochemicals and biomolecules (Cornara et al., 2017). Honey contains over 180 compounds of which, are hydrogen peroxide, methylglyoxal, flavonoid, and phenolic acids. Propolis has more than 300 bioactive compounds with the most evident ones being caffeic acid phenethyl ester (CAPE), chrysin, apigenin and quercetin. The major royal jelly proteins (MRJPs), acetylcholine, and the fatty acid 10 -hydroxy -2 -decenoic acid (10-HDA) characterize royal jelly (Ahmad et

al., 2020). Bee venom contains peptides: melittin, apamin and adolapin and they are reported to have immunomodulatory and anti-inflammatory effects. On the contrary, bee pollen has a rich profile of nutrients in amino acids, vitamins, minerals, carotenoids, and flavonoids (Moreno et al., 2015). The therapeutic possibilities of these constituents are more or less aligned to the modern clinical needs. The worldwide increase of antibiotic resistance, which is manifested by the prevalence of multidrug-resistant pathogens and the following mortality burden is a paramount challenge. At the same time, chronic inflammatory diseases such as rheumatoid arthritis, inflammatory bowel disease, and asthma are now becoming more and more frequent and widespread. In addition, neurodegenerative diseases like Alzheimer, Parkinson and multiple sclerosis are still lacking curative solutions and require long-term management approaches (Ali et al., 2020).

The pharmacological effects of bee-derived products are broad because they usually include antioxidant, antimicrobial, anticancer, anti-inflammatory, immunomodulatory, antiviral, hepatoprotective, cardioprotective and neuroprotective. The complex chemical structure of them allows them to interact with several biochemical pathways simultaneously to provide a polypharmacological range of therapeutic effects which is rarely obtained with single-target synthetic drugs (Grinn-Gofroń et al., 2025).

Moreover, the apitherapy is aligned with the modern paradigms of sustainability. The products of the bees are renewable, eco-neutral, and inherently connected with the services of pollination which are the basis of ecological integrity. The rise of sustainable agriculture, the increased interest in the environment and the increased demand of natural health products by the consumers have all contributed to the increased economic and scientific popularity of apitherapy (Gokulakrishnaa et al., 2020). Still, apitherapy is a poorly known term in the mainstream healthcare practice even though millennia of practical use and growing scientific support have substantiated it. The major obstacles include the lack of standardization of processing techniques, compositional differences that can be explained by the sources of floral and geographical origin, the lack of rigorously designed randomized controlled trials, and non-uniform regulatory frameworks that limit its widespread application. Scientific skepticism has persisted, and this is mainly because of safety issues, especially allergic reactions to the exposure of bee venom and bee pollen (Gupta et al., 2014), as mentioned in figure 1.

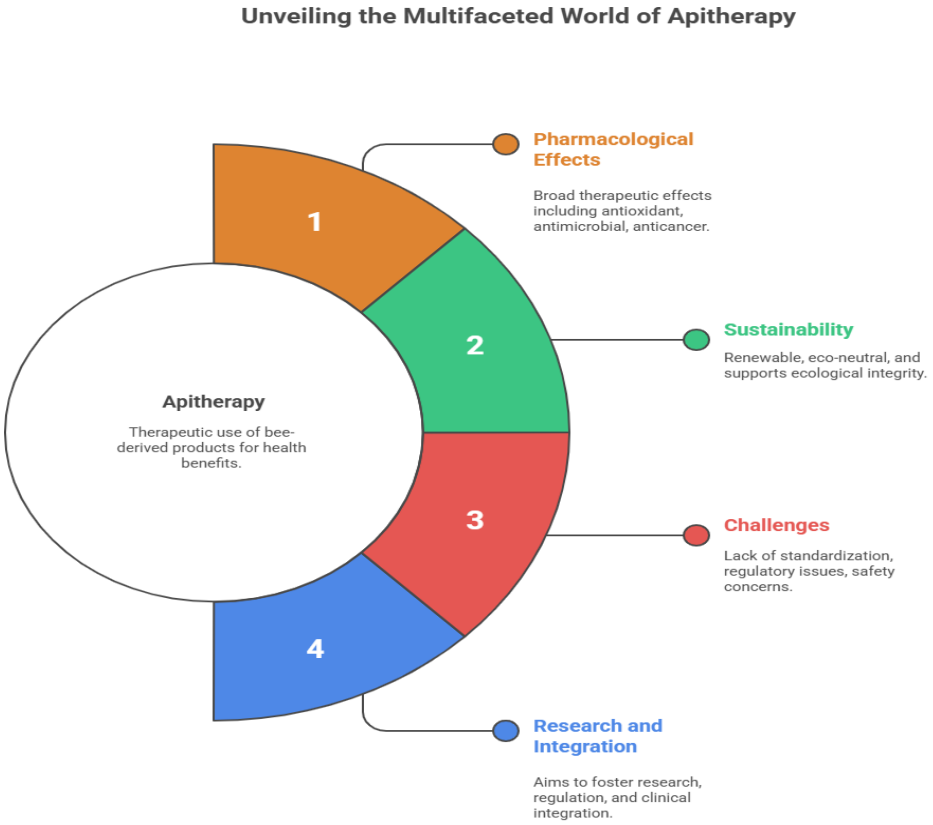

Figure 1: Therapeutic use of bee derived products for health benefits.

The gap is attempted to be filled in this manuscript by providing a comprehensive, methodologically sound exegesis of apitherapy. It includes the chemical constituents of bee products, pharmacodynamic characteristics, molecular processes, limited clinical evidence, market forces worldwide, and the key implementation challenges. The ultimate goal is to provide an elaborate academic framework that would be favorable to the further scientific research, regulatory formulation, and clinical integration of bee-origin therapeutics.

2. METHODOLOGY

The approach that is used in this study is a multi-layered model that takes a holistic, multi-layered approach to assessing apitherapy in terms of chemical, pharmacological, clinical and regulatory aspects (Çelik et al., 2020). A systematic literature search was conducted to guarantee the methodological rigor and reduce bias by searching databases, including PubMed, Scopus, ScienceDirect, Web of Science and SpringerLink. Articles that were released in the period 2000 to 2024 were accessed to obtain the current trends in the field. Keywords involved apitherapy, bee venom therapy, propolis pharmacology, Manuka honey antimicrobial activity, royal jelly 10-HDA, melittin anticancer and bee pollen immunomodulation. The inclusion criteria included those

studies that had provided detailed chemical analysis, pharmacological data, experimentally derived models or clinical studies. The exclusion criteria were focused on those publications which were not detailed in terms of their methods, statistical analysis or reproducibility. Since 186 articles were identified in the first step, 72 articles were chosen according to their relevance, quality of the methods used, and contribution to the field of apitherapy. A field photograph is taken as in figure 2.

Figure 2: A field photograph of Apiary.

The chemical profiling data have been obtained by analyzing the studies that utilized the high-level analytical methods such as the high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), liquid chromatography-tandem mass spectrometry (LC-MS/MS), nuclear magnetic resonance (NMR), and infrared spectroscopy, Fourier-transform (FTIR) (Yusnaini Md Yusoff, 2018).These techniques eased the discovery of major bioactive molecules that mediate therapeutic effects. A pathway level analysis was used to measure pharmacological activity. Canonical molecular pathways were overlaid on to biological responses, including NF-κB activation, MAPK/ERK signaling, PI3K/Akt survival pathways, Toll-like receptor (TLR) immune responses, and oxidative stress-related pathways involving reactive oxygen species (ROS) and antioxidant enzymes such as SOD, CAT, and GPx (Fakhri et al., 2022).

Analysis of in vivo and in vitro studies was done to determine dose response relationships, toxicity thresholds and therapeutic outcomes. Clinical data were evaluated based on inclusion criteria, sample size, treatment period and clinical endpoints. Although there is a shortage of randomized controlled trials with some of the

bee products, observational studies and early-phase trials were reviewed with cautiousness on the emergent trends and therapeutic suggestions. Besides pharmacological evaluation, reports on the World Health Organization (WHO), Food and Agriculture Organization (FAO), and international functional-food market assessments were conducted to provide a global market and regulatory analysis. This integrative method, was able to combine scientific, clinical and socioeconomic views to provide a holistic assessment of apitherapy (Anatolii Olshanskyi, 2025).

3. RESULTS AND DISCUSSION

The combined evaluation of chemical composition, pharmacological properties, and therapeutic mechanisms of bee-derived substances demonstrates a complex yet highly coordinated system of natural bioactive components with significant biomedical relevance (Machado et al., 2023). Results from the compiled studies reveal that each bee product honey, propolis, royal jelly, bee venom, and bee pollen possesses a distinctive biochemical profile contributing to unique as well as overlapping pharmacological activities. Integrating these findings with mechanistic insights highlights the multi-targeted therapeutic potential of apitherapy while simultaneously uncovering the major translational challenges that limit its clinical adoption (Naeem et al., 2023).

The chemical composition of bee products serves as the foundation of their therapeutic effects. Honey contains a rich mixture of phenolic acids, flavonoids, organic acids, and enzymes such as glucose oxidase, which is responsible for hydrogen peroxide production. Manuka honey, in particular, contains high concentrations of methylglyoxal (MGO), which accounts for its superior antibacterial properties (Cianciosi et al., 2018). These compounds collectively contribute to honey's ability to inhibit bacterial growth, accelerate wound healing, modulate oxidative stress, and support tissue regeneration. These results align with clinical observations showing improved healing outcomes in chronic wounds, burns, and infections when treated with honey-based formulations (Çobanoğlu et al., 2023).

Propolis is characterized by an exceptionally diverse phytochemical matrix, especially flavonoids and phenolic acids including caffeic acid phenethyl ester (CAPE), chrysin, pinocembrin, galangin, and ferulic acid. CAPE's inhibition of the NF-κB signaling pathway directly correlates with the strong anti-inflammatory and anticancer activities observed in both in vitro and in vivo studies (Hossain et al., 2022). These findings suggest that propolis may be particularly valuable in the management of inflammatory disorders, respiratory infections, metabolic syndromes, and cancer. Its antiviral activity, demonstrated against influenza, herpes simplex, and hepatitis viruses, further emphasizes its therapeutic versatility (Ożarowski & Karpiński , 2023).

Royal jelly exhibits equally significant biochemical sophistication, containing major royal jelly proteins (MRJPs), peptides, acetylcholine, and the unique fatty acid 10-hydroxy-2-decenoic acid (10-HDA). The neurotrophic and neuroprotective effects of 10-HDA correspond with results showing enhanced neuronal survival, reduced oxidative stress, and improved cognitive markers in experimental models (Ahmad et al., 2020). These benefits indicate potential applications in neurodegenerative disorders, age-related cognitive decline, and hormonal dysregulation. Additionally, royal jelly's estrogenic and antioxidant effects reinforce its value in female reproductive health and anti-aging therapies (Kumar et al., 2024).

Bee venom delivers a complex mixture of peptides including melittin, apamin, and phospholipase A2 (PLA2), each contributing to potent anti-inflammatory, analgesic, and anticancer effects. Melittin, the largest component, disrupts cancer cell membranes, induces apoptosis, and modulates immune responses through interaction with multiple cell-signaling pathways. These findings have significant implications for cancer research, particularly in breast, liver, prostate, and hematological malignancies (Zhang et al., 2018). Bee venom therapy has also shown promise in autoimmune and neurological conditions, including rheumatoid arthritis and multiple sclerosis, although its clinical use requires cautious dosing due to allergenic risks (Stela et al., 2024).

Bee pollen, widely recognized as a nutrient-dense natural supplement, contains proteins, essential amino acids, vitamins, minerals, carotenoids, and flavonoids. Its antioxidant and immune-stimulating activities are supported by experimental results showing enhanced macrophage activation, improved cytokine balance, and protection against oxidative cellular damage. These findings justify its application as a supportive therapeutic agent for fatigue, immune deficiencies, metabolic disorders, and inflammatory conditions (Alshallash et al., 2023).

Table 1: Chemical–biological correlations is provided in this table.

Sr. No.	Bee Product	Major Bioactive Compounds	Primary Therapeutic Effects	Citations
1.	Honey	Flavonoids, phenolic acids, glucose oxidase, methylglyoxal	Antimicrobial, wound healing, antioxidant	(Cornara et al., 2017)
2.	Propolis	CAPE, pinocembrin, chrysin, galangin	Anti-inflammatory, antiviral, anticancer	(Zullkiflee et al., 2022)
3.	Royal Jelly	10-HDA, MRJPs, acetylcholine	Neuroprotective, estrogenic, antiaging	(Ramadan et al., 2012)

4.	Bee Venom	Melittin, apamin, PLA2	Anti-inflammatory, anticancer, immunomodulatory	(Wehbe et al., 2019)
5.	Bee Pollen	Amino acids, carotenoids, vitamins, phenolics	Immune boosting, antioxidant, anti-fatigue	(Mărgăoan et al., 2019)

The therapeutic potential of these products is strongly linked to multi-target molecular mechanisms. For instance, inhibition of NF-κB and STAT3 pathways by propolis corresponds with decreased inflammatory mediator production and reduced tumor progression (Chang et al., 2017). Melittin-induced apoptosis through caspase activation correlates with observed reductions in tumor cell viability. Similarly, activation of antioxidant systems by honey and bee pollen aligns with increased activity of endogenous enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). In neuroprotective contexts, 10-HDA's ability to promote neurite outgrowth and regulate neurotransmission correlates with improvements in neurological outcomes reported in experimental studies (Yazlovytska et al., 2023).

The global market growth for bee-derived therapeutic products reflects increasing public confidence and demand for natural interventions. With projections indicating a rise from USD 9.6 billion in 2022 to USD 15.3 billion by 2027, apitherapy is becoming a central component of global nutraceutical and natural-health sectors. Countries such as Germany, South Korea, and Cuba have integrated apitherapy into formal healthcare systems, demonstrating successful regulatory and clinical pathways (Kurtuluş Merdan, 2021). However, the absence of standardized extraction protocols, variability in chemical composition due to regional and botanical differences, and the scarcity of large-scale randomized clinical trials remain major barriers. These factors contribute to inconsistent therapeutic outcomes and hinder global regulatory acceptance (Puranik et al., 2023).

A notable concern is allergenicity, particularly associated with bee venom and pollen. Although clinical evidence supports the therapeutic value of bee venom therapy in autoimmune diseases, hypersensitivity reactions remain a significant safety challenge. Development of controlled dosing systems, allergen-reduced formulations, and strict clinical protocols is necessary to enhance safety and acceptance. In summary, the merged results and discussion highlight the significant pharmacological potential of bee-derived products, supported by strong experimental and clinical evidence. Their ability to modulate diverse biological pathways positions them as valuable candidates for treating infectious, inflammatory, metabolic, neurological, and oncological disorders. However, scientific advancement must be accompanied by standardization, clinical trials, and regulatory harmonization to fully integrate apitherapy into global modern healthcare (Burzyńska et al., 2021).

5. CONCLUSION

Apitherapy offers significant potential for modern healthcare through its diverse range of bioactive compounds with multifunctional therapeutic properties. Honey, propolis, royal jelly, bee venom, and bee pollen demonstrate extensive biological activities relevant to infectious, inflammatory, metabolic, neurodegenerative, and oncological disorders. Despite challenges, apitherapy is positioned as a powerful natural therapeutic system that, with further scientific validation and regulatory support, can contribute substantially to global health and sustainable medicine.

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Beebread Against Biofilm Formation and Biofilm Eradication of Nosocomial Pathogens Staphylococcus aureus and Acinetobacter baumannii

Arı Ekmeğinin, Hastane Kaynaklı Patojenler Staphylococcus aureus ve Acinetobacter baumannii'nin Biyofilm Oluşumu ve Biyofilm Ortadan Kaldırılmasına Karşı Etkisi

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Abstract

Biofilm forming antibiotic resistant bacteria are a major health issue worldwide. Therefore, studies demonstrating biofilm inhibition and eradication by natural products are increasingly published. Bee products are extensively studied for their *in vitro* antimicrobial activity. Nevertheless, research on their antibiofilm properties is rather scarce. In our study we tested the antibiofilm activity of eight Greek bee bread samples (seven multifloral and one unifloral) against two major nosocomial pathogens, *Staphylococcus aureus* and *Acinetobacter baumannii*. We have demonstrated for the first time that bee bread collected in Greece is effective in preventing bacterial biofilm formation as well as eradicating already formed biofilm. Inhibition of biofilm formation depends on bee bread concentration and on the tested pathogen. Higher inhibition rates were observed against *A. baumannii* (70.8% - 87.3%) compared to *S.aureus* (50.10% - 90.80%). Regarding eradication, the best results were observed at concentrations greater than the minimal inhibition concentration (MIC). For example, one sample demonstrated the best eradication activity (84.1%) against *S. aureus* at concentration twice the MIC. Overall, higher eradication activity has been observed against *S. aureus* compared to *A. baumannii*. Considering that all tested bee bread samples demonstrated significant antibiofilm activity, against two major pathogenic bacteria, we suggest that bee bread is a promising source of antibiofilm agents.

Keywords: Bee products, Bee bread, Antibiofilm, Biofilm eradication, Nosocomial pathogens

Genetic Polymorphism in the New Chickpea (Cicer arietinum L.) Collection

Yeni Nohut (Cicer arietinum L.) Koleksiyonunda Genetik Polimorfizm

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Abstract

Chickpea (*Cicer arietinum* L.), which ranks third in the world in terms of cultivated area and productivity, is a crop of great socio-economic and nutritional importance. In the Republic of Azerbaijan, it is also one of the most widely consumed leguminous crops. There is a significant need in the country to develop new chickpea varieties that meet modern requirements, are resistant to diseases and pests, tolerant to drought and other stress factors, and possess high yield potential along with favorable technological characteristics. In this study, the genetic diversity of 120 chickpea accessions preserved in the Genebank of the Institute of Genetic Resources, Azerbaijan National Academy of Sciences (ANAS), was evaluated using yield indicators, technological parameters, and ISSR markers. The accessions were cultivated at the experimental base of the Institute of Genetic Resources in accordance with descriptors, and variation analysis was carried out for 7 yield-related traits (number of fertile branches, plant height, first pod height, number of pods per plant, number of seeds per plant, 100-seed weight, yield per m²), 2 biochemical traits (protein content, oil content), and 3 technological traits (water absorption capacity of seeds, seed coat-to-cotyledon ratio, cooking time). The number of fertile branches per plant ranged from 2 to 6, plant height from 55 to 95 cm, first pod height from 20 to 30 cm, number of pods per plant from 20 to 96, number of seeds per plant from 35 to 192, 100-seed weight from 28.5 to 44.0 g, and yield per m² from 100 to 460 g. The varieties Flip 09-94c (460 g), Flip 09-96c (431.1 g), and Flip 05-74 (386.1 g) outperformed the local cultivar Jamila in terms of yield per unit area. Biochemical and technological analyses of the accessions were performed at the “Grain Quality” laboratory of the Research Institute of Crop Husbandry, Ministry of Agriculture of Azerbaijan, using the Kjeldahl method for protein determination and the Soxhlet method for oil content. Water absorption capacity ranged from 90% to 99%. The longest cooking time was recorded for Flip 11-66c (2.5 hours), while the shortest was observed in Flip 11-167c (2 hours). Protein content among the studied accessions ranged between 18.8% and 25.0%, while oil content varied between 6.2% and 11.5%. For marker-assisted selection, ISSR marker analysis was conducted, and of the 97 bands recorded, 75 were polymorphic, resulting in 84% polymorphism. Cluster analysis, performed with SPSS 16 software to confirm the reliability of the results, grouped the accessions into six clusters. As a result, accessions such as Flip 07-220, Flip 07-283, Flip 09-40, Flip 09-259, Flip 09-36, Flip 07-301, Flip 07-306, Flip 07-22, Flip 07-297, and Flip 07-328 were identified as highly promising. During

the study, tall and high-yielding accessions resistant to lodging and diseases were selected, which will serve as initial genetic sources for the development of new varieties.

Keywords: Chickpea, Cicer arietinum L., ISSR marker, yield components, variation, cluster.

In Vitro Assessment of the Antimicrobial and Cytotoxic Effects of Bee Bread and Valya Propolis

Arı ekmeği ve Valya Propolisinin Antimikrobiyal ve Sitotoksik Özelliklerinin İn Vitro Değerlendirilmesi

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Abstract

The widespread and inappropriate use of antimicrobial agents has led to a steady increase in antimicrobial resistance among microorganisms. This situation, which directly affects human health, has accelerated research aimed at discovering new and effective antimicrobial agents. Similarly, studies focused on identifying compounds that can effectively eliminate cancer cells while causing fewer side effects have also been increasing. In this study, bee products (bee bread and propolis), which have emerged as important natural resources in these research areas, were evaluated. Bee bread and Valya propolis samples were extracted with 70% ethanol. After the removal of ethanol and water, the remaining dry matter was dissolved in DMSO and used for antimicrobial and cytotoxicity assays. Antimicrobial activities were tested against *Staphylococcus aureus* ATCC 25923, *Enterococcus faecalis* ATCC 29212, *Pseudomonas aeruginosa* ATCC 27853, *Escherichia coli* ATCC 25922, *Chromobacterium violaceum* ATCC 12472, and *Candida albicans* ATCC 10231 using the agar well diffusion method. Minimum inhibitory concentrations (MICs) were determined for isolates showing antimicrobial activity. The cytotoxic effects of the samples on the breast cancer cell line (MDA-MB-231), lung adenocarcinoma cell line (A549), and normal epithelial cell line (Vero) were evaluated using the MTT assay. The results indicated that bee bread showed no antimicrobial activity, while Valya propolis exhibited activity against *S. aureus*, *E. faecalis*, *C. albicans*, and *C. violaceum*. The MIC values determined for these isolates were 7.031±3.932 mg/mL, 4.687±1.804 mg/mL, 3.906±1.563 mg/mL, and 4.687±1.804 mg/mL, respectively. Cytotoxicity assays demonstrated that both bee bread and Valya propolis were non-toxic to A549 and Vero cells. However, Valya propolis showed cytotoxic effects against MDA-MB-231 cells at concentrations of 50–100 µg/mL, while bee bread exhibited cytotoxicity at 200–800 µg/mL. Taken together, these findings suggest that the active compounds within Valya propolis responsible for antimicrobial and cytotoxic activities should be further analyzed. The identification and detailed investigation of these compounds may provide valuable insights for future studies.

Keywords: Antimicrobial, Apitherapy, Cytotoxicity, Nature, Food, Propolis

Negative Anastasis in Breast Cancer After Bee Venom Exposure: An Epigenetic Insight

Ari Zehri Maruziyetinden Sonra Meme Kanserinde Negatif Anastaz: Epigenetik Bir Bakış

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Abstract

Anastasis is the reversal of apoptosis, but its selective regulation in cancer versus normal cells remains unclear. Negative anastasis, we suggested, refers to persistent cell death in cancer cells. Therefore, the present study investigated the epigenetic regulation of bee venom (BV)-induced anastasis in normal breast cells (MCF10A) compared to negative anastasis in breast cancer cells (MDA-MB-231).

Cells were treated with BV or cisplatin (at 0, 8, or 12µg/mL) for 24 hours (+24h) and then cultured in clean media up to 72h (-72h) (anastatic incubation). At each time, cell viabilities were evaluated by trypan blue and Annexin-V/PI assays. Cellular morphology was revealed by flow cytometry. The regulation of epigenetic markers was also screened. Epigenetic assays include H3K4 methylation by immunostaining, and gene expression profiles of epigenetic regulators, DNMT1, DNMT3A, EP300, EZH1, HDAC1, KDM6A, KMT2A, and TET by Q-PCR. The expression of apoptosis-related genes, BAX, BCL2, DFFPB, TP53, and RBBP4, and developmental genes, H19, IGF2, LHX4, and HOXB13, was also evaluated.

BV induced persistent cell death in MDA-MB-231 cells, while MCF10A cells were recovered. However, cisplatin induced irreversible cell death in both. Necrosis increased after BV for +24h, but apoptosis significantly increased after cisplatin for +24h, in both cells. Cisplatin also induced persistent apoptosis in MCF10A cells (+24h), but no significant difference was found at anastatic -72h. In anastasis, H3K4me1 decreased after BV in MCF10A cells but increased in MDA-MB-231 cells. Cisplatin induced an increase in H3K4me1 in MCF10A but a decrease in MDA-MB-231. H3K4me3 had a stable pattern in MCF10A cells after BV but decreased after cisplatin. In MDA-MB-231 cells, H3K4me3 level fluctuated after BV, but cisplatin provoked a decrease. Apoptosis-related genes were upregulated after BV in MDA-MB-231. TET was the overexpressed gene in MCF10A at +24h. EZH1 was the only overexpressed gene at anastatic -72h. Cisplatin induced DFFB upregulation from +24h to -72h in MDA-MB-231, suggesting persistent DNA fragmentation. But DFFB was downregulated in MCF10A after cisplatin. These suggest that bee venom-induced anastasis was regulated by H3K4me and TET upregulation. This study was supported by Karadeniz Technical University (FBA-2018-7951, FYL-2019-8116) and TUBITAK (123Z002).

Key words: anastasis, epigenetic, cancer, bee venom, cisplatin

Development of Eco-Friendly Propolis Extracts Using Deep Eutectic Solvents

Derin Ötektik Çözücüler Kullanılarak Çevre Dostu Propolis Ekstraktlarının Geliştirilmesi

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Abstract

Propolis is a natural resinous mixture collected from beehives, valued for its high biological activities, including antioxidant, antimicrobial, antiviral, and anti-inflammatory properties, making it a significant natural supplement. After raw propolis is harvested from beehives, it is purified from beeswax and impurities and can be consumed as extracts or processed using specific techniques. Ethanol, known for its high solvation capacity, is the most effective solvent for propolis extraction. However, ethanol-free, eco-friendly propolis extracts have recently gained attention. This study aimed to develop ecological propolis extracts using deep eutectic solvents (DES). DES mixtures, such as choline chloride, lactic acid, citric acid, ascorbic acid, and proline, were tested to identify solvent systems with the highest extraction capacity. A pooled sample of raw propolis collected from seven geographical regions of Turkey was used, and total phenolic content (TPC/mg GAE/mL) served as the primary evaluation parameter. The TPC of Anatolian propolis was found to be 0.90 mg GAE/mL in aqueous extract and 42.68 mg GAE/mL in ethanolic extract. Among the DES mixtures tested, the combination of choline chloride and lactic acid at a 1:10 ratio achieved the highest TPC value of 8.80 mg GAE/mL.

This study highlights the potential of DES as eco-friendly alternatives for propolis extraction, offering a sustainable approach to producing high-quality propolis-based products.

Acknowledgment:

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Keywords: Propolis, Deep Eutectic Solvent, Choline Chloride, Lactic Acid

New Liverwort Records from the Artabel Lakes Nature Park (Gümüşhane, Türkiye)

Artabel Gölleri Tabiat Parkı'ndan (Gümüşhane, Türkiye) Yeni Ciğerotu Kayıtları

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Abstract

The Artabel Lakes Nature Park, located in Gümüşhane Province in the Eastern Black Sea Region of Türkiye, represents one of the most ecologically diverse and least explored alpine areas of the country. During recent bryofloristic investigations conducted in 2025, three liverwort species, *Riccardia incurvata Lindb.*, *Marsupella sphacelata* (Giesecke ex Lindenb.) *Dumort.*, and *Anthelia juratzkana* (Limpr.) Trevis, were identified as new records for the bryophyte flora of Türkiye.

Specimens were collected from moist, shaded microhabitats along mountain streams, rocky slopes, and subalpine meadows situated between 2100 and 3400 meters above sea level. The identification of these taxa was based on detailed morphological examinations using stereomicroscopic and compound microscopic techniques, supported by comparisons with European and Asian floras.

Riccardia incurvata is typically a temperate to boreal species known from Northern and Central Europe, while *Marsupella sphacelata* and *Anthelia juratzkana* are characteristic of cold, high-altitude or subarctic environments. Their occurrence in northeastern Anatolia suggests that the Artabel Lakes region serves as a refugial zone harboring boreo-montane elements under specific microclimatic conditions.

These findings not only increase the known liverwort diversity of Türkiye but also provide important insights into the biogeographical patterns and ecological connections between the Caucasian and Eastern Black Sea Region Mountain systems. Continued bryological exploration in such high-altitude habitats will likely reveal further additions to the national bryophyte flora and improve our understanding of cryptogamic diversity in Anatolia.

Acknowledgments

This study was supported by Scientific and Technological Research Council of Türkiye (TUBITAK) under Grant Number 124Z844. The authors thank TUBITAK for their support

Keywords: Bryophyte diversity, Liverworts, *Riccardia incurvata*, *Marsupella sphacelata*, *Anthelia juratzkana*, New records, Türkiye.

In Silico and In Vitro Evaluation of Bis-Imidazole Derivatives as Potential HIV-1 Reverse Transcriptase Inhibitors

Bis-İmidazol Türevlerinin Potansiyel HIV-1 Ters Transkriptaz İnhibitörleri Olarak In Silico ve In Vitro Değerlendirilmesi

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Abstract

The discovery of novel HIV-1 reverse transcriptase (RT) inhibitors remains crucial due to the continuous emergence of drug resistance against current antiretroviral agents. In this study, three bis-imidazole derivatives (3e, 3f, and 3g) were evaluated for their inhibitory potential against HIV-1 RT using a combined in silico and in vitro strategy. Molecular docking simulations (PDB ID: 3T19, AutoDock 4.2.6) revealed distinct binding profiles. Compound 3e exhibited the most favorable binding energy (−9.18 kcal/mol) and demonstrated potent inhibition (K_i = 186.36 nM), despite the absence of hydrogen bonds, with stabilization mediated primarily through van der Waals interactions involving residues such as His235, Phe227, and Tyr319. Compound 3f showed strong inhibition (K_i = 1.96 µM), supported by four hydrogen bonds and extensive interactions with Asp117, Glu138, Tyr181, and Pro95, highlighting its stable accommodation within the RT binding pocket. Compound 3g displayed moderate inhibition (K_i = 8.59 µM) with three hydrogen bonds and interactions involving Tyr188, Trp229, and Lys101. For comparison, the reference inhibitor nevirapine (−9.53 kcal/mol, K_i = 103.97 µM) formed a single hydrogen bond and engaged residues such as Tyr318, His235, and Phe227.

Experimental validation through a colorimetric ELISA-based RT inhibition assay confirmed the computational predictions. Among the tested compounds, 3f exhibited the most potent dose-dependent inhibition in vitro, whereas docking suggested compound 3e as the most favorable binder. Together, these findings reveal bis-imidazole derivatives, particularly 3e and 3f, as promising scaffolds for the rational design of next-generation HIV-1 RT inhibitors, warranting further optimization and preclinical exploration.

Keywords: HIV-1 reverse transcriptase, bis-imidazole derivatives, molecular docking, ELISA assay, enzyme inhibition, antiviral drug discovery

Effect Of Electromagnetic Fields on The Amount Of 10-HDA In Royal Jelly Production

Arı Sütü Üretiminde Elektromanyetik Alanların 10-HDA Miktarına Etkisi

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Abstract

10-hydroxy-2-decenoic acid (10-HDA) is one of the most fundamental criteria used for determining the freshness and quality of royal jelly. The research, which focuses on factors affecting this criterion, aims to identify the effects of electromagnetic fields that may impact colonies during the production phase. In the study conducted during the summer season of 2025 at the Van Yüzüncü Yıl University Beekeeping Application and Research Center Directorate facility, a total of 9 honey bee colonies possessing Caucasian F1 hybrid queen bees were utilized. To determine the effect, magnetic influences of 300 µT and 600 µT were applied for 1 hour per day to groups each containing 3 colonies, using copper coil inductors. The quantities of 10-HDA in royal jelly samples collected from the colonies and preserved in the cold chain will be determined using high-performance liquid chromatography (HPLC) equipped with an ultraviolet absorbance detector. In addition to the 10-HDA content, larval acceptance rates in products from colonies subjected to 15 graftings using one-day-old larvae will also be evaluated using the Duncan Multiple Range Test, comparing the untreated control group to the treatment groups. This research will clarify how growing human-induced electromagnetic effects impact royal jelly, a key beekeeping product, and will result in recommendations for producer practices.

Keywords: Honey bee, Royal jelly, 10-HDA, Electromagnetic field

Özet

10-hidroksi-2-dekanoik asit (10-HDA), arı sütünde tazelik ve kalitenin belirlenmesi için kullanılan en temel ölçütlerden biridir. Bu ölçüt üzerine etkili faktörleri konu alan araştırma üretim aşamasında kolonilere yansıması muhtemel elektromanyetik alanların etkisini belirlemeyi amaçlamaktadır. Van Yüzüncü Yıl Üniversitesi Arıcılık Uygulama ve Araştırma Merkez Müdürlüğü işletmesinde 2025 yaz sezonunda yürütülen çalışmada Kafkas F1 melezi ana arıya sahip toplam 9 adet bal arısı kolonisi kullanılmıştır. Etkinin belirlenmesi amacıyla her birinde 3'er koloni bulunan gruplara bakır sarmalı bobinler yardımıyla günde 1 saat süreyle 300 µT ve 600 µT manyetik etki verilmiştir. Kolonilerden toplanan ve soğuk zincirde korumaya alınan arı sütü örneklerinde 10-HDA miktarları ultraviyole absorbans dedektörlü yüksek performanslı sıvı kromatografisi

(HPLC) kullanılarak belirlenecektir. Bir günlük yaşta larva kullanılarak 15 adet aşılama yapılan kolonilerden elde edilen ürünlerde 10-HDA miktarının yanı sıra tutma oranları da değerlendirmeye alınacak, etki verilmeyen kontrol grubu muamele grupları ile Duncan Çoklu Karşılaştırma Testi kullanılarak karşılaştırılacaktır. Böylece günümüz şartlarında giderek artan insan kaynaklı elektromanyetik etkilerin önemli arıcılık ürünlerinden olan arı sütüne etkisini ortaya koyulacak, bulguların değerlendirilmesiyle üretici koşullarına öneriler getirilecektir.

Anahtar Kelimeler: Bal arısı, Arı Sütü, 10-HDA, Elektromanyetik Alan

Honey Bee Diseases: Current Status and Approaches

Bal Arısı Hastalıkları: Güncel Durum ve Yaklaşımlar

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Abstract

Honey bees (*Apis mellifera*) occupy an indispensable position not only in the production of honey and other bee products but also in maintaining biodiversity, sustaining ecosystem balance, and supporting sustainable development through their critical role in plant pollination. In recent years, with the increasing influence of both abiotic stressors (such as pesticide exposure, habitat loss, climate change, and nutritional deficiencies) and biotic stressors (such as infections caused by bacteria, viruses, fungi, and parasites), significant declines in honey bee populations have been reported worldwide. This situation has led to the emergence of the phenomenon known as *Colony Collapse Disorder* (CCD), particularly since the early 21st century.

In this review, the major pathogens identified as key contributors to colony losses are examined comprehensively, including bacterial diseases (American foulbrood and European foulbrood), viral infections [*Acute Bee Paralysis Virus* (ABPV), *Chronic Bee Paralysis Virus* (CBPV), *Kashmir Bee Virus* (KBV), *Israeli Acute Paralysis Virus* (IAPV), *Deformed Wing Virus* (DWV-A), *Varroa destructor-1 Virus* (VDV-1/DWV-B), *Black Queen Cell Virus* (BQCV), *Sacbrood Virus* (SBV), and *Apis mellifera Filamentous Virus* (AmFV)], fungal pathogens (*Ascosphaera apis*), *Nosema* spp., and the most destructive parasitic mite, *Varroa destructor*. These pathogens, whether acting individually or through co-infections involving multiple pathogens simultaneously infecting the same host, impose substantial physiological stress on the host organism, leading to impairments in individual bee health and colony-level collapses. Such conditions not only weaken the immune response of honey bees but also enhance the synergistic interactions among viral and microbial agents, further increasing the pathogenic potential of ectoparasites such as *Varroa destructor*. Globally, the pathogens affecting honey bee colonies not only reduce productivity but also threaten colony vitality, thereby posing serious risks to ecosystem functioning and pollination services essential for agricultural production. Since the impacts of these pathogens manifest as both individual-level health impairments and colony-level collapses with consequent productivity losses, surveillance studies and preventive measures are of critical importance.

In conclusion, ensuring the continuity of honey bee populations and preserving ecosystem balance require the early implementation of integrated preventive strategies aimed at mitigating colony losses and promoting colony health.

Keywords: American Foulbrood, Colony Collapse Disorder, Honey Bee, *Nosema*, *Varroa,* Viral Diseases.

First Isolation and Characterization of Bombella apis from the Digestive System of Apis mellifera caucasica and Evaluation of Its Probiotic Potential

Apis mellifera caucasica'nın Sindirim Sisteminden Bombella apis'in İlk İzolasyonu ve Karakterizasyonu ve Probiyotik Potansiyelinin Değerlendirilmesi

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Abstract

Apis mellifera caucasica, a subspecies of *A. mellifera* L., is one of the most valuable honeybee lineages in Türkiye due to its high honey productivity and strong propolis collection ability. The digestive system of honeybees harbors a distinctive microbial flora that contributes to metabolic processes, the production of bee products, and immune defense mechanisms. Understanding this microbiota is therefore crucial both for bee health and for identifying microorganisms with potential probiotic properties.

In the present study, bacterial isolates were obtained from the honey stomachs of *A. mellifera caucasica* under sterile conditions. After dissection, homogenized samples were cultured on MRS agar, and isolates were characterized morphologically (Gram staining) and molecularly using 16S rRNA gene sequencing. The strain designated Amcs17 was evaluated for acid, pepsin, pancreatin, and salt tolerance, as well as for antimicrobial activity and antibiotic susceptibility.

The bacterium was identified as *Bombella apis* based on 16S rRNA sequence similarity. Importantly, this study reports for the first time the isolation of *Bombella apis* from the digestive system (honey stomach) of *Apis mellifera caucasica*. The strain exhibited limited tolerance to simulated gastrointestinal conditions and showed no antimicrobial activity against tested human pathogens. However, it was sensitive to several antibiotics, including spectinomycin (10 m mg/ml), erythromycin (15 mg/ml), ceftazidime (10 mg/ml), rifampicin (800 µg/ml), chloramphenicol (15 mg/ml), ampicillin (100 mg/ml), kanamycin (10 mg/ml), tetracycline (10 mg/ml), penicillin (10 mg/ml), and gentamicin (10 mg/ml). According to the acid, pepsin, pancreatin, and salt resistance tests, *Bombella apis* exhibited limited tolerance under these conditions within 24 hours.

These findings contribute to the understanding of the gut microbiota of *A. mellifera caucasica* and highlight the presence of *Bombella apis* as a newly identified member of this unique microbial community. Although

the strain showed limited probiotic potential, its discovery expands the known diversity of acetic acid bacteria in honeybee digestive ecosystems.

Keywords: *Apis mellifera caucasica, Bombella apis*, Stomach Microbiota, Probiotic Potential, Honeybee Health

Sensitive Determination of Bioactive Components in Medicinal Plants by Capillary Electrophoresis

Tıbbi Bitkilerdeki Biyoaktif Bileşenlerin Kapiler Elektroforez ile Hassas Tayini

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Abstract

Capillary electrophoresis (CE) plays a significant role in the analysis of traditional medicinal plants and their derived products, which hold great medical and economic importance. Its high separation efficiency and selectivity, along with the diversity of separation and analysis modes, allows the investigation of a wide range of molecules. Over the past decade, capillary electrophoresis combined with laser-induced fluorescence detection (CE-LIF) has attracted considerable attention because it can achieve very low detection limits at the nmol/L level. Using the CE-LIF technique, naturally fluorescent active components in sage and turmeric—plants used in traditional medicine and important in our diet—have been determined. Riboflavin (vitamin B2) is an essential micronutrient for human health. Since it cannot be synthesized or stored in the body, it must be obtained from dietary sources. *Salvia* species are widely used in traditional medicine due to their various bioactivities. Although many studies have reported their phenolic contents, there is almost no information about the riboflavin content of these plants. The riboflavin contents of 14 *Salvia* species collected from different regions of Anatolia were determined using CE-LIF. The limit of detection (LOD) of the method was determined to be 8 ng/mL. Turmeric has been used for more than 4000 years both as a spice and in traditional medicine. Its main bioactive compounds are curcumin, demethoxycurcumin (DMC), and bisdemethoxycurcumin (BDMC), which differ only in the number of methoxy substitutions on the aromatic ring. Taking advantage of the high separation efficiency of CE, these three curcuminoids were successfully separated in a short time and quantified in turmeric samples. The LOD values of curcumin, DMC, and BDMC with the LIF detector were determined as 0.081, 0.039, and 0.005 µg/mL, respectively.

Keywords: Sage, Curcuminoid, Sensitivity, Phytochemical analysis

Biological Activities of Propolis and Essential Oil Combinations

Propolis ve Uçucu Yağ Kombinasyonlarının Biyolojik Aktiviteleri

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Abstract

This study investigated the antimicrobial, antiviral, and antioxidant activities of propolis and various essential oils (lavender, thyme, and tea tree), both individually and in combination. The potential synergistic effects of propolis and essential oils were evaluated, considering their multiple biological effects. Propolis was collected from Ordu Province, Turkiye, and extracted with 70% ethanol. Experimental groups were prepared by mixing the propolis extract with essential oils (lavender, thyme, and tea tree) at a 1:10 ratio. Antimicrobial activity was investigated using well diffusion and minimal inhibitory concentration (MIC) methods on ATCC strains including *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhimurium*, and *Candida albicans*. Antiviral activity was assessed using HIV-1 reverse transcriptase (RT) inhibition and a colorimetric ELISA kit. In addition, the antioxidant capacities of propolis and oil combinations were analyzed by spectrophotometric methods. According to the results, the highest antimicrobial effect was observed in thyme oil and its combinations. Thyme oil created a 40 mm inhibition zone on *Candida albicans*. Propolis addition synergistically enhanced the activity of lavender and tea tree oils. MIC values were found in the range of 4–16 µg/mL. In terms of antiviral activity, RT inhibition rates were determined as follows: DMSO (43%), DMSO/propolis (82%), lavender oil (76%), thyme oil (73%), tea tree oil (96%), tea tree oil/propolis (95%), thyme oil/propolis (95%), and lavender oil/propolis (94%). Antioxidant analyses revealed that oil-propolis combinations had higher radical scavenging capacity than either oil or propolis alone, with the thyme-propolis group demonstrating a particularly significant advantage. These results demonstrate that propolis and essential oils, both alone and in combination, possess potent antimicrobial, antiviral, and antioxidant properties, and that the thyme oil-propolis combination is particularly promising in terms of broad-spectrum biological activity.

Keywords: Propolis, Essential Oils, Antimicrobial, Antiviral, Antioxidant, HIV-1 RT

Apilarnil-Loaded Alginate Microbeads: Physicochemical Properties, Bioactivity, and Release Behavior

Apilarnil Yüklü Aljinat Mikroküreler: Fizikokimyasal Özellikler, Biyoaktivite ve Salım Davranışı

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Abstract

Apilarnil, a bee product derived from drone brood, has recently gained attention due to its rich bioactive composition and potential health-promoting effects. Drone larvae contain mineral salts, vitamins, carbohydrates, lipids, and amino acids, all of which contribute to its antioxidant, antimicrobial, and hormone-regulating activities. Owing to these properties, apilarnil has been considered a promising candidate for use as a functional food component and dietary supplement. However, its sensitivity to environmental factors such as light, temperature, and pH, along with enzymatic degradation in the gastrointestinal system, limits its direct consumption and industrial applications. To address these challenges, apilarnil was encapsulated into alginate microbeads. The physicochemical and structural properties of the apilarnil-loaded alginate beads were investigated, along with their swelling behavior in water, simulated gastric fluid (SGF), and simulated intestinal fluid (SIF). The total protein and phenolic contents of the microbeads were quantified using Bradford's and Folin–Ciocalteu methods, respectively. Furthermore, amino acid release was evaluated by capillary electrophoresis. Collectively, these analyses provide a comprehensive evaluation of the biocompatibility, controlled release behavior, and antioxidant potential of apilarnil–alginate microbeads. These findings highlight the potential of encapsulation as an effective strategy to enhance the stability and applicability of apilarnil in functional food and nutraceutical formulations.

Keywords: Apilarnil, Biopolymer, Capillary Electrophoresis, Controlled Release, Encapsulation, Functional Food

Fate of Tea Polyphenols in the Gastrointestinal System: Stability and Bioaccessibility

Çay Polifenollerinin Gastrointestinal Sistemdeki Akıbeti: Stabilite ve Biyoerişilebilirlik

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Abstract

Tea is one of the most widely consumed beverages worldwide, and its health benefits such as antioxidants, anti-inflammatory, and antimicrobial activity are mainly attributed to polyphenols, particularly catechins. On the other hand, their possible health effects largely depend on how stable and bioaccessible they remain during gastrointestinal digestion. The aim of this review is to provide an overview and critical assessment of recent studies on the fate of tea polyphenols during *in vitro* digestion, focusing on their chemical transformations, degradation pathways, and the factors affecting their bioaccessibility (BA). The bioactivity and bioaccessibility of phenolic compounds are modulated by enzymatic and chemical reactions that take place during gastrointestinal digestion. Additionally, the interactions between tea polyphenols and other food components (e.g., proteins, lipids, carbohydrates) significantly influences polyphenol solubility thereby affecting their bioaccessibility. Only a small portion of these molecules become available for intestinal absorption, despite their encouraging bioactive potential. Recent studies underscore the imperative for advanced formulation strategies, such as encapsulation, nanoemulsion systems, and matrix optimization, to enhance polyphenol stability and bioaccessibility. Understanding the digestive destiny of tea polyphenols is critical for developing functional tea-based products that provide additional health advantages.

Keywords: Bioaccessibility, *In vitro* digestion, Stability, Tea polyphenols

1. INTRODUCTION

People in the East, especially in Asia, have been drinking tea plants for a long time. Many countries around the world grow it, but India, China, Kenya, Turkey, Sri Lanka, Vietnam, Indonesia, and Japan are the best places to find it (Azami & Forouzanfar, 2024; Chen et al., 2020, Wang et al., 2024). This plant makes tea that people can drink, and it is the second most popular non-alcoholic drink in the world, after water (Pan et al., 2022; Wei et al., 2024). According to Pan et al. (2022), more than three billion people across 160 countries and regions regularly consume tea as a beverage. As a result, tea plays a crucial role in promoting global economic growth. The global market value of tea is estimated to exceed $318 billion by 2025.

Tea's health benefits mainly come from its polyphenolic composition, which is what makes it culturally and economically important. Tea leaves have thousands of bioactive compounds in them, such as polyphenols, phenolic acids, coumarins, flavonoids, polyacetylenes, alkaloids, saponins, and terpenoids. Some of these are theanine and theaflavins (Samanta, 2020; Wang et al., 2022). Polyphenols are the main bioactive compounds in tea. They include catechins, gallic acids, theaflavins, tannins, and flavonoids. The content of polyphenols is mainly influenced by factors such as different organs, developmental stages, and tea processing techniques (Wang et al., 2022; Wong et al., 2022). The main polyphenolic compounds in tea varieties are given in Figure 1 (Pan et al., 2022).

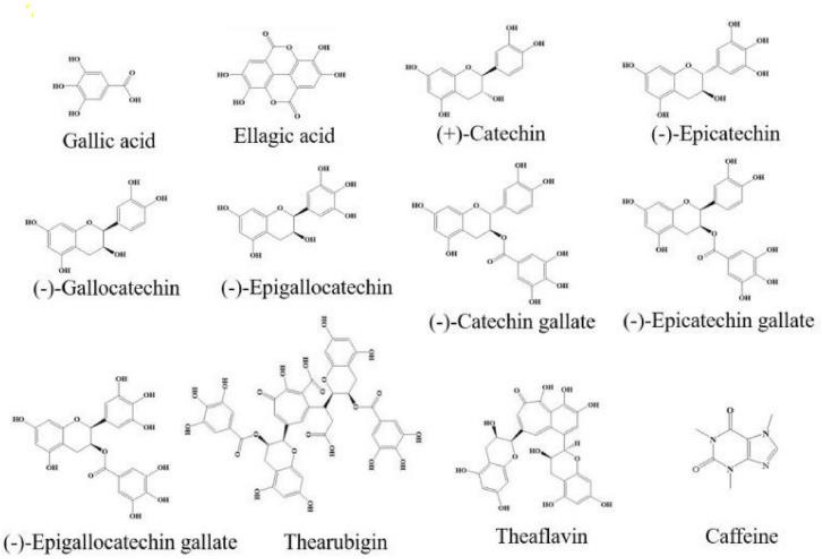

Figure 1. Main polyphenolic compounds in tea varieties (Pan et al., 2022)

Catechins constitute approximately quarter of tea leaves (in the dry weight) and 50-70% of total polyphenols (Aloo et al., 2024; Özcan Aykutlu, 2023; Wong et al., 2022). Similarly, the polyphenol concentration of green tea, a non-oxidized tea variety, varies between 30-40%, and these are catechin types such as catechin (C), epigallocatechin-3-gallate (EGCG), (-)-catechin gallate (CG), epicatechin (EC), gallocatechin (GC), epicatechin gallate (ECG), epigallocatechin (EGC), and gallocatechin gallate (GCG) (Azami & Forouzanfar, 2024). In fermented teas, however, this situation is different; most catechins are converted into secondary phenolic compounds, theaflavins (TF) and thearubigins (TR), as a result of oxidation and polymerization (Wong et al., 2022).

These polyphenolic compounds found in tea exhibit multiple physiological activities, including antioxidants, antimicrobial, antitumor, anti-inflammatory, immunomodulatory, anti-cancer, cardiovascular protection, and anti-diabetic properties (Pan et al., 2018; Wei et al., 2024; Zhang et al., 2021). However, despite this, the poor intestinal absorption and low bioavailability of these compounds limit their biological potential, making it essential to understand their fate within the gastrointestinal system (Sang et al., 2006; Yin et al., 2022).

Tea polyphenols (TPPs) exhibit poor stability when subjected of environmental factors such as temperature, light, pH fluctuations, and oxygen. Moreover, the harsh gastrointestinal conditions and limited permeability of intestinal membranes further restrict their absorption, resulting in low bioavailability after ingestion (Sang et al., 2006; Yin et al., 2022). The gastrointestinal tract (GIT) presents a challenging environment for tea polyphenols owing to its high pH, remaining dissolved oxygen, and enzymes in metabolism (Cai et al., 2018; Sun et al., 2012). Shim et al. (2012) found that catechin, epigallocatechin and epigallocatechin gallat showed significant degradation and low recovery (5.3%, 4.6%, and 6.1%, respectively) after passing through saliva, gastric juice, and reaching the upper small intestine in an *in vitro* gastrointestinal model. In addition to degradation, tea polyphenols undergo autoxidation and epimerization caused by dissolved oxygen remaining in the gastrointestinal tract. Studies have found that TPPs are high stability at lower the pH (Zeng et al. 2017). In the study conducted on green tea infusions, gastric phase conditions caused significant decreases in the total flavonoid and polyphenol content and antioxidant activities of the tea (Qin & Ketnawa, 2025). Su et al. (2003) reported that theaflavins were more susceptible to degradation than catechins under alkaline pH and high temperature conditions. Furthermore, epigallocatechin-3-gallate and epigallocatechin were fully dispossessed after 6 h of incubation (pH 7.4 water phase) while EC and ECG were just less than 35% degraded.

Bioaccessibility means to the fraction of polyphenols released into the water-soluble phase during digestion that becomes available for intestinal absorption *in vivo*. Since gastrointestinal (GI) digestion is a complex physiological process involving multiple dynamic factors, ***in vitro*** digestion models have inherent limitations, particularly in mimicking the colonic stage where microbial metabolism plays a crucial role (Annunziata et al., 2018). This metric is crucial for assessing the potential health effects of food products, particularly polyphenols, whose stability and solubility are significantly influenced by digestive circumstances (Qin & Ketnawa, 2025). TPPs can improve intestinal stability by reducing the gastrointestinal tract's overall exposure to reactive oxygen species and alkaline pH (Yang et al., 2018; Yin et al., 2022).

Several studies have investigated the bioaccessibility of tea polyphenols under simulated digestive conditions. For example, the *in vitro* BA of polyphenols in infusions of different tea was assessed by Tenore et al. (2015). A very low intestinal bioaccessibility of about 8% was found when bioaccessibility was examined utilizing a simulated GI digesting technique. This was explained by the neutral pH of the intestines, which leads to catechin autoxidation and epimerization. Furthermore, the food matrix has a significant influence on polyphenol release. De Lacey et al. (2012) observed that green tea-loaded edible gelatin-based films have been reported to reduce the bioaccessibility of flavanols. This is believed to be due to the gelatin limiting the release of green tea flavonols or binding to the compounds after release. Conversely, Peters et al. (2015) found that the bioavailability of green tea catechins was higher before ingestion. However, when green tea was

combined with ascorbic acid and sucrose duodenal bioavailability increased. Together, these findings highlight that the bioaccessibility of TPPs is strongly contingent on digestive pH, food matrix composition, and co-present nutrients or stabilizing agents, all of which govern their eventual absorption and biological activity. Overall, these findings show that the digestive environment has a significant impact on tea polyphenol absorption, emphasizing the necessity of developing techniques to improve their intestinal bioaccessibility.

Tea polyphenols can be considered food or nutraceutical products; however, numerous studies have reported their low intestinal absorption. This limited bioavailability is mainly attributed to interactions with the food matrix and degradation under neutral pH and enzymatic conditions during digestion. Therefore, strategies to increase intestinal bioavailability require the use of different technological delivery systems (Qin et al., 2025; Sang et al., 2006; Tenore et al., 2015). These technologies include applications such as microencapsulation, nanoencapsulation, fermentation, edible film and different food combinations. For instance, Annunziata et al. (2018) prepared powdered tea polyphenols in acid-resistant capsule form. The study found that the total polyphenol bioavailability of the encapsulated polyphenols was 13% to 23.77%, resulting in a significant increase in bioavailability compared to free forms. Similarly, in the other study the potential of alginate-based films as a vehicle was investigated for delivering tea polyphenols to the intestinal tract. The green tea polyphenols bioaccessibility was importantly increased by the films (54.41%) compared to free green tea extract (33.73%) (Benlloch-Tinoco et al., 2025). In another study, the total phenolic substance bioaccessibility of concentrated black tea extract was found to be 38.86%, while it was determined to be 67.98% in gelatin-based film form. Further evidence of improved intestinal delivery was provided by Chen et al. (2018) who co-encapsulated EGCG and quercetin within a water/oil/water double emulsion gel structure. The results demonstrated that the bioaccessibility values of EGCG and quercetin increased by 2 and 4 times, respectively. Similarly, in the study where microencapsulation method was used to increase the bioaccessibility of green tea extract, the bioaccessibility of total polyphenols was determined as 25.9% in the free extract and 28.2% in the microencapsulated form (Silva et al., 2021). Moreover, Peters et al. (2010) reported that under *in vitro* digestion conditions, the presence of sucrose and ascorbic acid enhanced the bioavailability of catechins by increasing the bioaccessibility and intestinal uptake of green tea extract (Peters et al., 2010).

4. CONCLUSION

Tea polyphenols exhibit remarkable antioxidant and health-promoting properties. However, their bioactive properties strongly depend on their stability and bioaccessibility within the digestive system. These compounds experience pH fluctuations, enzymatic degradation, and interactions with dietary macronutrients during digestion, all of which can weaken their structure and reduce their effectiveness in the body. Therefore,

developing protective delivery systems represents a promising approach to enhance the physiological efficacy of tea polyphenols.

Overall, improving the stability and bioaccessibility of tea polyphenols requires an integrated approach that combines physicochemical stabilization and formulation innovation. Current studies have shown that new food technologies, such as encapsulation, nanoemulsion, protein–polyphenol complexation, and pH-controlled systems, have shown promise in improving the protection and controlled release of tea polyphenols in simulated digestive conditions.

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Indonesian Propolis: A Natural Multi-Therapeutic Approach for Women's Health Challenges

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Abstract

This collection of clinical and quasi-experimental studies evaluates Indonesian propolis including propolis wax from Tetragonula sp.—across key women's health indications: primary dysmenorrhea, anemia in pregnancy, emesis gravidarum, and vulvovaginal candidiasis.

Methods: Designs included pre-experimental one-group pretest-posttest (dysmenorrhea: n=31; anemia: n=44), a quasi-experimental two-group pretest-posttest (emesis gravidarum: propolis vs vitamin B6; n=42), and candidiasis studies using propolis wax either as transparent soap (1% or 2%) in leukorrhea (n=36; treatment vs control) or as a 5% ovule compared with nystatin in a randomized, limited-sample trial (n=40). Outcomes were pain intensity (Numeric Rating

Scale), hemoglobin (Hb), vomiting frequency, and mycological/clinical responses. Results: In dysmenorrhea, a single 3,450 mg propolis capsule reduced pain significantly (Wilcoxon p=0.001), with "no pain" increasing to 71% at 3 hours. In pregnant women, 504 mg/day propolis for 5 days increased mean Hb from 11.7 to 14.3 g% (p<0.001). For emesis gravidarum, both propolis (~3.3 g/day for 7 days) and vitamin B6 significantly reduced vomiting (within-group p=0.000), with no between-group difference (p=0.627). In leukorrhea due to Candida albicans, transparent soap with 1% or 2% propolis wax significantly decreased fungal counts over 7 days, while controls increased; effects were similar between concentrations. In limited vaginal candidiasis, a 5% propolis wax ovule once daily for 7 days achieved culture outcomes comparable to nystatin.

Conclusions: Indonesian propolis demonstrates antifungal, anti-inflammatory, and antioxidant activities that translate into clinically meaningful improvements in menstrual pain, pregnancyrelated anemia, emesis gravidarum, and Candida-associated vaginitis. Propolis appears to be a promising adjunct or alternative therapy.

Keywords: *Indonesian propolis, Tetragonula sp. propolis wax, Primary dysmenorrhea, Emesis gravidarum, Pregnancy anemia, Vulvovaginal candidiasis*

Melissopalynology and Therapeutic Potential of Melliferous Plants: Apitherapy and Bee Product Implication in the Thal desert

Melissopalinoloji ve Melliferous Bitkilerin Terapötik Potansiyeli: Tal Çölü'nde Apiterapi ve Arı Ürünlerinin Etkisi

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Abstract

This study has discussed the diversity, composition, and therapeutic value of melliferous plants in Thal desert and how it is relevant to apitherapy and bee products. The current research on melissopalynology was reviewed to determine the sources of floral materials that are used to produce honey, pollen, and nectar in dry regions. Phytochemical studies showed that bioactive compounds such as phenolics, flavonoids, essential micronutrients were always present in bee products and their antioxidant, antimicrobial, and immunomodulatory properties are based on this. The review also emphasized that pollen spectrum and nectar composition had direct effect on honey quality, medicinal effectiveness and nutritional value, where seasonal variations and differences in regions had an impact on resources. It was discovered that beekeeping activities in the Thal Desert were intertwined with biodiversity conservation because the conservation of the native melliferous flora guaranteed sustainability of honey production and therapeutic value. In addition, the integration of ethnobotanical know-how and contemporary analytical evidence showed that desert bee products can be used as complementary and alternative medicine. It was found out that the combination of the melissopalynological knowledge with phytochemical and pharmacological analysis were the complete framework to comprehend the health value of bee products. These results highlighted the need to conserve desert ecosystems in order to maintain apiculture, facilitate apitherapy and investigate future uses of Thal Desert melliferous plants in human health and nutrition.

Keywords: Pollen Analysis, Nectar, Chemicals, Arid Ecosystem, Apiaries

Using Technology in Royal Jelly Production: Larva Transfer System

Arı Sütü Üretiminde Teknoloji Kullanımı: Larva Transfer Sistemi

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Abstract

Royal jelly is a bee product secreted from the hypopharynx and mandibular glands of young honey bees and used in the nutrition of both larvae and queens. It has the highest nutritional value among bee products (such as pollen, propolis, honey, bee bread). It is a valuable product also used in the field of apitherapy. The biggest problem with royal jelly is that it is difficult to produce and is done in a limited time period. The time-consuming step in royal jelly production is larva transfer. Performing larva transfer by non-professionals reduces the success rate. Larvae between 1.5-1.8 mm, which is the ideal size for royal jelly production, should be identified and transferred to appropriate cells. The designed larva transfer machine is designed to detect the location and characteristics of healthy larvae in the combs with image processing, automatically collect the larvae without damaging them and transfer them to cells. Laboratory studies of this system, designed to assist the beekeeper, minimize problems experienced during larva transfer and increase royal jelly production, are ongoing.

Keywords: Beekeeping, Image processing, Royal jelly, Larva transfer

Note: The product was developed within the scope of TÜBİTAK Technology and Innovation Support Programs Directorate (TEYDEB) project number 2210790. We would like to thank TÜBİTAK for their support.

Determination of Anticholinesterase, Antiglaucoma and Antidiabetic Effects of Some Vitamins

Bazı Vitaminlerin Antikolinesteraz, Antiglokom ve Antidiyabetik Etkilerinin Belirlenmesi

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Abstract

Many B group vitamins (niacin, riboflavin, pyridoxine, cobalamin) act as coenzymes for enzymes. There are also vitamins with antioxidant properties such as vitamins C and E. Vitamins also act as inhibitors for enzymes in the regulation of metabolic pathways. Vitamins are utilised in the treatment of diseases such as Alzheimer, diabetes and cancer. The concentration at which a vitamin halves the enzyme activity is the IC_{50} value of this vitamin. With this value, the biological activity, potency and possible toxicity of the vitamin can be determined.

determine their potency with IC_{50} values. In this way, anticholinesterase, antiglaucoma and antidiabetic effects of vitamins will be determined with vitamin-containing nutrition. In our study, vitamins C, D, E, B_{12}, B_1-B_6 were used. Vitamins showed inhibition effect on human carbonic anhydrase-II (HCA-II) enzyme with IC_{50} values in the range of 0.00443-0.184µg/ml. Vitamin D showed the strongest effect with 0.00443µg/ml. Vitamins showed an effect on butyrylcholine esterase enzyme in the range of 0.00584- 0.740µg/ml and the vitamin with the strongest inhibition effect was vitamin B_{12} with an IC_{50} value of 0.00584 µg/ml. Vitamins E, C and D had no effect on α-glucosidase enzyme. Vitamins B_{12} and B_1-B_6 also showed inhibition effect on α-Glucosidase with IC_{50} values in the range of 19,714-172,5µg/ml. Here again, vitamin B_{12} showed the strongest effect.

Keywords: Alzheimer, Diabetes, Enzyme, Glaucoma, Inhibition, Vitamin

Comparative Evaluation of the Bioactive Properties of Naturally Grown Vaccinium and Rubus Samples Under Different Geographical and Topographical Conditions

Coğrafi ve Topoğrafik Farklılıkların Doğal Vaccinium ve Rubus Örneklerinin Biyoaktif Özellikleri Üzerindeki Etkilerinin Karşılaştırmalı İncelenmesi

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Abstract

Oxidation is an inevitable process in life. However, natural products play a crucial role in protecting against oxidative damage. Naturally produced foods have seen an extraordinary increase in demand in recent times. In particular, the species of Rubus and Vaccinium, collectively referred to as "berries," have attracted attention due to their antioxidant properties and a wide range of therapeutic benefits. These species are not only utilized in folk medicine but are also the subject of numerous scientific studies.

In September 2023, Rubus and Vaccinium species were collected from natural forest areas with varying topographical and geographical characteristics in the Akılbaba Plateau of Giresun. The antioxidant profiles and phenolic compound content of these berries were determined using High-Performance Liquid Chromatography (HPLC). The statistical impact of different topographical and geographical features on the bioactive properties was evaluated.

Keywords: *Vaccinium arctostaphylos* L.(Likarpa), *Rubus sp.* (böğürtlen), antoxidant, berry

Algerian Propolis as an Effective Food Preservative: Antioxidant and antibacterial activities and evaluation of oral toxicity

Etkili Bir Gıda Koruyucu Olarak Cezayir Propolisi: Antioksidan ve antibakteriyel aktiviteler ve oral toksisitenin değerlendirilmesi

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Abstract

Natural preservatives have attracted attention of food industry researches. They are considered as a good alternative to synthetic ones. They have gained acceptance among consumers and are almost used as a multifunctional material instead of a combination of different organic compounds. Propolis is a complex material collected by honeybees from plant and tree buds, resins and exudates. Propolis has been used in traditional and complementary medicine from decades. In addition, several researches have proved its effectiveness and demonstrated that it possesses a large spectrum of biological properties. We reported in the present presentation our investigation on the potential use of Algerian propolis as a food preservative. Antibacterial activity was evaluated using agar diffusion method and the determination of minimal inhibitory concentration on different Gram-positive and Gram-negative bacteria. Antioxidant activity was evaluated using four assays (DPPH, ABTS, FRAP and CUPRAC). In addition, the possible toxicity and side effects of propolis were evaluated for a daily oral administration of 300 mg/kg in rats during 14 days. The tested propolis demonstrated effective antimicrobial and antioxidant activities and didn't cause any mortality or sign of toxicity in rats. Our results suggested the possible use of Algerian propolis as food preservative.

Keywords: Propolis, Antibacterial Activity, Antioxidant Activity, Oral Toxicity, Food Preservative.

Study of the Dielectric Properties of Solvothermal Synthesized Cdse;0.5%Ho Nanocrystal

Solvotermal Yöntemle Sentezlenen CdSe;0.5%Ho Nanokristalinin Dielektrik Özelliklerinin İncelenmesi

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Abstract

The synthesis of cadmium selenide nanoparticles (CdSe;0.5%Ho) doped with rare earth elements holmium (Ho) was carried out by solvothermal method using cadmium nitrate and sodium selenite as precursors. Hydrazine nitrate and ethylenediaminetetraacetic acid were used as capping agents to control the size of the nanoparticles. As the size decreases to the Bohr radius (usually around a few anemometers), all electronic properties change and become equally important, depending on the size. At this size, the transition of semiconductor nanoparticles occurs, where electrons and holes are confined beyond the natural Bohr radius. The crystalline nature of the samples and the particle size properties depend not only on the size but also on the shape. The powder was characterized by X-ray diffraction analysis (XRD). The morphology of the prepared CdSe;0.5%Ho nanoparticles was studied by scanning electron microscopy. Dielectric studies were carried out for a granulated sample of CdSe;0.5%Ho nanoparticles. The conductivity of CdSe;0.5%Ho nanoparticles was studied. The obtained results are discussed. The frequency dependence of the dielectric constant, dielectric loss and alternating current conductivity was also studied.

Keywords: Nanomaterials, CdSe, Solvothermal, Method, Electrical Sciences, Diffraction Analysis

Pharmacology of Bee Products

Arı Ürünlerinin Farmakolojisi

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Abstract

Bee products are inexhaustible sources of bioactive molecules. There are extensively used in folk medicine for the prevention and self-treatment of several diseases and has become actually the objective of many scientific investigations. Different biological and pharmacological effects of honey, pollen, propolis, royal jelly and bee bread have been referred to their antioxidant, antibacterial, antitumoral, anti-inflammatory agents, antihyperglycemic effect and renal disease protection. Oxidative stress is believed to be responsible for the occurrence of several pathologies. Scientific reports from our laboratory have shown that bee products have a wide chemical composition and multi-functional properties. In this context, and in order to understand the relationship between biomolecules from beehive products and their functional potential, we will investigate the antioxidant properties of Moroccan bee products, their capacities for preventing lipid peroxidation and scavenging free radicals was generally correlated with their phytochemical screening. In vivo, propolis and honey preparations were able to attenuate diabetic hepato-renal damage, probably through antioxidant and detoxification properties. The protective role of some honeybee products against reactive oxygen species induced damage and nephrotoxicity in diabetic rats, gives hope that some of these products will have similar protective action in humans. In the rat diabetic nephropathy model, honey, propolis and pollen also showed significant effect on glucose homeostasis and improving kidney function. The possible mechanism of action is discussed. A compilation on therapeutic properties of honeybee products in experimental animal models and human health will be presented. It might be concluded that bee products are a potential target, to be used in the management of chronic kidney diseases, proteinuria, diabetes, cancer and inflammation. Overall, chemical characteristics of bee products may allow the extracts to be used as bioactive ingredients in the food industry, but they also present potential for the pharmaceutical or nutraceutical sectors for the prevention and/or treatment of health disorders.

Keywords: Propolis, Bee pollen, Honey, Royal jelly, Phenolic compounds

Uca Andız (İnula helenium L.)Növünün Antimikotik Xassələri

Antimycotic Properties of Tall Elecampane (Inula helenium L.)

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Abstract

The genus *Inula* L. (elecampane), belonging to the tribe *Inuleae* Cass. of the family *Asteraceae* Bercht. et J.Presl., is represented by perennial plants distributed in Europe, Asia, and Africa. Species of the genus *Inula* are rich in biologically active substances. Their roots contain up to 44% inulin, polysaccharides, resins, small amounts of alkaloids, saponins, and up to 4.3% essential oil.

The main object of the present study, *Inula helenium* L. (tall elecampane), is the type species of the genus *Inula*. Tall elecampane is an officinal medicinal plant included in pharmacopoeias. It is widely used in scientific, practical, experimental, and folk medicine, as well as in homeopathy and pharmacology. It is mainly used in the treatment of gastrointestinal disorders, respiratory tract diseases, gallbladder and urinary bladder diseases, liver diseases, pulmonary tuberculosis, diabetes mellitus, bronchitis and bronchial asthma, allergies, skin diseases, rheumatism, epilepsy, arthritis, atherosclerosis, malaria, gynecological diseases, as well as purulent wounds and ulcers. It exhibits anthelmintic, antibacterial, antifungal, antiprotozoal, antihistaminic, antipyretic, expectorant, diaphoretic, hemostatic, sedative, anti-inflammatory, and diuretic effects.

Inula helenium is rich in numerous chemical compounds, including saponins, sesquiterpenoids, coumarins, flavonoids, essential oils, vitamins C and E, steroids, carotene, bitter substances, resins, and other biologically active compounds. The species is also known for its ornamental, dye-producing, and melliferous properties. In Azerbaijan, it is found in the Samur–Davachi lowland, the Guba region of the Greater Caucasus (eastern and western parts), the Bozqir plateau, the northern, central, and southern parts of the Lesser Caucasus, and in Nakhchivan—from the lower mountain belt to subalpine meadows, among shrubs, along river and lake shores, in gardens, and in fields. According to its moisture requirements, it is a xeromesophytic plant. Its geographical type is European–Siberian.

The plant material of the studied *I. helenium* species was collected during the mass flowering phase from meadows and household plots in the villages of Gendov, Shahnezarli, Guneshli, and Mollakamilli of the Shabran district. According to the conducted studies, the yield of essential oil obtained from the aerial parts of *I. helenium* during the flowering phase was 1.8%. A total of 53 components were identified, accounting for

91.4% of the oil. The dominant components of the essential oil were alantolactone (30.3%), carvacrol (11.0%), 4-vinyl-2-methoxyphenol (7.3%), β-caryophyllene (6.6%), camphor (5.6%), and isoalantolactone (5.4%).

Considering recent scientific research aimed at studying new medicinally important plant species, we investigated the antimycotic properties of *I. helenium*. This is because plant-based preparations are safer and more effective compared to synthetic drugs, both in terms of efficacy and side effects. The experiment was carried out in two stages:

1. growth of fungi on solid nutrient media;
2. growth of fungi in aqueous extracts of different concentrations.

In the first stage, after contact of *I. helenium* with fungal test cultures (*Fusarium oxysporium*, *Trichoderma lignorum*, *Aspergillus niger*), compared with the control (8–9 cm), good results were obtained, and limited growth was observed (0.5–3.3 cm). In the second stage, all concentrations of the aqueous extract of *I. helenium* (5, 10, 15 g), unlike the control (biomass 5.12, 5.43, 5.52 g/L), completely destroyed the *Aspergillus niger* culture, demonstrating a fungicidal effect. In *Fusarium oxysporium* and *Trichoderma lignorum*, a fungistatic effect (0.04–0.38 g/L) was observed.

Thus, the antifungal effect of the aqueous extract of *I. helenium* on fungi is higher than its effect on solid nutrient media. This suggests that the aqueous extract of *I. helenium* can be used in the future as a component of newly developed antifungal medicinal preparations.

Keywords: Asteraceae, *Inula helenium*, Essential Oil, *Fusarium oxysporium*, *Trichoderma lignorum*, *Aspergillus niger* Fungal Cultures

Phytocoenoses Formed by Species of the Genus Trigonella L. in the Flora of Azerbaijan

Azerbaycan Florasında Trigonella L. Cinsine Ait Türlerin Oluşturduğu Fitosenozlar

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Abstract

During the present study, plant communities formed by species of the genus *Trigonella* L. (Fabaceae Lindl.) within the territory of the Republic of Azerbaijan were investigated. Globally, the genus *Trigonella* comprises about 130 species, of which 23 occur in the Caucasus region. Statistical analysis revealed that 17 species are represented in the flora of Azerbaijan. The investigation of phytocoenoses formed by *Trigonella* species was conducted in line with the Presidential Decree (24 March 2006) on the "National Strategy and Action Plan on the Conservation and Sustainable Use of Biological Diversity," where the conservation of biodiversity is defined as one of the main objectives.

During the study, the abundance of dominant and subdominant species, vertical stratification, ecological groups, life forms, phenological phases, and geobotanical descriptions of associations were analyzed, modern classification of phytocoenoses was elaborated. Based on field geobotanical surveys and the evaluation of collected descriptions, it was determined that plant communities with the participation of *Trigonella* species are classified into 4 vegetation types, 5 formation classes, 5 formation groups, and 15 associations. The results of the study demonstrated that species of the genus *Trigonella* L. occur across a range of vegetation types, including subalpine meadows, dry steppes, semi-deserts, and hole-meadow, each characterized by distinct ecological and phytocoenotic features.

Among the vegetation types recorded for *Trigonella*, the following were identified:

Subalpine meadow vegetation type – with widespread formations such as *Thymuseta–Astracanthetum–Trigonelosum*;

Dry steppe vegetation type – *Trigonelleta–Artemisetum–Bothrrochlosum*;

Semi-desert vegetation type – *Ephemereta–Trigoneleta–Artemisiosum*;

Hole-meadow vegetation type – *Tamarixeta–Cynodonetum–Trigonellosum*.

The majority of *Trigonella* species recorded within these formations are valuable forage legumes, readily grazed by both large and small livestock. Therefore, the preservation of these species is highly important for improving the forage balance of winter pastures in Azerbaijan. Moreover, some species possess medicinal, essential oil, vitamin-rich, and melliferous properties. Considering these valuable traits, the study of plant

communities formed by *Trigonella* species is of great importance for the improvement and sustainable use of pastures, the conservation of phytocoenoses as integral components of ecosystems, and for addressing global ecological challenges in the context of biodiversity conservation.

This study contributes to the achievement of the UN Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land).

Keywords: Phytocoenosis, Formation, Synusia, Association, Vegetation, Geobotanical

Determination of Biochemical and Globulin Reserve Proteins in Chickpea (Cicer arietinum Linn.) Variety Samples

Nohut (Cicer arietinum Linn.) Çeşit Örneklerinde Biyokimyasal ve Globulin Depolama Proteinlerinin Belirlenmesi

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Abstract

Legumes, known as the Leguminosae family, constitute the largest family of flowering plants, comprising 650 genera and over 18,000 species that have been cultivated by humans for 3000 years. Among the widely distributed leguminous plants in the world, which range from perennial tree forms to annual herbaceous forms, 6 species are economically more valuable. These are: beans, chickpeas, lentils, green gram, soybeans, and broad beans. The production of high-quality plant protein is one of the pressing global issues. Chickpea (*Cicer arietinum Linn*.), an annual plant belonging to the Fabaceae family, is one of the most consumed leguminous plants worldwide. Chickpea is the cheapest source of protein with the highest nutritional value to reduce food shortages in developing countries. People worldwide obtain 22% of their plant proteins and 7% of their carbohydrates from legumes. Our objective was to evaluate the biochemical indicators and reserve proteins of 25 local and introduced chickpea samples preserved in the National Genbank. The determination of protein and the essential amino acids lysine and tryptophan was carried out in our samples. The protein content varied between 18.0% and 22.5%. The lysine content changed between 680-870 mg/100g. The tryptophan content varied between 110-230 mg/100g. A series of technological analyses were conducted on the seeds of the chickpea collection samples. Water absorption was between 11-16 ml, the cooking time ranged from 28-38 minutes, and the mass of 100 seeds varied between 28.0-39.7 grams. For the first time in Azerbaijan, the electrophoretic analysis of leguminous plants was carried out using a new method, a modification of the ACID-PAGE technique, utilizing protein markers. The polymorphism of the electrophoregrams of globulin reserve proteins in the chickpea samples was determined, and the genetic diversity indices by zones (Nei: Hω=0.600; Hɤ=0.578; Hβ=0.591; Hα=0.624) were established. The highest genetic diversity was observed in the Hα=0.624 zone.

A cluster analysis method was used to determine the genetic distances between chickpea genotypes based on the polymorphism of globulin reserve proteins. The genetic distance between the studied chickpea genotypes was determined.

Keywords: Chickpea, Protein, Lysine, Tryptophan, Globulin

The Truth About Microplastics in Honey

Balda Mikroplastik Gerçeği

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Abstract

Plastics are widely used in many different areas of our daily lives thanks to their properties such as lightness and durability. Over time, plastics break down into small particles (<5 mm) called "microplastics" due to mechanical wear, temperature changes, and the effects of microorganisms. It is known that many areas around the world, including air, soil, water, sea, deserts, and glaciers, are contaminated with microplastics. It has been shown that microplastics can enter the human body through respiration, ingestion, and skin contact, and can be transported throughout the body through the circulatory system. It has also been reported that they can accumulate in the body and have toxic effects on various tissues, organs, and systems.

Microplastics have also been detected in honey, an essential part of our diet. The first studies on microplastics in honey originated in European countries. Microplastic contamination in honey was first reported in 2013. These results attracted the attention of the scientific community, and research on microplastic contamination in honey has begun to increase.

Because of its sticky structure, honey can easily absorb microplastics. Sources of microplastic contamination in honey can be assessed as environmental, beekeeping activities, production conditions, and consumer exposure. Bees contribute to the dispersal of microplastics into the environment and their transport to the hive. Contaminants transported to the hive can enter the human food chain through honey. To this end, beekeepers can raise awareness by providing information about microplastics and encouraging them to take the necessary measures to reduce contamination.

Keywords: Microplastics, Honey, Contamination, Bee

In Vitro Digestion and Colonic Fermentation: The Next Step for Phenolics Bioaccessibility

In Vitro Sindirim ve Kolon Fermantasyonu: Fenoliklerin Biyoerişilebilirliğinde Bir Sonraki Adım

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Abstract

Revealing the fate of phenolic compounds with potential health effects in the gastrointestinal system is crucial for understanding their bioaccessibility. *In vitro* studies offer significant advantages over *in vivo* experiments, as they are devoid of ethical constraints, require less time, and allow precise control of experimental parameters, making them valuable tools for investigating the digestive fate of bioactive compounds. *In vitro* digestion models simulate gastric and intestinal environments through controlled pH, enzyme, and bile salt conditions. However, in the case of phenolics, colonic transformations facilitated by gut microbiota play a crucial role in determining their ultimate bioaccessibility. An exhaustive evaluation of phenolic bioaccessibility necessitates a comprehensive methodology that combines *in vitro* digestion with colonic fermentation models. This is vital for simulating the microbial action in the large intestine, which degrades and transforms phenolic compounds into metabolites that may possess different or enhanced biological activity. This review aims to provide a more holistic understanding of phenolic bioaccessibility by evaluating studies that combine *in vitro* digestion and colonic fermentation. In this context, considering the physiology of the large intestine, this review will discuss the fundamental design concepts and operational parameters of the most commonly employed *in vitro* colon fermentation models, particularly in relation to studying the microbial transformation and bioaccessibility of phenolic compounds.

1. INTRODUCTION

We are currently experiencing a *"polyphenol revival"* — a surge of scientific and consumer interest acknowledging polyphenolic compounds as vital components of the human nutrition, supported by accumulating evidence of their benefits in promoting health. Despite the considerable growing body of scientific studies, the gastrointestinal fate of phenolic compounds has not yet been sufficiently clarified.Therefore, the bioaccessibility of phenolic compounds—namely, their release from the complex food

matrix within the gastrointestinal tract to become available for absorption—is of critical importance. Their bioavailability denotes that, after absorption, they circulate through the vascular system, and be delivered to different tissues throughout the body (Jakobek & Blesso, 2024)

2. AN OVERVIEW OF CURRENT *IN VITRO* HUMAN COLON FERMENTATION MODELS

To gain a comprehensive understanding of the bioaccessibility of phenolic compounds, different *in vitro* digestion models have been performed to assert their biotransformation processes and stability throughout the gastrointestinal tract. *In vitro* digestion models can be utilized to simulate physiological conditions and to assess the extent to which nutrients and bioactive compounds in foods become bioaccessible following consumption (Pavez-Guajardo et al., 2020). The gastrointestinal fate of food components, especially polyphenols, is typically simulated using *in vitro* digestion models of different complexities—static, semi-dynamic, and dynamic—as well as through cell-based and *ex vivo* experimental approaches (Değirmenci et al., 2024). Research on microbial fermentation and the conversion of phenolic compounds in the large intestine is still very rare, despite the abundance of data on digestion processes taking place in the oral, gastric, and small intestinal phases. Today, the digestion model developed by the international INFOGEST consortium (Brodkorb et al., 2019; Minekus et al., 2014) is the most widely used static *in vitro* digestion method. It simulates three main phases of digestion — oral, gastric, and small intestinal — and is widely applied in studies investigating the digestion of carotenoids and phenolic compounds in various foods (Değirmenci et al., 2024). Indeed, a review of existing studies indicates that only a very limited number of *in vitro* digestion studies focus on the large intestine phase, highlighting an underexplored area in the simulation of colonic conditions.

Models simulating the stomach and small intestine remain more sophisticated than those representing the colon mostly because of the complexity of replicating several key factors — including mechanical forces, water content, nutrient absorption, and the dense, semi-solid, anaerobic microbial processes occurring within the colonic environment (Hernalsteens et al., 2021).

A microbial inoculum, an appropriate culture medium, the test substrate, and an appropriate bioreactor are the four key components required for an *in vitro* colonic fermentation system. The static colonic fermentation (batch) model represents the most basic approach for simulating colonic fermentation and is valued for being simple, rapid, and cost-efficient. While this model does not depend upon any specific equipment, experimental steps can still vary in sophistication—from basic vessels to much more sophisticated bioreactors. Regardless of type of the equipment, the colon fermentation process typically involves the use of a fecal inoculum along with a suitable culture medium (Veintimilla-Gozalbo et al., 2021). An overview of the currently available *in vitro* human colon models is given in Figure 1.

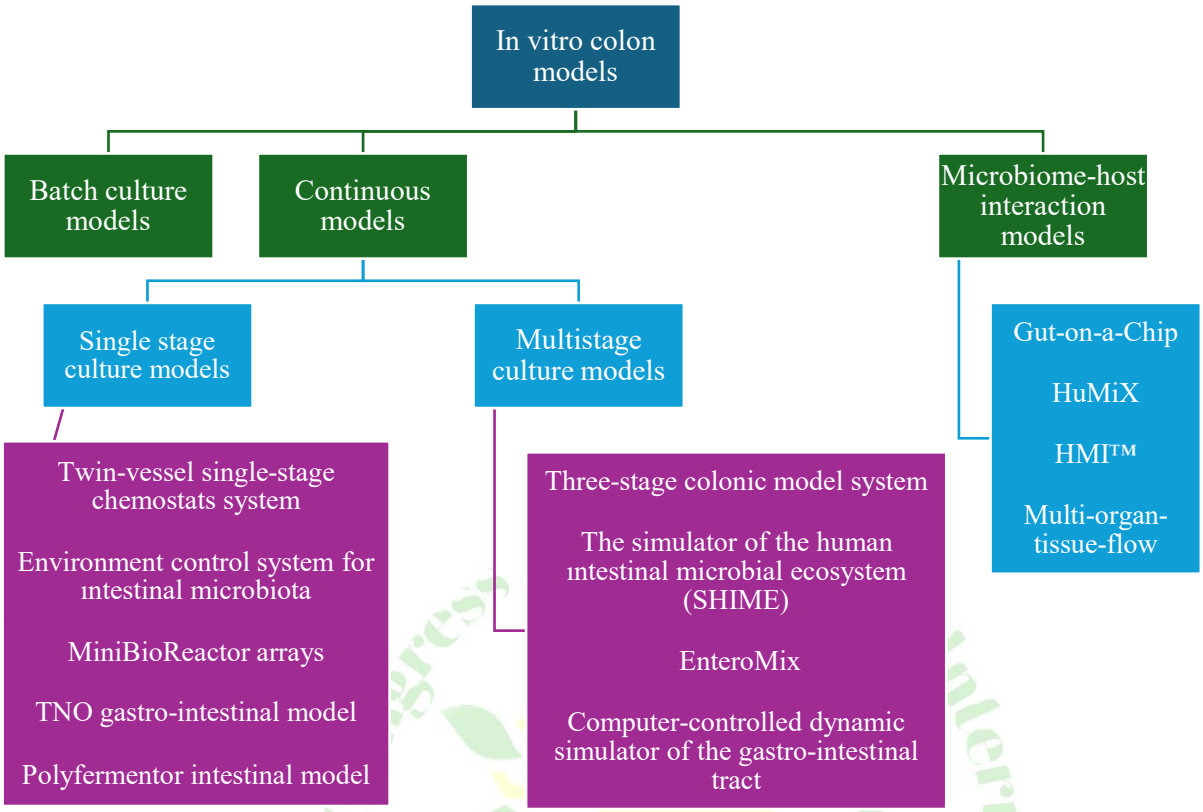

Figure 1. *In vitro* colon models (Based on the data from Roupar et al., 2021)

3. GUT MICROBIOTA AND COLONIC MICROBIAL TRANSFORMATION OF DIETARY POLYPHENOLS

The most significant and dominant components of the human body microbiota are the gut bacteria. The large intestine contains an outstandingly rich microbiota, estimated at 10^{11}–10^{13} CFU encompassing more than 500 species, a level substantially higher than the microbial counts found in the stomach (≈10^{3} CFU) and the small intestine (≈10^{4}–10^{8} CFU) (Tang et al., 2025; Sousa et al., 2008). The composition and abundance of gut microbiota are influenced by different factors, including intestinal motility, pH, redox potential, host secretions (such as digestive enzymes, stomach acid, bile, and mucus), reduced enzyme activity, and the presence of an intact ileocecal valve along different parts of the gastrointestinal tract. External influences such as antibiotic treatment, illness, stress, aging, unhealthy dietary patterns, lifestyle habits, physical activity can also lead to variations in the gut microbiota (Dziewiecka et al., 2022; Madhogaria et al., 2022; Woodmansey, 2007). Approximately 99% of the gut microflora is anaerobic species, as the intestinal environment is characterized by relatively low oxygen levels that favor their proliferation. In contrast, the cecum harbors

higher densities of aerobic species (Madhogaria et al., 2022). Due to the acidic medium created by gastric juices secreted from the stomach, pancreas, and biliary system, the composition of the gut microbiota in the proximal intestine closely resembles that of the stomach (Vuik et al., 2019). Both the diversity and abundance of bacterial populations increse from the duodenum to the ileum toward the distal regions of the intestine, mainly due to the gradual elevation in pH levels (Santhiravel et al., 2022). The human gut microbiota is composed primarily of Firmicutes (Streptococcus, Roseburia, Faecalibacterium, Eubacterium, Clostridium, Ruminococcus, and Lactobacillus species), which account for about 60–80% of the total bacterial population, and Bacteroidetes, representing roughly 20–40%. Smaller proportions belong to Proteobacteria and Actinobacteria (Dziewiecka et al., 2022).

The large intestine's primary functions include absorbing water and nutrition, synthesizing some vitamins through its microbial activity, and forming, storing, and eliminate feces from the body, a process that takes 12 to 24 hours. This duration is probably long enough for phenolic compounds to accumulate and for metabolic and microbial changes to occur in the gut lumen (Mosele et al., 2015).

Phenolics are capable of establishing covalent bonds with various compounds of the food, particularly dietary fibers, thus preventing their absorption in the small intestine and allowing them to reach the colon intact. They become accessible to the gut microbiota in the colon, which converts them into various metabolics with bioactive potential (Rocchetti et al., 2018; Quirós-Sauceda et al., 2014, Manach et al., 2005). More specifically, polyphenols are absorbed in the ileum and, following conjugation reactions, can be secreted back into the intestinal lumen via bile. During the fermentation process that occurs under the influence of the gut microbiota, they undergo deconjugation and are broken down into smaller bioactive metabolites (Gross et al., 2010; Selma et al., 2009; Manach et al., 2005). It is known that the interaction between phenolic compounds and the gut microbiota occurs through two main mechanisms. The enzymes of the microorganisms present in the gut microbiota both exert physiological effects on the host cell and facilitate the absorption of these compounds while phenolic compounds themselves can modulate the microbial composition by stimulating or inhibiting the growth of certain bacterial species (Özcan, 2014). Bacterial enzymes may break down glycosidic, ester, amidic, glucuronidic, lactone, and sulfated connections. Additionally, they catalyze a variety of biotransformation reactions that alter the structure and activity of polyphenolic compounds, including as dehydroxylation, demethylation, decarboxylation, reduction, and ring-opening (Dall'Asta et al., 2012).

Quercetin and kaempferol are first reduced to their dihydro forms dihydroquercetin and dihydrokaempferol, respectively. These intermediate products are converted into phenylpropionic acids and ultimately degraded through the phenylacetic and benzoic acid catabolic pathways to form their final products

(Mosele et al., 2015; Peng et al., 2014; Mullen et al., 2008). The hydroxylation of the B-ring (the placement of –OH groups) in flavonols and anthocyanins determines the structural properties of the final metabolites formed during the digestion of these compounds. In the case of anthocyanidins, malvidin is converted to syringic acid (3,4-dimethoxybenzoic acid), peonidin to vanillic acid (3-methoxy-4-hydroxybenzoic acid), pelargonidin to 4-hydroxybenzoic acid, whereas cyanidin predominantly generates protocatechuic acid (3,4-dihydroxybenzoic acid) upon microbial degradation (Aura, 2008). Anthocyanidins are prone to chemical degradation under acidic conditions; yet the formation of measurable phenolic acids requires the action of microbial enzymes. This means that while chemical and enzymatic breakdown pathways can produce similar products, the transformation remains incomplete in the absence of active gut microbiota (Aura et al., 2005). The *in vivo* metabolism and gut catabolism usually act sequentially on the same catabolite. Through hydrogenation, the bacterial species *Slackia equolifaciens* and *Adlercreutzia equolifaciens* have been demonstrated to reduce resveratrol, forming the metabolite dihydroresveratrol (Luca et al., 2020). Specifically, dihydroresveratrol is converted into glucuronyl-dihydroresveratrol sulfate through the chemical reactions of glucuronidation and sulfation. This resulting compound is considered a key metabolite of resveratrol, produced collaboratively by both gut bacteria and the host body (Rotches-Ribalta et al., 2012). The majority of resveratrol (bioaccessibility 36–85%) is absorbed within 24 hours. However, a significant fraction of this absorbed compound (8–63%) is converted into derivative metabolites by microbiota. Consequently, the main form of resveratrol found circulating throughout the body is largely these microbially-produced metabolites such as 3,4′-dihydroxy-trans-stilbene, lunularin, and dihydroresveratrol, rather than the parent compound itself (Shahidi & Peng, 2018; Bode et al., 2013). Li et al. (2022) reported that dihydro-resveratrol, lunularin, and their combined treatment produced substantially stronger anti-proliferative and anti-inflammatory effects in renal and colonic cell lines at concentrations relevant to those found *in vivo*, indicating that these microbial metabolites may significantly underlie the chemopreventive properties ascribed to resveratrol in the kidney and colon. Those arising from polyphenol degradation by gut microbiota can mimic prebiotic activity, influencing the growth dynamics of targeted microbial populations. Colonic bacteria metabolize the free phenolics and sugars released when C–C and C–O linkages in terminal phenolic oligomers and polysaccharides are cleaved, utilizing them as a carbon source for their metabolic activities, which in turn leads to the production of health-promoting metabolites that benefit the host (Lippolis et al., 2023; Aravind et al., 2021; Shahidi & Yeo, 2016; Mosele et al., 2015). In this context, dihydroresveratrol has stronger antioxidative activity than vitamin E (Yao et al., 2022), while resveratrol-derived microbial metabolites more broadly have the potential to influence gut health by modulating microbial activity (Chen et al., 2024).

4. CONCLUSION

Scientific studies aiming to determine the fate of polyphenolic compounds within the gastrointestinal tract have typically focused on simulating the mouth, stomach, and small intestine. However, the stability of these compounds throughout the gastrointestinal system and the microbial transformation processes occurring in the large intestine play a crucial role in defining the final bioaccessibility of these compounds. Therefore, to model the behavior of phenolic compounds in the colon, considering the microbial transformations and host-related factors that occur under the influence of the gut microbiota is a more accurate approach for obtaining results closer to the actual bioaccessibility of the phenolics. Although advanced and innovative studies have demonstrated microbial transformations in some food products using simulated colonic biotransformations and in silico approaches, the fact that many foods have not yet been evaluated even with the most basic *in vitro* colonic fermentation methods represents a significant limitation of the current research. Another major limitation is that *in vitro* digestion studies tend to focus on specific groups of bioactive compounds in fruit- and vegetable-derived foods, while the influence of the food matrix has been evaluated in only a limited number of studies. Future research should place particular emphasis on refining the standardization of colonic fermentation models, embedding physiologically representative gut microbiota within these systems, and aligning them with metabolomics-based analytical methodologies.

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Recent Perspectives on the Antimicrobial Potential of Bee Products Against Multidrug-Resistant Microorganisms: A Review

Çoklu İlaç Dirençli Mikroorganizmalarla Mücadelede Arı Ürünlerinin Antimikrobiyal Potansiyeli Üzerine Güncel Yaklaşımlar: Bir Derleme

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Abstract

The global escalation of antibiotic resistance has become a major challenge in infectious disease management, prompting the need to explore bioactive natural compounds as alternative therapeutic agents. Bee products—particularly propolis, honey, pollen, bee bread (perga), and royal jelly—have long been recognized for their protective and healing properties. Recent scientific evidence demonstrates that phenolic compounds, flavonoids, and antimicrobial peptides within these products exhibit significant inhibitory activity against multidrug-resistant (MDR) pathogens.

This review summarizes the latest findings on the antimicrobial activities of bee-derived substances, focusing on their mechanisms of action, effectiveness against clinically relevant resistant bacteria such as carbapenem-resistant *Enterobacteriaceae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*, as well as their potential synergistic interactions with conventional antibiotics. Furthermore, the review discusses challenges related to standardization, formulation and bioavailability which must be addressed before their clinical implementation.

Overall, bee products hold great promise as complementary or alternative antimicrobial agents in the fight against multidrug-resistant infections. Further multidisciplinary research is essential to optimize formulations, establish dosage standards, and validate clinical efficacy.

Keywords: Bee Products, Antimicrobial Resistance, Carbapenem Resistance, Propolis, Natural Compounds, Review

Phytochemical characterisation and in vitro evaluation of the antioxidant activity of extracts from Calendula officinalis L.

Calendula officinalis L. özütlerinin fitokimyasal karakterizasyonu ve antioksidan aktivitesinin in vitro değerlendirilmesi

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Abstract

Medicinal plants are known for their therapeutic properties. Rich in active ingredients, they can be used to treat various conditions naturally. The aim of our study is to promote the species *Calendula officinalis* L. To this end, an *in vitro* evaluation of the antioxidant activity of the aerial parts of this plant was carried out. Two extractions were performed by maceration using water and ethanol as different solvents. Qualitative phytochemical analyses were performed using colorimetric reactions, and the total polyphenol content and condensed and hydrolysable tannin content were also determined. Various complementary methods were used to identify the extract under study that has the highest antioxidant capacity. These methods include: DPPH, ABTS, FRAP and CAT. The results obtained showed significantly higher levels of total phenols and catechin tannins in the hydro-ethanolic extract of *C. officinalis* (3.293 mgEAG/g lyophilisate and 0.082 mgEQU/g lyophilisate, respectively) compared to the aqueous extract (0.26 mgEAG/g lyophilisate and 0.014 mgEQU/g lyophilisate). However, hydrolysable tannins showed significantly higher values in the aqueous extract (1.203 mgEAT/g lyophilisate) compared to the alcoholic extract (0.121 mgEAT/g lyophilisate). Regarding antioxidant activity, the aqueous lyophilisate of C. officinalis recorded low IC50 concentrations for DPPH and ABTS free radicals (2.921 mg/ml and 2.835 mg/ml, respectively) compared to the hydro-ethanolic lyophilisate (5.942 mg/ml and 3.139 mg/ml, respectively). However, the total antioxidant capacity (FRAP and CAT) was practically comparable for the two extracts studied. The data required for this study confirmed that *Calendula officinalis* L. could potentially be a source of phenolic compounds used as an antioxidant agent. This capacity could be key to developing various therapies.

Keywords: *Calendula officinalis* L., Phenolic Compounds, Phytochemical Analyses, Antioxidant Activity, In Vitro

Geospatial Distribution and Centers of Origin of Iris hippolyti (Vved.) Kamelin Endemic Species in Uzbekistan

Iris hippolyti (Vved.) Kamelin Endemik Türünün Özbekistan'daki Coğrafi Dağılımı ve Köken Merkezleri

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Özet

Bu çalışma, Iridaceae familyasına ait endemik bir tür olan *Iris hippolyti* (Vved.) Kamelin'in Özbekistan'daki coğrafi dağılımını ve olası köken merkezini incelemektedir. Türün yayılış desenlerini ve evrimsel yoğunlaşma alanlarını belirlemek amacıyla Coğrafi Bilgi Sistemleri (CBS) tabanlı Kernel Yoğunluk, Nokta Yoğunluğu, Ortalama Merkez ve Standart Mesafe analizleri uygulanmıştır.

Elde edilen sonuçlar, *I. hippolyti*'nin başlıca yoğunlaşma alanlarının Nuratau ve Aktau sıradağları içerisinde yer aldığını ve bu alanların Pamir-Alay'ın güneybatısı ile Surkhandarya Dağları yönünde uzandığını göstermektedir. Ortalama Merkez ve Standart Mesafe analizleri, bu bölgelerin türün çeşitlenme ve süreklilik açısından olası merkezleri olduğunu doğrulamaktadır.

Bu araştırma, Nuratau–Aktau dağ sistemlerinin Orta Asya'daki endemik flora için sığınak (refüj) alanları olarak biyocoğrafik önemini vurgulamakta ve nadir ile sınırlı yayılışa sahip türlerin korunmasına yönelik önemli çıkarımlar sunmaktadır.

Anahtar Kelimeler: Iridaceae, endemizm, CBS, kernel yoğunluk, nokta yoğunluğu, köken merkezi, Özbekistan

Abstract

This study investigates the geospatial distribution and potential center of origin of the endemic species *Iris hippolyti* (Vved.) Kamelin, belonging to the family Iridaceae, in Uzbekistan. Geographic Information System (GIS)-based analyses were performed using Kernel Density, Point Density, Mean Center, and Standard Distance methods to identify the distribution patterns and evolutionary hotspots of the species. The results show that the main concentration zones of *I. hippolyti* occur within the Nuratau and Aktau ranges, extending towards the southwestern Pamir-Alay and Surkhandarya Mountains. The Mean Center and Standard Distance analyses confirm these regions as the probable centers of diversification and persistence. This research highlights the biogeographical significance of the Nuratau-Aktau mountain systems as refugial zones for

endemic flora in Central Asia and provides important implications for the conservation of rare and localized species.

Keywords: Iridaceae, endemism, GIS, Kernel Density, Point Density center of origin, Uzbekistan

1. INTRODUCTION

The genus *Iris* L. (Iridaceae) comprises more than 300 species distributed across temperate regions of the Northern Hemisphere, with major diversity centers in the Mediterranean Basin, the Near East, and Central Asia. According to Peter Goldblatt (2008), the Iris family represents one of the most morphologically diverse groups among monocots, with extensive adaptive radiation into arid and semi-arid habitats.

In Uzbekistan, 12–14 species of *Iris* have been reported (Vvedensky, 1941; Tojibaev et al., 2014), among which Iris hippolyti is a narrowly endemic species confined to the Nuratau and Aktau mountain ranges. It typically grows on rocky and sandy slopes at altitudes between 600–1,200 m, preferring dry steppe and foothill zones.

Despite its restricted distribution, little attention has been paid to the spatial ecology and potential origin zones of *I. hippolyti*. Determining its geospatial pattern helps to understand both its evolutionary history and conservation status. Therefore, the present study applies GIS-based spatial statistics to analyze the distribution, density, and center of origin of *I. hippolyti* and its related taxa within Uzbekistan.

2. MATERIALS AND METHODS

Geospatial data for I. hippolyti and its closely related species (*I. svetlanae, I. narbutii, I. bucharica*) were compiled from herbarium specimens (TASH, LE) and verified field observations recorded between 2015 and 2024. Additional georeferenced records were obtained from the Global Biodiversity Information Facility (GBIF). A total of 50 occurrence points were processed.

All coordinates were projected using the WGS 1984 coordinate system. The analyses were carried out in ArcGIS 10.8 software.

The following statistical tools were applied:

Kernel Density Analysis — to determine the core areas of species concentration and visualize probability-based density surfaces.

Point Density Analysis — to evaluate the number of occurrences per unit area and identify distribution gradients.

Mean Center and Median Center — to locate the statistical center of the distribution.

Standard Distance — to measure the spatial dispersion and range of occurrence. For Kernel and Point Density analyses, the raster cell size was set to 1 km, and the search radius to 25 km. Visualization used classified color ramps representing density gradients.

3. RESULTS AND DISCUSSION

The Kernel Density map (Figure 1) revealed that Iris hippolyti shows the highest concentration in the Nuratau–Aktau mountain system, particularly in the western part of the Navoiy and Jizzakh regions. Secondary clusters were detected along the Surkhandarya and Kugitang foothills, extending southwards towards the Tajik border. The Point Density analysis (Figure 2) confirmed these zones as the most significant accumulation centers, showing density values up to 68.6 points/km². The Mean Center (green point) was located near 39.3°N and 66.5°E, corresponding to the central Nuratau ridge.

The Standard Distance circle encompasses the Nuratau, Aktau, and southwestern Hissar–Kugitang systems, suggesting historical continuity of Iris taxa within these regions.

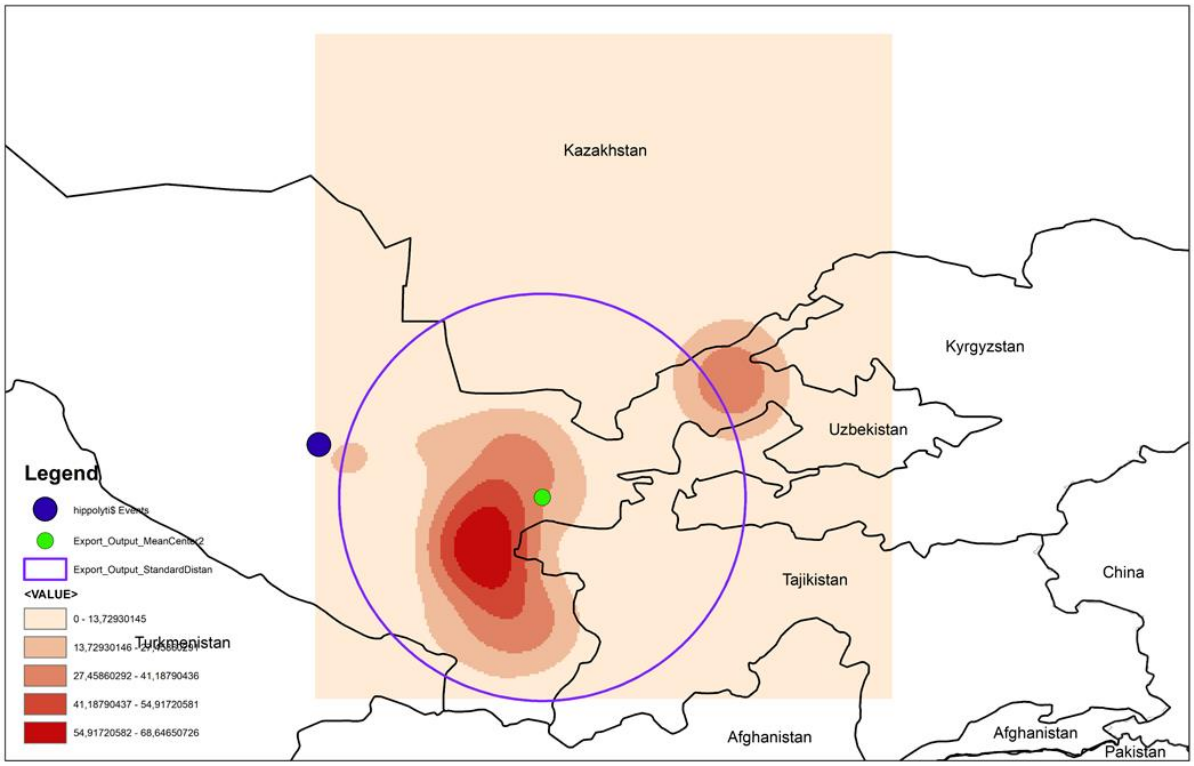

Figure 1. Kernel density analysis map based on endemic and related species of the *Iris hippolyti* group

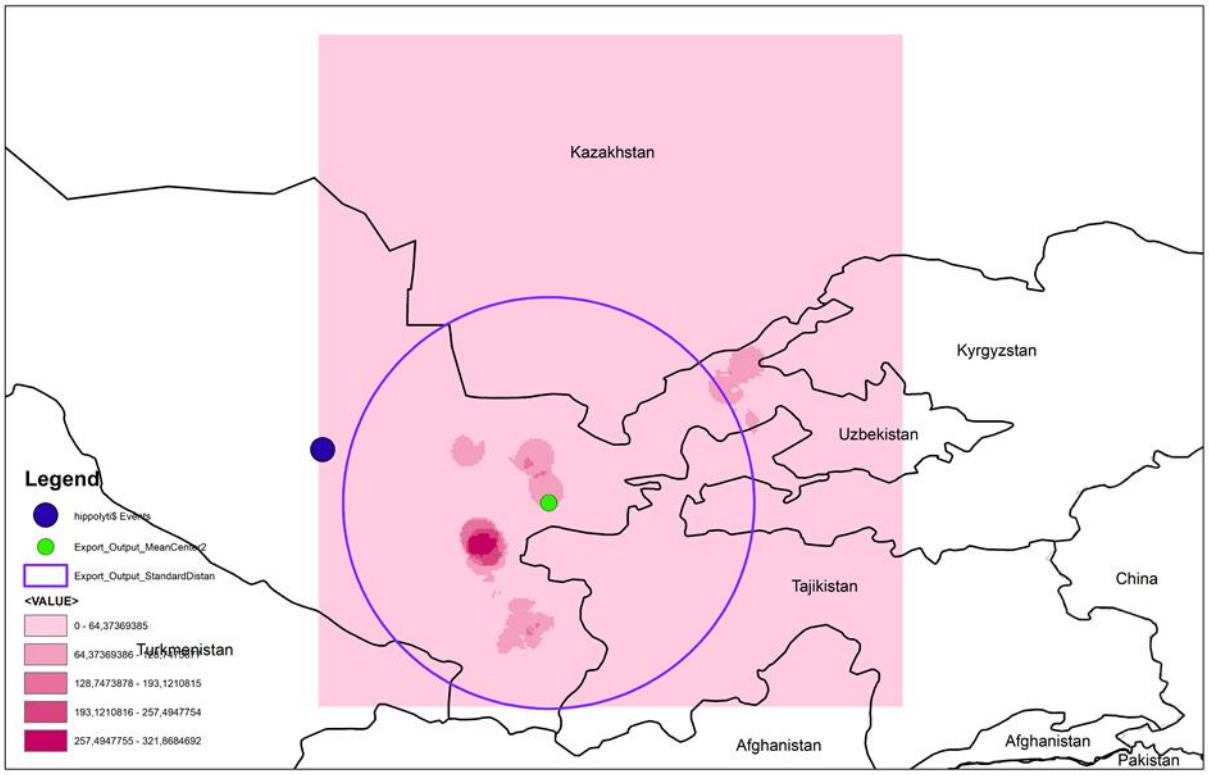

Figure 2. Point density map based on endemic and related species of Iris hippolyti.

These findings agree with the florogenetic hypothesis proposed by Goldblatt (2008) and Tojibaev et al. (2014), emphasizing the Central Asian mountains as a major center of diversification for the genus Iris. The geomorphological isolation and microclimatic variation of the Nuratau ridge likely served as a refugium during Pleistocene climatic oscillations, enabling long-term survival and speciation of I. hippolyti.

Moreover, the overlapping density zones with I. svetlanae and I. narbutii suggest that the Nuratau-Aktau complex represents not only a refugial but also an evolutionary interaction zone for multiple Iris species.

4. CONCLUSION

The GIS-based geospatial analysis of Iris hippolyti has identified the Nuratau–Aktau system as the principal center of distribution and origin within Uzbekistan. The high species density and spatial clustering in this region reflect the evolutionary and ecological stability of the landscape.

From a conservation standpoint, these results underline the necessity of protecting microhabitats of I. hippolyti, which are currently threatened by grazing, land degradation, and climate change. Integrating GIS data into regional conservation planning will support long-term monitoring and management of this and other endemic Iris species.

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Heavy Metal-Driven Modulation of Olive Bioactivity by Thermal Power Plant: Cytotoxic Effects on Cancer and Healthy Cells

Termik Santral Bölgesindeki Zeytin Biyoaktivitesinin Ağır Metal Destekli Modülasyonu: Kanser Ve Sağlıklı Hücreler Üzerindeki Sitotoksik Etkileri

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Abstract

Thermal power plants (TPP) release various pollutants, including heavy metals, into the environment, which can accumulate in soil, water, and food sources. These contaminants pose significant risks to human cells by inducing oxidative stress, DNA damage, and altered cellular functions. Olive extracts, rich in polyphenols and antioxidants, exhibit notable anti-cancer effects by inducing apoptosis, inhibiting cell proliferation, and reducing oxidative stress in cancer cells. However, it is not clear whether heavy metal accumulation in olive extracts by TPPs affects its anti-cancer activity. This study investigated the impact of heavy metal accumulation—caused by proximity to the Muğla Yatağan TPP, Türkiye —on the chemical composition and selective cytotoxicity of olive fruit and leaf extracts on normal and cancer cells.

Olive samples were collected from three regions at varying distances from the TPP: near (<1 km), intermediate (5 km), and remote (13 km). Extracts were analyzed for heavy metal content and tested on five cancer cell lines (MDA-MB-231, HT29, A549, HepG2, MCF7) and four healthy cell lines (ARPE-19, MCF10A, BEAS-2B, HUVEC) at concentrations ranging from 0.032 µg/mL to 500 µg/mL for 24h. Cell viability was assessed using the MTT assay, and IC50 and Selectivity Index (SI) values were calculated.

Results showed that samples from regions near the TPP had significantly higher levels of toxic metals (As, Cd, Cr, Ni, Pb) and lower concentrations of essential nutrients (Ca, Mg, Fe, Mn). Leaf extracts from the TPP region exhibited enhanced cytotoxicity, particularly against colon and lung cancer cells, with notable selectivity compared to normal lung and vascular endothelial cells. Furthermore, increased cytotoxicity was also observed in liver and metastatic breast cancer cells. However, some extracts also showed cytotoxicity in healthy cells, indicating a potential reduction in the health-promoting effects of olives exposed to industrial pollution. These findings suggest that environmental contamination from thermal power plants alters the bioactivity of olive extracts, potentially compromising their therapeutic value. This research was supported by TÜBİTAK (2209-A Project No: 1919B012306896) and Karadeniz Technical University (Project No: FLÖ-2024-11149 and FLÖ-2024-11176).

Keywords: Cytotoxicity, Cancer, Olive, Thermal Power Plant, Heavy Metal Accumulation

In Silico Evaluation of Calotropis Procera Phytochemicals as Potential Inhibitors of Escherichia Coli DNA Gyrase A

In Silico Analizi ile Calotropis Procera Fitokimyasallarının Escherichia Coli DNA Gyrase A Üzerindeki Potansiyel İnhibitör Etkileri

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Abstract

Antimicrobial resistance (AMR) poses a serious global health threat, diminishing the effectiveness of existing antibiotics and creating an urgent need for novel therapeutic alternatives. Natural products and phytochemicals from medicinal plants offer a promising source of bioactive compounds with unique structural properties and diverse biological activities. *Calotropis procera*, a traditionally used medicinal shrub, contains cardenolides, flavonoids, and terpenoids that have been reported to exhibit antibacterial, anti-inflammatory, and anticancer properties. The present study investigated the inhibitory potential of selected phytochemicals from *C. procera* against *Escherichia coli* DNA gyrase A, an essential bacterial enzyme involved in DNA replication and a validated antibacterial target.

A set of bioactive compounds, including calotropin, calotropagenin, calotoxin, uscharin, frugoside, isorhamnetin-3-O-rutinoside, kaempferol-3-O-rutinoside, and quercetin-3-O-rutinoside, were subjected to computational evaluation. Pharmacokinetic profiling using SwissADME indicated high gastrointestinal absorption and favorable drug-likeness for calotropin and calotropagenin, while glycosidic flavonoids showed multiple violations of Lipinski's rule, limiting oral bioavailability. Toxicity prediction revealed that calotropin and calotropagenin were non-mutagenic and safe, whereas uscharin demonstrated potential reproductive toxicity.

Molecular docking was performed with AutoDock 1.5.6, and the results demonstrated that calotoxin (–8.8 kcal/mol), isorhamnetin-3-O-rutinoside (–8.3 kcal/mol), and calotropagenin (–8.2 kcal/mol) exhibited stronger binding affinities with DNA gyrase A compared to ciprofloxacin (–7.9 kcal/mol). Hydrogen bonding and hydrophobic interactions with active site residues further supported their potential as enzyme inhibitors.

Collectively, these findings highlight the antibacterial potential of *C. procera* phytochemicals, particularly cardenolides and flavonoid derivatives, as natural inhibitors of DNA gyrase. The integration of ADME, toxicity, and docking analyses provides a comprehensive understanding of their pharmacological profiles. This study suggests that *C. procera* bioactive compounds may serve as promising candidates for the

development of safe, effective, and plant-based antibacterial agents to address the growing challenge of antibiotic resistance.

Keywords: *Calotropis procera*, DNA gyrase A, antimicrobial resistance, phytochemicals, molecular docking, drug-likeness

Knowledge Levels of Beekeepers in Türkiye About Bee Venom Allergy and Traditional Treatment Methods They Use Against Bee Stings

Türkiye'deki Arıcıların Arı Zehiri Alerjisi ve Arı Sokmalarına Karşı Kullandıkları Geleneksel Tedavi Yöntemleri Hakkındaki Bilgi Düzeyleri

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Abstract

The purpose of this study is to evaluate the knowledge that beekeepers have about anaphylaxis caused by bee stings, as well as the traditional medicinal methods they use to treat them.

This cross-sectional study was conducted on 275 beekeepers in Türkiye participated voluntarily in the study. The study population consisted of individuals aged 18 and over who practiced beekeeping in Türkiye between February and August 2024. The data was collected using a questionnaire form consisting of questions about descriptive characteristics, knowledge of adrenaline auto-injectors and venom immunotherapy, and traditional treatment methods used against bee stings. The mean age of the participants was 44.51 ± 11.36 years, and 80.7% were male. 44% of the participants had been beekeeping for 1-5 years, and 47.3% had a beekeeping training certificate. Most participants (92.7%) reported not having a bee allergy, while 90.2% were aware that bee venom can be life-threatening. Meanwhile, 60.4% were aware of anaphylaxis, and 53.1% were aware of immunotherapy. Conversely, 58.2% reported not being aware of adrenaline auto-injectors. 52.7% of the participants reported using traditional methods to treat bee stings. The most commonly used methods were ice/cold application (14.7%), metal contact (9.5%), and ammonia (7.7%). In conclusion, while beekeepers' knowledge of bee venom allergy and anaphylaxis is generally adequate, there is a lack of awareness of life-saving devices, such as auto-injectors.

Keywords: Bee Sting, Anaphylaxis, Traditional Treatment, Bee Venom Allergy, Beekeeper

Storage-Dependent Variations in 10-HDA Content and Protein Profile of Royal Jelly

Depolama Koşullarına Bağlı Olarak Arı Sütünün 10-HDA İçeriği ve Protein Profilindeki Değişiklikler

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Abstract

Royal Jelly (RJ) is a valuable bee product widely used in the food, health, and cosmetic industries owing to its bioactive components. Among these, trans-10-hydroxy-2-decenoic acid (10-HDA) and Major Royal Jelly Proteins (MRJPs) are the most critical biochemical markers, determining the authenticity, functional value, and therapeutic potential of the product. The stability of these compounds can be affected by environmental factors such as storage temperature and duration, which presents difficulties with maintaining uniform quality standards. The present study aimed to investigate the effects of different storage conditions (−20 °C, +4 °C, and 25 °C) on 10-HDA content and MRJP protein profiles over a 12-month period. The 10-HDA levels were quantified using HPLC-UV, and protein profiles were analyzed through SDS-PAGE electrophoresis. The findings demonstrated that samples stored at −20 °C and +4 °C mainly maintained stable 10-HDA concentrations throughout the experimental period. Conversely, sample stored at room temperature (25 °C) exhibited significant decreases ($p < 0.05$) in 10-HDA content initially in the sixth month. Protein analysis further revealed that MRJPs remained structurally integrity during cold storage, whereas prolonged room temperature storage resulted in a gradual decrease in band intensity and the formation of low-molecular-weight degradation products after 9–12 months. These findings highlight that cold-chain storage is essential for preserving the chemical stability and for maintaining the structural integrity of MRJPs. The degradation observed under room temperature conditions may represent a concern to the functional and therapeutic properties of RJ, which could compromise both consumer safety and product efficacy. Consequently, the establishment and implementation of appropriate storage procedures, particularly cold-chain systems, are essential across all stages from production to consumption. This study offers an integrated evaluation at both the 10-HDA and protein levels, offering valuable insights into the influence of storage conditions on the preservation of RJ quality parameters. The findings highlight the critical role of cold storage in preserving the biological activity and quality of RJ. Furthermore, the findings provide a substantial scientific basis for future initiatives aimed at developing standardized quality criteria, and contributing to regulatory frameworks for RJ products.

Keywords: Royal jelly (RJ), trans-10-hydroxy-2-decenoic acid (10-HDA), Major royal jelly proteins (MRJPs), Storage stability, Cold-chain storage

Eco-geobotanical Assessment of Gakh Forest Areas

Gakh Orman Alanlarının Eko-jeobotanik Değerlendirmesi

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Abstract

The ecological problems of forests in Azerbaijan include, in part, illegal logging, unsustainable forest management, forest land degradation, forest fires, and the effects of climate change. One of the main problems has been the reduction of forests by illegal logging, especially in forestry areas. This problem has now been eliminated. Unsustainable forest management, including overgrazing, also exacerbates the problem. Degradation of forest lands due to erosion, salinity, and other factors leads to a decrease in forest productivity. Climate change is affecting Azerbaijan's forests and necessitates the development of regional adaptation measures. Climate change should be taken into account when planning and implementing forest restoration work. Industrial and domestic pollution also negatively affect the health of forests.

Of the 500 identified plant species, 33 are ancient tertiary forests, 160 are boreal, 10 are steppe, 115 are xerophytes, 2 are desert, 56 are Caucasian, 3 are cosmopolitan, 15 are adventive, and 106 are species with unknown range. Plant species with a wide range include oak, alder, beech, apple, pear, willow, etc. Typical and widespread local species in the area are blackthorn, birch, buckthorn, etc.; indicator species are oak and poplar; species typical for plant groups of the zone are juniper, ironthorn, sedge, etc.; rare, endangered species are Pastukhov stone ivy, incomplete limodorum, Red dust-headed orchid, Caucasian eyebrow orchid, Yulia Novruzgulu, etc.; Particularly important species (endemic and relict) – Azerbaijani rose hip, berry-bearing blackthorn, hazelnut, Caucasian persimmon, common chestnut, Pastukhov stone ivy, etc. are widespread.

The main stages of eco-geobotanical assessment are as follows :

- In the first stage, a comparative assessment (evaluation) of Gakh soils was carried out based on the properties of the main and open soil quality scales, as well as a classification of agro-industrial lands.
- In the second stage, an ecological assessment and ecological classification of soils was carried out, taking into account the scores of certain ecological and soil factors;
- In the third stage, an eco-geobotanical assessment of soil and vegetation cover was carried out using forest indicators and ecological scores of soils within landscape complexes.

The main plant formations widespread in the area were identified (mesophilic and xerophilic forests), and based on the methodology, scales were compiled to assess the compliance of the degrees of manifestation of

individual characteristics of the territory's soils with the ecological requirements of the above-mentioned plant formations during the research conducted by us in the field of ecological assessment.

Thus, the results of the eco-geobotanical assessment of the soil and vegetation cover of Gakh in landscape complexes varied between the following parameters:

Mesophilic forests: 78 points (washed mountain-forest brown, typical mountain-forest brown, carbonated mountain-forest brown, grayish carbonated mountain-brown)

Xerophilic forests: 94 points (washed mountain-forest brown, typical mountain-forest brown, carbonated mountain-forest brown, Grayish carbonated mountain-brown).

Keywords: Evo-geobotanical assessment, Soil, Plant, Environment

Rare and Endangered Herbaceous Plants of the Gabala Region Biodiversity

Gabala Bölgesinin Nadir ve Nesli Tehlike Altındaki Otsu Bitkilerinin Biyoçeşitliliği

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Abstract

The territory of Azerbaijan has a rich flora. There are 4,500 species of higher spore and flowering plants. The plant species found here are grouped into 125 families and constitute 66% of the total number of plant species growing in the Caucasus. Azerbaijan's rich flora and diverse vegetation are attributed to the diversity of its physical, geographical, and natural-historical conditions, as well as the complex history of its flora, which was shaped by the influence of distant floristic regions. There are currently 460 rare and endangered plant species in Azerbaijan's natural flora. According to the Red Book of the Republic of Azerbaijan, published in 2023, 287 species of herbaceous plants are classified as rare and endangered. 8 species of these plants are located in the territory of the Gabala region.

Allium oreophilum C.A.Mey.-It is a perennial herb. The stem is 5-20 cm tall. It is a cryptophyte (geophyte) and light-loving plant. It is widespread in rocky places and rocky outcrops in the upper mountain belt.

Allium tripedale Trautv. (= Nectaroscordum tripedale (Trautv.) Grossh. It is a thick-stemmed, glabrous, perennial plant, 50-80 cm tall. In high mountain belts, it is found in rock crevices, rocky and gravelly areas, and sometimes in extremely humid environments. It is a mesoxerophyte.

Coeloglossum viride Hartm. It is a perennial herb. It is mainly distributed in the subalpine and alpine zones, rarely in the middle mountain zone, in meadows, grassy slopes, and in light forests of the upper mountain zone.

Aquilegia olympica Boiss. It is a perennial herbaceous plant that grows up to 60 cm tall. It is found singly, rarely in small groups (1-5 individuals) in bushes, meadows, and forest glades from the subalpine to the alpine zones. It is a xeromesophyte.

Primula juliae Kusnez. It is a perennial herb. The stem is bare, 8-12 cm long. Found in the upper and sometimes middle mountain belt, along forest rivers, on rocky slopes, and in ravines. It is an ornamental plant.

Pseudovesicaria digitata (C.A.Mey.) Rupr. It is a biennial, naked, herbaceous plant. It is widespread in rocky and clayey areas in the Alpine belt.

Chamaesciadium acaule C.A.Mey.It is a perennial plant with a dense root system and no stem or a very short stem. The flowering period falls in July and August, and the fruiting period falls at the end of August.

Omphalodes rupestris Rupr. ex Boiss. It is a perennial herbaceous plant, 10-15 cm tall, covered with recumbent hairs. It is widespread on rocky, stony, and clayey slopes of middle and upper mountain belts, in calcareous areas, and in riverbeds.

Keywords: Rare herbs, Mesoxerophyte, Xeromesophyte, Decorative

The influence of Trichoderma on morphometric parameters and nitrogen metabolism of durum wheat of the Goytepe variety grown on the Absheron Peninsula

Absheron Yarımadası'nda yetiştirilen Goytepe çeşidi makarnalık buğdayın morfometrik parametreleri ve nitrojen metabolizması üzerine Trichoderma'nın etkisi

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Abstract

The geoecological state of Absheron's landscapes is further exacerbated by natural degradation processes such as wind erosion, soil salinization, and desertification. However, along with environmental factors, soil microflora also significantly influences plant development. One common component of the rhizosphere microflora is fungi of the genus *Trichoderma*, which possess a well-developed enzymatic system and are capable of synthesizing physiologically active substances that influence biochemical processes occurring in plants.

A scientific study examined the effect of *Trichoderma* on the growth process and distribution of various forms of nitrogen in the organs of durum wheat (*Triticum durum Desf. L.*) of the Goytepe variety, grown in the Absheron Peninsula. The experiments were conducted at the experimental plot of the Azerbaijan Scientific Research Institute of Agriculture on the Absheron Peninsula. Before sowing, wheat seeds were soaked for 15 hours in a Trichoderma Asperellum culture solution.

Treating wheat seeds with *Trichoderma* culture medium had a positive effect on all physiological and morphological parameters studied. The experimental plants showed an increase in root length (by 10%) and dry biomass (by 33%). This increase in root dry mass may indicate a positive effect of *Trichoderma* on root tissue formation in the experimental plants. The experimental plants also showed increases in stem length (7%), spike length (8%), and the number of grains per spike (25%).

An analysis of data studying the effect of *Trichoderma asperellum* on the content and distribution of nitrogenous substances (total, protein, and non-protein) in plants revealed that the total nitrogen content increased compared to the control by 6% in roots, 4% in stems, 6% in seeds, and 15% in ears. The distribution of protein nitrogen, which is of particular interest to us, since its content is an important indicator of biosynthetic processes and a criterion for plant stability, showed that in plants treated with the Trichoderma culture medium, the protein nitrogen content was higher in stems by 4%, in seeds by 13%, and in ears by 10%. And in roots, it decreased by approximately 1%.

Thus, the study results showed that treatment with *Trichoderma* fungi had a positive effect on plant organs, including biomass accumulation and protein-nitrogen synthesis, especially in ears and seeds. Furthermore, despite the decrease in protein nitrogen content, root growth exceeded the control for most of these parameters. All of this plays a crucial role in plant adaptation and survival in these unfavorable conditions.

Keywords: *Trichoderma*, Durum Wheat, *Triticum durum Desf. L.*, Morfometric Parameters, Nitrogen Metabolism

Biological Activity of Artemisia verlotiorum Extracts

Artemisia verlotiorum Ekstraktlarının Biyolojik Aktivitesi

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Abstract

Artemisia, one of the largest genera in the Asteraceae family, is an important plant group found worldwide with versatile uses such as for pharmacological, food, and ornamental purposes. *Artemisia verlotiorum*, a member of this genus, grows naturally in the temperate regions of Turkey and is known to be on the pollen collection routes of bees, thereby affecting the biochemical composition of bee products. In this study, the phenolic content, antioxidant, and antimicrobial potential of extracts obtained from the *A. verlotiorum* plant using different methods were investigated to evaluate their potential applications in the apiculture sector. Within the scope of the study, various extracts were prepared from the plant using different solvents, and their total phenolic content was determined by the spectrophotometric method as Gallic Acid Equivalent (mg GAE/mL). The antimicrobial activity was tested against *Candida albicans* ATCC 10231, *Staphylococcus epidermidis* ATCC 12228, and *Staphylococcus aureus* ATCC 25923 strains using the disk diffusion method. The results of the analyses revealed that the total phenolic content of *A. verlotiorum* extracts varied within a wide range, from 0.244 ± 0.005 to 30.404 ± 0.364 mg GAE/mL, with statistically significant differences ($p<0.05$). In antimicrobial tests, the extracts showed efficacy against all tested microorganisms, with inhibition zone diameters observed to range from 3.00 ± 0.00 to 37.00 ± 1.00 mm. It was determined that the extraction methods and solvent types created a statistically significant difference in terms of inhibitory activity on microorganisms. These results indicate that the *A. verlotiorum* plant possesses a rich phenolic content and broad-spectrum antimicrobial activity. These findings of potent biological activity strongly support that *A. verlotiorum* extracts are a promising candidate agent for natural, effective, and eco-friendly control strategies against pathogenic microorganisms and parasites that threaten colonies in beehives.

Keywords: *Artemisia verlotiorum*, Phenolic Content, Antimicrobial Activity, Apiculture, Natural Control, Bioactive Compounds.

Vegetative Propagation Methods of Camellia japonica Adapted to Absheron Conditions

Absheron Koşullarına Uyum Sağlayan Camellia japonica'nın Vejetatif Çoğaltma Yöntemleri

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Abstract

Camellia japonica (Japanese camellia) is an evergreen shrub with high ornamental value. When propagated by seed, cultivar traits are not preserved; therefore, vegetative methods are more appropriate. In the Absheron Peninsula, the climate is subtropical but with hot-dry summers and occasional frosts in winter. For this reason, proper application of vegetative propagation methods is essential.

Propagation by Cuttings

The most common method for camellia is propagation by stem cuttings. Semi-hardwood cuttings are taken in July–August, 8–10 cm long with 2–3 leaves. To stimulate rooting, auxin-based growth regulators are applied — particularly IBA (indole-3-butyric acid) at concentrations of 200–600 ppm. Cuttings are planted in an acidic, well-drained substrate (peat + sand mixture, pH 5.5–6.5). For root initiation, high humidity and a temperature of 20–25 °C are required. In Absheron conditions, where mist systems are often unavailable, plastic coverings can be used to maintain a humid microclimate.

This method is mainly used to preserve cultivar traits. In early spring or autumn, *Camellia japonica* or other hardy camellia species are employed as rootstocks. Grafting provides an opportunity to obtain cultivars that are more resistant to climate stress.

Role of Growth Stimulators

Research has shown that rooting percentages can be improved not only with IBA but also with NAA (naphthalene acetic acid) and combined formulations. In some cases, synthetic auxins such as 2,4-D, applied in low concentrations, accelerate root formation. Since alkaline soils in Absheron may hinder rooting, the use of growth stimulators becomes even more critical.

Vegetative propagation of *Camellia japonica* in Absheron is feasible, provided that soil acidity is regulated, shaded sites are selected, and humidity is maintained. Propagation by cuttings is the most accessible method, while grafting is particularly important for preserving valuable cultivars. The correct application of growth stimulators can increase rooting success two to three times and ensure the production of high-quality seedlings.

Keywords: *Camellia japonica*, Vegetative Propagation, Stem Cuttings, Grafting, Growth Stimulators, Absheron Climate.

The Place and Position of Caryophyllaceae in the Petrofit-Floristic Complexes of Azerbaijan

Azerbaycan'ın Petrofito-Floristik Komplekslerinde Karanfilgillerin Yeri ve Konumu

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Abstract

Addressing the issues arising from the "National Strategy and Action Plan on the Conservation and Sustainable Use of Biodiversity in the Republic of Azerbaijan," approved by the decrees of the President of the Republic of Azerbaijan, Mr. Ilham Aliyev, in 2006 and 2020, including the prevention of the decline in the reserves of some species of Caryophyllaceae, is one of the current priority tasks. Taking this into account, we have determined the place and position of species belonging to the family Caryophyllaceae Juss. (Carnation family) within the flora biodiversity of Azerbaijan's petrofit-floristic complexes.

Petrofit-floristic complexes represent a certain form of relief. Their formation is mainly characterized by the presence of soft rocks on the earth's surface, absence of vegetation cover, and water erosion acting on these factors. The process model is determined based on complex indicators.

Research was conducted between 2019 and 2025 in the territory of the Republic of Azerbaijan, specifically in the Small Caucasus in the districts of Tovuz, Gadabay, Dashkasan, and Goygol, and in the Greater Caucasus in the districts of Gakh, Sheki, Gabala, Ismayilli, and Zagatala. Based on literature data and field studies, the species belonging to the family Caryophyllaceae Juss. (Carnation family) within Azerbaijan's petrofit-floristic complexes were studied in terms of their flora biodiversity.

The species studied in the petrofit-floristic complexes inhabit rocks and screes, dry stony slopes of high and medium mountains, as well as moist places among rock cracks. Species such as Minuartia orenaria, Minuartia biebersteinii, and M. intermedia are distributed in ravines, gullies, and stony screes. These species play an important role in the formation of rock-scree vegetation. Petrofits adapt to the harsh environmental conditions through evolution, which results in the development of adaptation reactions in plants. Representatives of the genera Minuartia Loefl, Cerastium L., Silene L., and others belonging to the family Caryophyllaceae Juss. are widespread in the subalpine zone petrofits. Species of Caryophyllaceae Juss. found in the petrofit-floristic complexes have a close relationship with the xerophytic flora of Northern Iran, while another group is closely related to the xerophytic flora of the Greater Caucasus.

Keywords: Petrofit, Vegetation Type, Xerophilous, Xerophyte

Evaluation of the Antioxidant and Antiradical Activity of Phytocompositions from Medicinal Plants of Azerbaijan

Azerbaycan'ın Tıbbi Bitkilerinden Elde Edilen Fitobileşimlerin Antioksidan ve Antiradikal Aktivitelerinin Değerlendirilmesi

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Abstract

The present study provides a comprehensive investigation of the antioxidant and antiradical activity of extracts derived from natural phytocompositions obtained from medicinal plants growing in the territory of Azerbaijan. As the principal analytical approach, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay was employed, enabling a quantitative assessment of the ability of the tested samples to inactivate reactive oxygen species. The experimental work involved the preparation of aqueous–ethanolic extracts from various morphological parts of the plants (roots, leaves, fruits, and inflorescences), thereby allowing a comparative analysis of biological activity depending on the localization of phytochemical constituents. The findings demonstrated that the extracts of the investigated species exhibit pronounced antioxidant properties, with the most significant activity recorded in the roots of *Glycyrrhiza glabra* L. and the inflorescences of *Alhagi pseudalhagi* L. These samples were characterized by the lowest IC_{50} values, comparable to those of the standard antioxidant Trolox. The results confirm the high biological activity of the studied extracts and underscore the feasibility of their further exploration as potential natural sources of antioxidants for preventive and therapeutic applications.

Keywords: 2,2-Diphenyl-1-Picrylhydrazyl (DPPH), Antioxidant, Antiradical

Ethnobotanical and Therapeutic Properties of Tree and Shrub Plants Distributed in the Lowland Areas of Karabakh

Karabağ'ın Düzlük Alanlarında Yayılış Gösteren Ağaç ve Çalı Bitkilerinin Etnobotanik ve Terapötik Özellikleri

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Abstract

Ethnobotany encompasses the cultural, medicinal, ecological, and economic relationships between humans and plants, focusing on the diversity of plant use among ethnic groups, the efficient and purposeful utilization of plant resources, the development of new pharmaceutical preparations, and the organization of biodiversity conservation. Ethnobotanical research conducted in the lowland areas of Karabakh covers the period from 2020 to 2025. The main objective of the study is the inventory of tree and shrub species with medicinal properties found in the region. In total, information on the medicinal effects of approximately 60 tree and shrub species was collected and inventoried for the study area. For each identified species, ethnobotanical characteristics were determined, including the plant parts used in traditional medicine, methods of preparation, modes of administration, and the diseases treated.

Analysis of the ethnobotanical survey revealed that the primary users of medicinal plants are housewives aged between 36 and 61. The most commonly used plant parts are leaves, while the main methods of preparation are infusions and decoctions. The results of the surveys were categorized into 11 disease groups. The highest use values (0.91–0.89) were recorded for treatments targeting respiratory disorders, gastrointestinal diseases, and for the calming effects on the nervous system. This indicates a consensus among informants regarding the potential therapeutic efficacy of medicinal plants against specific ailments.

Keywords: Ethnobotanical Use, Medicinal Effects, Ethnic Groups, Quantitative Indices

Pharmacological Effects and Medical Significance Of Hypericum perforatum L.

Hypericum perforatumu L.'Nun Farmakolojik Etkileri ve Tıbbi Önemi

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Abstract

Hypericum perforatum L. (*Hypericum* L., *Hypericaceae* Juss.) is a medicinal plant widely distributed in many parts of the world, including Azerbaijan and the Nakhchivan Autonomous Republic. It has long been used in folk medicine for the treatment of various diseases. Due to its biologically active compounds (hypericin, hyperforin, flavonoids, etc.), this plant exhibits a wide range of pharmacological effects. In modern phytotherapy, *Hypericum perforatum* is especially known for its antidepressant, anti-inflammatory, antibacterial, and antioxidant properties. This article systematically analyzes the chemical composition, pharmacological mechanisms, medical applications, and significance of *Hypericum perforatum* based on scientific literature and contemporary research.

The chemical composition of *Hypericum perforatum* is diverse and biologically active. This rich chemical complex determines the plant's broad pharmacological spectrum. The identification of key compounds such as hypericin and hyperforin as active ingredients has enabled their use in standardized pharmaceutical formulations.

The aerial parts of the plant contain the following main components:

- Hypericin and pseudohypericin – possess antidepressant and photosensitizing effects.
- Hyperforin – acts as an inhibitor of monoamine reuptake.
- Flavonoids – exhibit antioxidant and capillary-strengthening effects.
- Organic acids and essential oils – the plant contains isovaleric acid, chlorogenic acid, ascorbic acid, and small amounts of essential oils, which may have immunomodulatory and tonic effects.
- Tannins and other phenolic compounds – hydrolyzable tannins, catechins, and chlorogenic acid with astringent and antibacterial activity contribute to the plant's anti-inflammatory and wound-healing properties. These substances also help balance intestinal microflora and enhance antioxidant defense.

The pharmacological effects of *Hypericum perforatum* L. are closely related to its rich and varied composition of bioactive compounds. Its therapeutic importance is mainly characterized by psychotropic, anti-inflammatory, antimicrobial, and antioxidant properties.

The pharmacological characteristics of *Hypericum perforatum* can be grouped as follows:

- Antidepressant effect – increases the activity of neurotransmitters such as serotonin, dopamine, and noradrenaline due to the presence of hypericin and hyperforin.
- Antimicrobial and antiviral effect – effective against certain bacteria and herpes viruses.
- Anti-inflammatory and antioxidant effect – provided by flavonoids and phenolic compounds.
- Wound-healing and regenerative effect – application in ointment or extract form accelerates skin lesion recovery.

Contraindications and Precautions:

- Hypericin may cause photosensitivity – protection from sunlight is recommended.
- High risk of drug interactions (e.g., with antidepressants, anticoagulants, oral contraceptives).
- Use during pregnancy and lactation should be under medical supervision.

Hypericum perforatum occupies an important place in phytotherapy due to its rich chemical composition and diverse pharmacological effects. Its main advantage lies in its natural origin and relatively low toxicity. However, pharmacokinetic interactions and the risk of photosensitivity should be considered in its use. Future research should focus on new extraction methods and further clinical validation of the plant's efficacy.

Keywords: *Hypericum perforatum*, Antidepressant Effect, Bioactive Compounds, Pharmacological Properties, Phytotherapy

The Role of Natural Sciences in Understanding and Managing Ecotourism

Eko Turizmi Anlamada ve Yönetmede Doğa Bilimlerinin Rolü

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Özet

Bu araştırma, doğa bilimlerinin (ekoloji, koruma biyolojisi, çevre bilimleri ve fiziki coğrafya) Özbekistan'da ekoturizm bilgisinin oluşumu ve yönetim süreçleri üzerindeki etkisini incelemektedir. Özbekistan'ın kültürel mirasın ötesine geçerek doğa temelli ve sürdürülebilir turizmi geliştirme hedefi doğrultusunda, ekoturizm rotalarının planlanması, biyolojik çeşitliliğin korunması ve ekosistemlerin turizm kullanımı karşısında zarar görmesinin önlenmesi açısından sağlam bir doğa bilimi altyapısının uygulanması büyük önem taşımaktadır.

Ana koruma alanlarına (Zaamin Milli Parkı, Ugam–Chatkal Milli Parkı ve seçilmiş doğa koruma alanları) odaklanan karma yöntemli bir vaka çalışması yaklaşımıyla yürütülen araştırmada; doküman analizi, paydaş görüşmeleri, ekolojik envanter verileri ve saha gözlemleri bir arada kullanılarak, doğa bilimlerinin ekoturizmin planlama, izleme ve operasyonel yönetim süreçlerindeki rolü ve etkisi değerlendirilmiştir.

Elde edilen bulgular, doğa bilimi temelli girdilerin ekoturizm güzergâhlarının planlanması ve yorumlanmasına giderek daha fazla entegre edildiğini; kurumsal koordinasyonun artırılması ve uygulamalı bilimsel yatırımların güçlendirilmesinin ise hem ekolojik sürdürülebilirliği hem de ziyaretçi deneyimini iyileştireceğini göstermektedir. Çalışma, Özbekistan'da politika geliştirme, eğitim, izleme ve topluluk temelli ekoturizm uygulamalarına doğa bilimi yaklaşımlarının daha etkin biçimde entegre edilmesine yönelik önerilerle sonuçlandırılmaktadır.

Anahtar Kelimeler: Doğa bilimleri, ekoturizm, Özbekistan, Ugam–Chatkal, Zaamin, biyolojik çeşitlilik, koruma, sürdürülebilir turizm, izleme, uyarlanabilir yönetim

Abstract

The research paper is focused on how natural sciences (ecology, conservation biology, environmental science, and physical geography) shape ecotourism knowledge and management in Uzbekistan. With Uzbekistan seeking to develop nature-based and sustainable tourism beyond cultural heritage, application of good natural-science knowledge will be crucial for ecotourism trail planning, biodiversity conservation, and protecting ecosystems from tourism versus use. Based on a mixed-methods case study approach with focus on key areas of protection (Zaamin national park and Ugam-Chatkal national park, and selected nature reserves), the study combines document analysis, stakeholder interviews, ecological inventory data, and site observation to assess

the impact and role of natural sciences in planning, monitoring, and operational management of ecotourism. Results are that natural-science inputs are increasingly being incorporated into ecotourism route planning and interpretation and more institutional coordination and applied science investment would enhance ecological sustainability and visitor experience. The article concludes with recommendations to incorporate natural-science approaches into policy, training, monitoring, and community-based ecotourism in Uzbekistan.

Keywords: Natural sciences, ecotourism, Uzbekistan, Ugam-Chatkal, Zaamin, biodiversity, conservation, sustainable tourism, monitoring, adaptive management

1.INTRODUCTION

Ecotourism—nature tourism which emphasizes conservation, local people, and education—has been a strategic choice for the majority of nations in their pursuit of sustainable alternatives to mass cultural tourism. Uzbekistan, with its classical Silk Road cultural past, has a natural diversity of environments (mountain ranges, tugai, deserts, lakes and wetlands) rich in potential for new development of ecotourism. Transition from predominantly cultural and historic to combined nature-based tourism raises problems of management of prime importance: the conservation of biodiversity, the prevention of habitat degradation, the creation of environmentally sensitive visitor experience, and realization of benefits for local communities.

Natural sciences provide the empirical basis for addressing the challenges. Ecology, conservation biology, hydrology, geomorphology, and related disciplines generate the information required to map sensitive habitats, identify priority species and corridors, project carrying capacities, and design monitoring programs that identify early indicators of environmental deterioration. In the case of Uzbekistan, parks such as Zaamin and Ugam-Chatkal are ecotourism hubs and so are a useful prism through which to examine how science knowledge informs management choices.

This paper examines the role of natural sciences in ecotourism understanding and management in Uzbekistan. The objectives are to: (1) document how natural-science knowledge is currently being utilized in site selection, route planning, visitor management, and interpretation; (2) evaluate strengths and weaknesses in the science–management interface; and (3) recommend pragmatic recommendations to improve the application of natural-science evidence in ecotourism management.

Ecotourism and the science–management nexus

Ecotourism is optimally sustainable if it is founded on firm ecological understanding (Faxon & Chapman, 2025). Research pieces maintain that successful ecotourism is contingent upon reliable biological surveys and habitat maps to identify conservation priorities carrying capacity and impact assessments to define acceptable levels of visitation and adaptive management systems derived from monitoring data to adjust operation practice (Narmanov, Narmanov & Azizakhan, 2023). Interpretation and environmental education, based on

quality natural-science content, increase visitor knowledge and conservation support (Gulomkhasanov, Uktamova, & Akramov, 2021).

Natural sciences in protected-area tourism management

Protected areas worldwide integrate natural-science products—vegetation maps, species lists, hydrological studies into zoning, trail placement, and infrastructure siting to reduce human presence in sensitive areas (Kenjaeva, Baxitjanova & Khojanova, 2024). Scientific observation is at the core of detecting trends and confirming the ecological sustainability of tourism operations (Yakubovna, 2016). In transition economies, however, literature refers to the presence of an ongoing scientific-management disconnection due to funding, capacity, and institutional fragmentation (Umarova & Raimjanova, 2024). Uzbekistan's ecotourism potential and recent developments

Recent country profiles and policy briefs emphasize Uzbekistan's natural resources, such as mountain park complexes (Ugam-Chatkal, Zaamin), tugai forests, and steppe/lake ecosystems as a priority for sustainable diversification of tourism (World Bank; national tourism strategies). Local reports and research document increased interest in planning ecotourism routes and developing small-scale eco-lodges, but document shortages in monitoring, research funds, and connecting scientific findings to day-to-day park management and private sector operators (Gulomkhasanov et al., 2021). Lists of protected areas and biodiversity surveys exist for most parks but are unevenly distributed and some are outdated, limiting their utility for adaptive management and tourism planning.

2.MATERIALS and METHOD/METHODS

A mixed-methods case study design was used to yield both quantitative and qualitative elements of the natural sciences' application in ecotourism management. Three representative ecotourism sites in Uzbekistan were the objects of research: Ugam-Chatkal National Park, Zaamin National Park, and Zarafshan reserve complex. They were selected because they are among the most dynamic in nature-based tourism and have registered biodiversity and management systems.

Official documents were collected from Ministry of Ecology, Ministry of Tourism, park management plans (where available), World Bank and UNWTO reports, and recent grey and peer-reviewed literature on Uzbek ecotourism. These reports were scanned for mentions of ecological inventories, zoning, carrying capacity studies, and monitoring practices. Existing ecological inventories, species records, and Protected Areas databases were merged to evaluate currency and completeness of baseline natural-science data for management.

3.RESULTS and DISCUSSION

Degree of integration of natural sciences into site planning

Documentation review and interviews revealed that natural-science products shape top-level protected-area zoning and designation in Uzbekistan. National parks such as Ugam-Chatkal and Zaamin possess underlying lists of biodiversity and maps used to determine strict conservation areas, recreation zones, and sustainable-use areas. Park managers said they use species lists and habitat maps to determine where trails and visitor facilities can be allowed. But the detail and freshness of these inventories are variable—some were developed during the 1990s or early 2000s and have not been regularly updated, so their value for use in planning today is restricted.

Ecological monitoring and adaptive management

Adaptive management—where monitoring data directly inform managerial action—was found to have limited application. Sporadic, occasional surveys of biodiversity (birds, large mammals, important plant communities) were often conducted regularly through short-term research projects or university collaborations. Regular, long-term, standardized monitoring programs (such as annual transects for vegetation cover, soil compaction, or indicator species trend) were not commonly in place. Interviewees noted that monitoring is project-based (donor or academically initiated) rather than institutionalized within park budgets.

Natural sciences are necessary but underbudgeted

The study attests that natural sciences are appreciated as being useful for ecotourism planning and there exist some scientific products (inventories, maps) for Uzbekistan's principal parks. However, there exists a strong gap between the theoretical role of science in adaptive ecotourism management and the real capacity to institutionalize monitoring and to translate results into operations. This concurs with other countries in transition's literature where funding cycles and administrative fragmentation undermine the science–management interface.

4.CONCLUSION

Natural science is fundamental to ecotourism's comprehension and sustainable management. Core scientific work exists in Uzbekistan and has guided protected area zoning and some management decisions, but systemic shortfalls remain—particularly regarding long-term monitoring, institutional capacity, and mechanisms that shift science into routine management practice. Institutionalizing monitoring, park-level capacity building, leveraging the strength of community science, and enhancing more conservation science-tourism authority integration can enable Uzbekistan to make its budding ecotourism industry more ecologically sustainable while enhancing visitor experience and local livelihoods. The transition will require strategic investments, policy coordination, and sustained cooperation among scientists, managers, communities, and the tourism industry.

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Biochemical and Histopathological Evidence for Beneficial Effects of Salvia Macrosiphon Mucilage on the Rat Model of ulcerative colitis

Rat Ülseratif Kolit Modelinde Salvia Macrosiphon Mukusunun Yararlı Etkilerine Dair Biyokimyasal ve Histopatolojik Kanıtlar

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Abstract

Background**:** Idiopathic inflammatory bowel disease (IBD) is a sharply increasing chronic inflammatory condition of the gastrointestinal tract, mainly consisting of Crown's disease and Ulcerative Colitis (UC). The incidence of IBD is rapidly increasing worldwide, especially in the last decades. *Salvia Macrosiphon* (or *Maryam Goli* in Persian), which belongs to the *Lamiaceae* family, has always been of interest due to its potential therapeutic effect in different complexities like constipation, liver disorders, gout, rheumatic diseases, and chronic pains. This plant may play an anti-inflammatory role in IBD, due to some compositions present in it.

Objectives: In this study, the anti-inflammatory effects of *Salvia Macrosiphon* Mucilage (SMM) on colonic tissues of the rats with acetic acid-induced Ulcerative Colitis (UC) were assessed.

Methods: In this experimental study, *Salvia Macrosiphon* Mucilage was used in rats with acetic acid-induced UC. There were 7 groups of study, each containing 6 rats. SMM was administered orally (10, 50, 100, and 150 mg/kg) to four groups of rats. The negative and positive control groups received saline and dexamethasone respectively after the acetic acid-induced UC.

Colonic inflammation was evaluated by gross morphologic damage, histological injury, myeloperoxidase activity and TNF-α, IL-1beta inflammatory markers in colonic mucosa.

Results: The result showed that SMM reduced the colonic level of inflammatory factors such as tumor necrosis factor-α (TNFα) and interleukin-1β (IL1β). Moreover, the mucilage of this plant was able to significantly reduce Myeloperoxidase (MPO) compared to the negative control group.

Conclusion: These considerations illustrated that SMM may have a modulatory effect on inflammatory bowel disease.

Keywords: Inflammatory Bowel disease (IBD), tumor necrosis factor-α (TNFα), interleukin-1β (IL1β), *Salvia Macrosiphon* mucilage (SMM), Rat.

Determination of antioxidant and antiviral properties of saponins obtained from Yucca aloifolia var. tricolor

Yucca aloifolia var. tricolor'dan Elde Edilen Saponinlerin Antioksidan ve Antiviral Özelliklerinin Belirlenmesi

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Abstract

Secondary metabolites of plant cells, which possess a rich array of antioxidants, play a significant role in inhibiting free-radical oxidation. One such compound is glycyrrhizin saponins. Saponins are synthesized in intensively functioning organs, and their content and rate of biosynthesis vary widely. This indicates the significant role of saponins in metabolism. Membranotropic saponins are divided into triterpene and steroid groups.

Steroid saponins were isolated from the roots of *Yucca aloifolia var. tricolor*, a member of the agave subfamily of the asparagus family, growing in Absheron. Accumulating in the roots, especially during winter, steroid saponins protect the membrane's lipid bilayer from crystallization. The antiradical, antioxidant, and antiviral properties of the saponins were studied. The studies were conducted on 7-day-old seedlings subjected to cold stress (4°C) in the presence and absence of saponin, as well as on Gizella 6 cherry rootstocks infected with the PNRSV virus. The DPPH assay demonstrated the saponins' high antiradical activity. The 50% inhibition index (IC) was observed at a concentration of 7.3 ml. The characteristics of the millisecond delayed fluorescence of Chl *a*, as well as the spectral characteristics, showed that the blocking of electron transfer in the Qa–Qb region in the electron transport chain of PS II and the decrease in the absorption capacity of the energy harvesters Chl *a* and Chl *b* under cold stress conditions were corrected in the presence of saponins. Using a BioTek Epoch 2 spectrophotometer, we demonstrated a reduction in PNRSV infection in Gizella 6 cherry rootstocks treated with saponin. After three weeks of experimentation, resistance to this virus was observed. By the third week of the experiment, PNRSV activity had decreased by 25%. It was established that the combined action of steroid saponins exhibited membranotropic properties under these conditions. Protection of the thylakoid membrane's lipid components from thermal damage resulted in the activation of protein electron carriers in the PSII electron transport chain and the stabilization of energy-harvesting pigments. As high-molecular antioxidants, saponins also neutralize reactive oxygen molecules by quenching O^2 and OH, maintaining redox equilibrium in photochemical reactions. Steroidal saponins of *Yucca aloifolia*

var. tricolor are natural antioxidants with a wide range of pharmacological properties, making their further study advisable for the development of new drugs.

Keywords: Antioxidant, Antiviral, Steroid Saponin.

Naxçivanda Apiterapiya Turizminin Potensiali

The Potential of Apitherapy Tourism in Nakhchivan

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Özet

Naxçıvan zəngin florası, ekosistemi və məhsuldar arı növləri ilə apiterapiya turizmi üçün böyük potensiala malikdir. Bölgədə ənənəvi arıçılıq fəaliyyətləri və yüksək keyfiyyətli bal istehsalı turistlər üçün cəlbedici təcrübələr yaradır. Apiterapiya, arı məhsullarının – bal, propolis, polen, arı südü, apilarnil və pətək havası – sağlamlıq və xəstəliklərin dəstəkləyici müalicəsində istifadəsinə əsaslanır. Dünyada Sloveniya, Almaniya, Yaponiya və Yeni Zelandiya kimi ölkələrdə apiterapiya turizmi uğurla inkişaf etdirilsə də, Naxçıvan hələ beynəlxalq miqyasda tam olaraq tanınmamışdır. Bölgənin potensialını artırmaq üçün təhsil proqramları, sertifikatlaşdırma, markalaşma və turizm infrastrukturunun inkişafı vacibdir. Dövlət dəstəyi, ekoturizm və mədəni turizmlə inteqrasiya imkanları Naxçıvanı regional və qlobal apiterapiya turizmi xəritəsində fərqləndirə bilər. Strategiya və davamlı idarəetmə ilə Naxçıvan həm iqtisadi, həm də sağlamlıq turizmi sahəsində önəmli mərkəzə çevrilə bilər.

Keywords: Naxçıvan, apiterapiya, arıçılıq, sağlamlıq turizmi, ekoturizm

GİRİŞ

Apiterapiya, bal arısı (Apis mellifera) və onun təbii komponentlərindən - bal, propolis, kral jeli, polen, arı mumu və arı zəhərindən (apitoksin) - müalicə və sağlamlığın qorunması üçün istifadə edən ənənəvi bir üsuldur. Bu təcrübə yalnız alternativ bir müalicə deyil, həm də arı məhsullarının bioloji aktivliklərindən (antibakterial, antioksidant, iltihab əleyhinə və s.) istifadə etməyi hədəfləyən tamamlayıcı bir sağlamlıq yanaşması hesab olunur (Weis, 2022; El-Didamony, 2024). Apiterapiya tarixi kökləri Qədim Misir və Yunan təbabətinə gedib çıxan bir təcrübə olsa da, bu gün də elmi tədqiqatların mərkəzinə çevrilib. Müasir biotibbi tədqiqatlar göstərir ki, arı məhsulları yaraların sağalması, immun sisteminin tənzimlənməsi və nevroloji xəstəliklərin dəstəkləyici müalicəsi kimi sahələrdə ümidverici nəticələr verir (Pasupuleti və b., 2017; Sadek və b., 2024).

Son illərdə təbii və holistik müalicə metodlarına artan qlobal maraq apiterapiyanın yenidən canlanmasında mühüm rol oynamışdır. İnsanlar indi yalnız xəstəliklərin müalicəsinə deyil, həm də həyat keyfiyyətinin yaxşılaşdırılmasına və immunitetin gücləndirilməsinə yönəlmiş "təbii sağlamlıq" fəaliyyətlərinə müraciət edirlər. Bu tendensiya sağlamlıq iqtisadiyyatının artım məlumatlarında aydın şəkildə özünü göstərir; Qlobal Sağlamlıq İnstitutunun (2024) hesabatına görə, qlobal sağlamlıq turizmi sektoru hər il 8%-dən çox artaraq

trilyon dollarlıq iqtisadi həcmə çatıb. Eynilə, Grand View Research (2022) tərəfindən aparılan hesabatda təbii müalicə və sağlamlıq turizminə tələbatın pandemiyadan sonrakı dövrdə sürətlə artdığı, xüsusilə bitki mənşəli, heyvan mənşəli və apiterapiya məhsullarının istifadəsində artım müşahidə olunduğu göstərilir. Bu ümumi tendensiyanın davamı olaraq, apiterapiya da turizm sektorunda yeni bir ölçü qazanıb. Bu gün arı məhsullarından istifadə edən terapiyalar, spa müalicələri və "arı pətəyi havası ilə nəfəs alma terapiyaları" bir çox ölkədə turist təcrübəsinin bir formasına çevrilib. Xüsusilə Sloveniya, Almaniya və Yaponiya kimi ölkələrdə yerləşən "api-sağlamlıq" mərkəzlərində ziyarətçilər pətək kimi mühitlərdə dincələ, arı pətəklərinin havasını udlaya və ya propolis və bal əsaslı masajlarla cavanlaşdırma seanslarında iştirak edə bilərlər (Arih, 2015; Going.com, 2024). Bu cür təcrübələr həm ənənəvi arıçılıq biliklərini, həm də təbiətin müalicəvi gücünü turizmlə birləşdirərək yerli inkişafa töhfə verir. Eyni zamanda, apiterapiyanın sağlamlıq turizmi ilə qarşılaşdığı yerlərdə nəzərə alınmalı ən vacib amillər təhlükəsizlik və elmi etibarlılıqdır. Arı zəhərinin və ya digər arı məhsullarının ayrı-seçkilik edilmədən istifadəsi allergik reaksiyalar kimi ciddi nəticələrə səbəb ola biləcəyi üçün bu terapiyalar mütəxəssis nəzarəti altında və müvafiq sertifikatla təklif olunmalıdır (Bava və b., 2023).

Naxçıvanın apiterapiya və arıçılıq turizminin müasir vəziyyəti

Azərbaycanın dağlıq və ekoloji cəhətdən müxtəlif bölgələrindən biri olan Naxçıvan arıçılıq və apiterapiya təcrübələri üçün əhəmiyyətli potensiala malikdir. Bölgədə arıçılıq fəaliyyətləri ənənəvi metodlarla həyata keçirilir və yüksək keyfiyyətli bal istehsal olunur. Xüsusilə Batabat Təbii Gölü ətrafında arıçılıq fəaliyyətləri bölgənin ekoturizm potensialını artırır. Bu bölgə təbii gözəlliyi və arıçılıq fəaliyyətləri ilə turistləri cəlb edir (Furkan Gençoğlu, 2022). Apiterapiya sağlamlıq məqsədləri üçün arı məhsullarının istifadəsi kimi müəyyən edilir və qlobal alternativ tibb təcrübəsi hesab olunur. Apiterapiya təcrübələri Naxçıvanda hələ geniş yayılmasa da, bölgənin təbii sərvətləri və arıçılıq ənənəsi bu sahədə potensialı artırır. Arı məhsullarının müsbət sağlamlıq təsirləri elmi tədqiqatlarla dəstəklənir. Məsələn, arı zəhərinin iltihab əleyhinə və ağrıkəsici xüsusiyyətlərə malik olduğu məlumdur (Şafa Kərimova, 2023). Naxçıvanda apiterapiya və arıçılıq turizminin inkişaf etdirilməsi üçün əvvəlcə bölgənin ekoturizm infrastrukturu gücləndirilməlidir. Batabat Təbiət Gölü ətrafında arıçılıq fəaliyyətinin təşviqi və bu bölgənin təbiət turizmi mərkəzi kimi inkişaf etdirilməsi apiterapiya turizminə yol açа bilər. Bundan əlavə, sağlamlıq turizmi çərçivəsində arı məhsullarından istifadə üçün zəruri hüquqi qaydaların müəyyən edilməsi və bu ərazidə səhiyyə işçilərinin hazırlanması vacibdir. Cənub-şərqi Azərbaycan ərazisində yerləşən Naxçıvan zəngin florası və unikal ekosistemi ilə diqqət çəkən bir bölgədir. Dağlıq ərazisi və iqlim müxtəlifliyi müxtəlif bitki örtüyünün və arı növlərinin yaşamasına imkan verir və bu da bölgəyə arıçılıq və bal istehsalı üçün böyük potensial verir (Əliyeva, 2023). Arıçılıq həm iqtisadi, həm də ekoloji cəhətdən regionda strateji əhəmiyyət kəsb edir. Bal arıları təkcə qiymətli bal və arı məhsulları istehsal etmir, həm də bitkiləri tozlandırmaqla kənd təsərrüfatı məhsullarının məhsuldarlığını 20-

50% artırır (Azərbaycan Respublikası Prezidentinin Fərmanı, 2012). Naxçıvanın florasına quraq iqlimə uyğunlaşdırılmış bitkilər, eləcə də Zəngəzur dağlarının rütubətli havası sayəsində inkişaf etmiş meşə ekosistemləri daxildir. Bölgənin nektar ehtiyatları olduqca zəngindir; Yonca, xaşa, şənbəllə və xəşənbül kimi bitkilər arılar üçün vacib bal mənbələridir. Bundan əlavə, söyüd, ağ akasiya, iydə, armud, alça, qavalı və müxtəlif növ qoz-fındıq kimi bitkilərlə dəstəklənən parklar və yaşıllıqlar arıçılığın yem bazasını gücləndirir (Azərbaycan Respublikası Prezidentinin Fərmanı, 2012). Naxçıvanda rast gəlinən sarı Qafqaz arisi (Apis mellifera caucasica) uzun dili sayəsində dərin borulu çiçəklərdən nektar toplayaraq yüksək məhsuldarlıq əldə edə bilir (Macahel Arıcılık, n.d.).

Arıçılığa dövlət dəstəyi sektorun inkişafında mühüm rol oynayır. 2003-2005-ci illər arasında Şahbuz rayonunun 10 kəndində 903 arı ailəsi paylanmış və 2013-cü ildə arıçılıq fəaliyyətinə təxminən 271.000 manat kredit verilmişdir. Bundan əlavə, müasir istehsal müəssisələri, damazlıq ana arı proqramları və arı xəstəliklərinə qarşı tədbirlər arıçılığın dayanıqlığını artırır (Azərbaycan Respublikası Prezidentinin Fərmanı, 2012).

Bal istehsalı arı ailələrinin gücü və düzgün mövsümi miqrasiya təcrübələri ilə artır. Standart, güclü arı ailəsi əlverişli hava şəraitində bir mövsümdə 50-60 kq bal istehsal edə bilər. Arıların payız və yaz aylarında Arazboyu düzənliyinə köçürülməsi onların qışlamasını yaxşılaşdırır və erkən yazda məhsuldarlığı artırır. Bundan əlavə, paket arıçılığın tətbiqi qış itkilərini azaldır və istehsal xərclərini azaldır (Azərbaycan Respublikası Prezidentinin Fərmanı, 2012).

Naxçıvanda arı məhsulları yalnız balla məhdudlaşmır. Apiterapiyada arı südü, polen, propolis, apilarnil və pətək havası (apiair) kimi məhsullar istifadə olunur. Pətək havası bronxit, astma, allergiya və xroniki ağciyər xəstəlikləri kimi xəstəliklərə xüsusilə müsbət təsir göstərir. Apilarnil maddələr mübadiləsi, cinsi funksiyalar, sinir və endokrin sistem xəstəlikləri və yaşlanma ilə əlaqəli depressiya üçün istifadə edilə bilər (Azərbaycan Respublikası Prezidentinin Fərmanı, 2012).

NƏTİCƏ

Zəngin təbii sərvətləri və biomüxtəlifliyi sayəsində Naxçıvan apiterapiya turizmi üçün böyük potensiala malikdir. Apiterapiya, xüsusən də sağlamlıq və sağlamlıq turizmi kontekstində alternativ müalicə üsulları ilə maraqlanan turistlər üçün cəlbedici bir seçimdir. Bu potensialdan səmərəli və davamlı istifadə etmək üçün təhsilə və potensialın artırılmasına üstünlük verilməlidir. Səhiyyə işçiləri, turizm mütəxəssisləri və sahibkarlar üçün apiterapiya üzrə ixtisaslaşmış təlim proqramları və praktik təcrübələr təşkil edilməli, onları həm tibbi biliklər, həm də turizm idarəetmə bacarıqları ilə təchiz etməlidir. Bundan əlavə, yerli sakinlər və müəssisələr arasında apiterapiya xidmətləri və sağlamlıq turizmi haqqında məlumatlılıq artırılmalıdır.

Keyfiyyət və etibarlılıq üçün sertifikatlaşdırma və akkreditasiya sistemlərinin yaradılması vacibdir. Apiterapiya mərkəzlərinin milli və beynəlxalq standartlara uyğun sertifikatlaşdırılması və gigiyena və təcrübə standartlarının müəyyən edilməsi turistlərin inamını artıracaq və regionun nüfuzunu artıracaq. Bundan əlavə, Naxçıvanın apiterapiya məkanı kimi brendləşdirilməsi vacibdir. Regionun təbii sərvətləri və unikal arıçılıq mədəniyyəti üzərində güclü bir brend qurulmalı, rəqəmsal marketinq və sosial media kanalları vasitəsilə təşviqat tədbirləri aparılmalı və beynəlxalq bazarlara genişlənmək üçün beynəlxalq əməkdaşlıqdan istifadə edilməlidir.

Təyinat yerlərinin idarə olunması baxımından apiterapiya mərkəzləri, təbii parklar və sağlamlıq müəssisələri turizm marşrutuna inteqrasiya olunmalıdır. Turistlərin daşınması və yerləşdirilməsi üçün infrastruktur təkmilləşdirilməli və ekoloji dayanıqlılıq prinsipləri qəbul edilməlidir. Beləliklə, apiterapiya turizmi regional iqtisadiyyata töhfə verəcək və Naxçıvanı beynəlxalq sağlamlıq və sağlamlıq turizmi xəritəsinin ön sıralarına çıxaracaq. Təhsil, sertifikatlaşdırma, brendinq və təyinat yerlərinin idarə olunması sahəsində strateji addımlar apiterapiya turizminin yüksək keyfiyyətli və davamlı şəkildə inkişafına imkan verəcək.

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Study of bioecological properties and vegetative propagation Trachelospermum jasminoides of the species (LINDL.)LEM.

Trachelospermum jasminoides (Lindl.) Lem. türünün biyoekolojik özellikleri ve vejetatif çoğaltılması üzerine bir çalışma

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Abstract

Trachelospermum jasminoides (Lindl.)Lem. is a species of the genus *Trachelospermum* in the family *Apocynaceae* of the order Gentianales. It is native to East and Southeast Asia, including Japan, Korea, southern China, and Vietnam. *Rhynchospermum jasminoides* was first described in 1846 by the English botanist John Lindley, but was reclassified in 1851 by the French botanist Charles Antoine Lemaire. The genus name is derived from the Greek words trachelos (neck) and sperma (seed), meaning "star jasmine", based on the shape of the seeds. One of the common names for the plant, Confederate jasmine, has led to a misconception that it is native to the southeastern United States. However, Edwin Menninger, in his book Flowering Vines of the World, notes that this name comes from the Federation of Malay States, the region where the plant grows.

It is a perennial evergreen plant up to 10 m tall. The stem is brown, scaly. Young shoots are pubescent, becoming bare over time. The length of the leaf petals is 3-12 mm. The leaf blade is oval to ovate or narrowly elliptical, 2-10 x 1-4.5 cm, the underside is thin, smooth or sometimes slightly hairy. The flower base is 2-6 cm, hairy or bare. The stamens are in the middle of the tube. The fruits are linear 10-25 cm x 3-10 mm., the seeds are oblong, 1.5-2 cm. in size.

This is an extremely popular and memorable fragrant, fast-growing semi-tropical evergreen shrub, with opposite, elliptical, leathery, shiny dark green leaves up to 5 cm long on the stems, the stems lie flat on the ground, but when supported, the stems can bend up to 6 m.

Trach. jasminoides is mainly propagated by cuttings. Thus, cuttings 10-12 cm long, treated with a 0.01% heteroauxin solution, are kept for two hours and planted in special pots made of a peat-perlite mixture, after 15-20 days the plant has roots. The rooting rate of such seedlings was 35-50%, and in untreated seedlings - 28-30%.

Trach. jasminoides is planted in the north in spring, in the south in September-October. It should be planted in a sunny or semi-shaded place, where it will bloom a little less, in deep, loose, healthy, well-drained soil, protected from cold winds. It can withstand temperatures down to -10°C, sometimes even -15°C, and can withstand very severe frosts if the soil is dry enough. This plant has bright, cream-colored, star-shaped flowers with a strong, sweet scent. This plant grows well in any soil, but it grows best in fertilized soil. The alkaline soils typical of the southwestern desert cause iron chlorosis. It is harvested from the plant in the wild for a wide range of medicinal purposes, and is also a source of essential oil and fiber.

During the analysis of the chemical composition of representatives of the genus *Trachelospermum*, more than 130 compounds were studied, including various lignans, triterpenoids, flavonoids, alkaloids, etc. The medicinal properties of the plant were first described more than a thousand years ago in the Chinese treatise on medicinal plants of the Han Empire. In traditional medicine, the decoction was used to treat rheumatism, gonit, lumbago, pharyngitis and hematomas. Modern studies confirm the anti-inflammatory and analgesic, antitumor and antiviral properties of *Trach. jasminoides* preparations, as well as antibacterial, gastrointestinal and antioxidant activities.

The plant *Trach. jasminoides* is used for many purposes and has been used for thousands of years. The flowering stem has analgesic, antibacterial, antirheumatic, spasmolytic, cleansing, antipyretic, anti-inflammatory, tonic and vasodilator properties. The decoction of the plant is used to treat rheumatoid arthritis, sore throats, various boils and abscesses. The seeds have cardiotonic and hemostatic properties. The whole plant is used in combination with other foods and herbs to treat rheumatism. The valuable oil of this plant, obtained by steam distillation, is also used in the production of high-quality perfumes. Its leaves have a general strengthening and tonic effect. This plant is especially useful for elderly people.

Trach. jasminoides is often used as a houseplant and ornamental plant, but can also be grown outdoors as it is hardy to -8°C. The plant should be planted in full sun, but can also be grown in shade. It has bright, cream-colored, star-shaped flowers with a strong, sweet scent. It usually grows as a drooping shrub or groundcover. It grows well in most soils, but thrives best in well-fertilized soil.

Due to its high decorativeness, abundant flowering and ecological adaptability

Trach. jasminoides is widely recommended for use in landscape design and urban greening.

Study of Summer Plants of the Genus Rosa L. Distributed in the Flora of the Nakhchivan Autonomous Republic

Nahçıvan Muhtar Cumhuriyeti Florasında Yayılmış Rosa L. Cinsine Ait Yaz Bitkilerinin İncelenmesi

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Özet

Bu çalışmada, Nahçıvan Özerk Cumhuriyeti florasında yaygın olan *Rosa L.* cinsinin türleri incelenmiş ve çalışma alanının ilkbahar (gecikmeli) bitki örtüsünde bu cinsin yedi türünün bulunduğu tespit edilmiştir. Çalışma ayrıca bu türlerin ekolojik gruplarını, alan sınıflarını, çiçeklenme ve meyve verme aşamalarını ve dağılım alanlarını da sunmaktadır. İncelenen türler, bölgenin etekleri, ovası ve alt, orta ve üst dağ kuşağındaki bitki örtüsü türlerinde yaygın olarak görülmektedir. Bölgenin ilkbahar florasında kaydedilen *Rosa L*. cinsinin yedi türü, bal bitkileri olarak da özel bir öneme sahiptir.

Anahtar Kelimeler: Yaz Bitkisi, *Rosa*, Cins

Abstract

In this study, the species of the genus *Rosa* L., which is widespread in the flora of the Nakhchivan Autonomous Republic, were examined, and seven species of this genus were found in the spring (delayed) vegetation of the study area. The study also presents the ecological groups, habitat classes, flowering and fruiting stages, and distribution areas of these species. The species examined are commonly found in the vegetation types of the foothills, plains, and lower, middle, and upper mountain belts of the region. The seven species of the genus *Rosa* L. recorded in the spring flora of the region are also of particular importance as honey plants.

Keywords: Summer Plant, *Rosa*, Genus

1. INTRODUCTION

The Nakhchivan Autonomous Republic, possessing rich and diverse landscape zones, is distinguished by its unique soil-climatic conditions, variety of relief, and high number of sunny days. These factors have created conditions for the formation of natural vegetation cover with a rich floristic composition in the region. The flora of the Republic is of significant scientific and practical importance, both in terms of species diversity and the existence of endemic and relict species. Among this rich floristic diversity, species belonging to the genus Rose (Rosa L.) hold a special place.

Recently, as a result of global climate change, anthropogenic impacts, and environmental degradation, a number of negative changes have been observed in the natural phytocoenoses of the region. The disruption of the ecological balance in soil-plant relationships, and the decrease in the productivity and species diversity of the vegetation cover are the main consequences of these processes. These changes are also affecting the life activity and distribution dynamics of plants that pass through the vegetation phase during the spring period, especially those belonging to the genus Rosa L.

The genus Rosa L. is a group of plants distinguished by both its ecological plasticity and its pharmacological and decorative importance. Species belonging to this genus enter the vegetation phase during the spring period and are distributed across various ecological conditions. However, in the modern period, as a result of changes in the ecological environment, a decrease in some aboriginal species and an increase in adventive and secondary species are observed, which disrupts the natural floristic balance.

All these factors necessitate a complex study of the distribution characteristics, ecological adaptations, and floristic status of species belonging to the genus Rosa L. during the spring period. The data obtained from this research are highly important, both for clarifying the floristic map of the region and for the protection of rare and naturally distributed species.

2.MATERIALS and METHODS

Species belonging to the genus Rose (Rosa L.) distributed in various physical-geographical regions of the Nakhchivan Autonomous Republic were used as the main material in the research work. Plant sample collection, phenological observations, and ecology-geographical analyses have been carried out since 2019. Field studies were mainly conducted during the spring months—from the end of March until the end of June—a period that corresponds to the vegetation, flowering, and initial fruiting phases of Rosa species. The local flora in the research areas was studied, species belonging to the genus Rosa L. were identified, and herbarium materials were collected.

For the clarification of species names, the work "Plant World of Azerbaijan" by A.M. Asgarov [5] and Flora World Online [10] were used, and reference was made to primary research sources and the factual data obtained during the field studies [6, pp. 104-110; 7, pp. 5-8; 9, pp. 267-268].

3.RESULTS and DISCUSSION

One of the economically important families of the Nakhchivan AR is the Rose family (Rosaceae Juss.). As a result of the conducted research, the species belonging to the genus Rose (Rosa L.) within the Rosaceae family were studied in the spring flora of the region. During the study, 7 species belonging to the genus were recorded, and the taxonomic composition of the species is reflected in the table noted below (Table 1).

Table 1. Floristic Analysis of Spring/Summer Plants of the Genus Rosa L.

	Name of the Species	Ecological Groups	Areal Class	Flowering and Fruiting Phase
1.	*Rosa canina*	Mesophyte	Western Palearctic	V, VI-VII
2.	*R. iberica*	Xerophyte	Anatolia-Caucasus	VI
3.	*R. hracziana*	Xerophyte	Atropatena	V, VII
4.	*R. rapini*	Xerophyte	Near East	V, VI
5.	*R. Kazarjanii*	Mesophyte	Atropatena	V, VI
6.	*R. spinosissima*	Xerophyte	Palearctic	V, VI
7.	*R. tschatyrdağı*	Xerophyte	Atropatena	V

As a result of the conducted research, 7 species belonging to the genus Rosa were recorded in the spring vegetation of the Nakhchivan Autonomous Republic flora. Four of these species belong to the xerophyte (drought-tolerant) and 3 to the mesophyte (relatively demanding of moisture) ecological groups. In terms of areal distribution, the majority of the species are floristic elements of the Atropatena (3 species) and Palearctic regions (2 species), with species originating from Asia Minor-Caucasus and the Near East also encountered. The flowering period of the species mainly falls in May and June, which is considered an important indicator for the beekeeping potential of the region [1, pp. 9-11; 3, pp. 177-187; 4, pp. 56-60; 8, pp. 55-60].

Rosa canina L. - Dog Rose. Distributed on grassy slopes, in forests, clearings, along riverbanks, and in thickets in the middle, upper, and subalpine belts. Areas: Biçənək, Batabat, Kükü, Ərəci Mountain (Xəzinə dərə), Keçili, Xurs, Ələhi, Şurut, Tilləк Forest. Mesophyte. Usage: Medicinal, tanning, dyeing, edible. AC: Western Palearctic. F, V; f, VI-VII.

Rosa iberica Stev. ex Bieb. – Georgian Rose. Distributed in forests, thickets, clearings, mountain slopes, river valleys, and among thickets on stony and rocky slopes around the villages of Əylis, Biləv, and Behrud in Ordubad district. Xerophyte. AC: Asia Minor-Caucasus. F, V; f, VI.

Rosa hracziana Tamamsch. – Hraczian Rose. Distributed on dry grassy, stony-gravelly slopes, among thickets, and in thicket jungles in the subalpine belt. Areas: Nəsirvaz, Urmus, Nürgüt in Ordubad district (Isayev, Hajiyeva, Nuriyev, 1977). Xerophyte. AC: Atropatena. F-V; f-VII.

Rosa rapini Boiss. - Rapin Rose. Distributed on dry, gravelly, and stony-gravelly slopes in the lower, middle, and upper mountain belts (up to 2300 m). Areas: Qazançı, Kənd Şahbuz, Nəhəcir, Milax. Xerophyte. AC: Near East. F, V; f, VI (Figure 1).

Figure 1. Rosa rapini

Rosa kazarjanii Sosn. – Kazarjan Rose. Distributed on grassy slopes, in thickets, and in forest clearings in the upper and subalpine mountain belts. Areas: Batabat massif in Şahbuz district (near the lower lake), Əlincə Fortress in Culfa district, and Gəvik and Qəndi forests near Ərəfsə village. Discovered by Ə.Ş. İbrahimov on 12.VI.1985. Mesophyte. AC: Atropatena. F-V; f-VI.

Rosa spinosissima L. (Rosa pimpinellifolia L.) – Burnet Rose / Many-spined Rose. Distributed in stony places, on sunny slopes, in thicket jungles, and in forest clearings from the lower to the middle mountain belt. Areas: Tillək, Talalar forests, Batabat, Biçənək, Nüs-Nüs, Gücəzur. Xerophyte. AC: Palearctic. F-V, f-VI (Figure 2).

Figure 2. *Rosa spinosissima*

Rosa tschatyrdağı Chrshan. - Chatyrdag Rose. Distributed in the lower and middle mountain belts. (Isayev, Hajiyeva, Nuriyev, 1977). Xerophyte. AC: Atropatena. F V.

As a result of the conducted research, it has been established that the 7 species belonging to the genus Rosa L. recorded in the spring vegetation of the Nakhchivan Autonomous Republic flora are also of particular importance as melliferous plants. All of these species fall into the category of melliferous plants due to their distinctive characteristics [2, pp. 45-48].

Melliferous plants hold a special place in the rich flora of the Nakhchivan Autonomous Republic. The flowers of Rosa species are attractive to bees and secrete abundant amounts of nectar and pollen. Specifically, Rosa canina and Rosa pimpinellifolia are among the species from which bees collect the most pollen. Although Rosa species are not distinguished by high honey yield, their flowers constitute an important food source for bees in terms of both nectar and pollen. This, in turn, facilitates the healthy development of bee colonies and the pollination of other melliferous plants.

These species, adapted to the climate and soil conditions of Nakhchivan, are drought-resistant, which makes them a stable nectar source. These species mainly flower during May and June, and this period contributes to the increase in productivity in beekeeping.

4. CONCLUCION

As a result of the conducted research, it has been established that 7 species of the genus Rosa L. are found in the spring vegetation of the Nakhchivan Autonomous Republic flora. Analysis of the ecological groups of the species belonging to the genus revealed that 2 species are mesophytes and 5 species are xerophytes. According to the analysis of geographic areal classes, 3 species of the genus are grouped under the Atropatena, 1 species under the Asia Minor–Caucasus, 1 species under the Western Palearctic, 1 species under the Near East, and 1 species under the Palearctic areal class.

The Rosa L. species studied in the spring vegetation are important not only from a floristic perspective but also as melliferous plants, constituting a significant source of nectar and pollen for bees.

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Neuroprotective Effects of Royal Jelly on Alzheimer's Disease: In Vivo Study

Arı Sütü'nün Alzheimer Hastalığı Üzerine Nöroprotektif Etkileri: İn Vivo Çalışma

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Abstract

Alzheimer's disease is a progressive neurodegenerative disorder that affects the brain. It is the leading cause of dementia and cognitive decline in the elderly. Some studies have shown that royal jelly, thanks to its beneficial natural components, may help support brain health and prevent the cognitive decline associated with Alzheimer's disease. This research aims to study the neuroprotective effect of royal jelly against Alzheimer's disease through an experiment conducted on NMRI mice. The mice were divided into five groups: a control group, an Alzheimer's model group, two groups treated with royal jelly at two different doses (150 and 300 mg/kg), and a reference group treated with rivastigmine at a dose of 1.5 mg/kg. The experimental protocol was carried out in two phases: The first phase consisted of a 45-day treatment period during which the mice received daily doses of royal jelly (150 and 300 mg/kg) as well as rivastigmine (1.5 mg/kg) via intragastric gavage. The second phase involved the induction of Alzheimer's disease through oral administration of aluminum chloride combined with D-galactose via intraperitoneal injection over the following 45 days. Subsequently, neurological tests were performed, including memory and behavioral assessments, as well as histological examinations of the brain, particularly in the hippocampus and cortex. The neurological tests showed positive results in terms of reduced anxiety and improved behavioral activity in Alzheimer's model mice treated with royal jelly at doses of 150 and 300 mg/kg, compared to the untreated Alzheimer's model group. Memory test results also indicated that mice treated with royal jelly at these doses showed significant recovery, with improvements in memory and learning ability. As for the histological study, both doses demonstrated positive effects; examination of brain tissues (hippocampus and cortex) revealed that royal jelly helped reduce neuronal damage and improve tissue structure. These results suggest that royal jelly has promising neuroprotective properties against the cognitive decline associated with Alzheimer's disease.

Keywords: Royal jelly, Alzheimer's, Brain, Mice, Neurological tests

Importance Bee Products in Nutrition

Beslenmede Arı Ürünlerinin Önemi

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Abstract

Honey, pollen, bee bread, royal jelly and propolis have high dietetic and nutritional value and beneficial effects to human health. Honey is good source of energy and carbohydrates as well as minerals and vitamins. Also, honey contains antioxidants, aromatic components and enzymes. The source of flower nectar categorizes different types of honey, according to some data there are hundreds of types of honey, and each boasts special health and nutritional benefits. Nutritional properties of honey also depend on the type and content of pollen grains and other ingredients. People commonly take bee pollen for nutrition. Bee pollen contains many BAC-like carotenoids, polyphenols, flavonoids, alkaloids, glycosides, as well vitamins, minerals and other antioxidants. Numerus studies have linked bee pollen and its compounds to health benefits such as decreased inflammation, as well as improved immunity, menopausal symptoms and wound healing. Pollen is a functional food for human consumption with a wide range of functional properties, such as antioxidant, antimicrobial, anti-inflammatory, anti-radiation and hepatoprotective activity. The chemical composition of propolis, as well as the content of biologically active compounds in it, depends on its botanical and geographical origin, the type of bees, as well as the season in which propolis is collected. Propolis is available today in numerous preparations, which can be in the form of capsules, drops, sprays, creams, powders and lozenges. It has a preventive effect on sore throats and periodontitis. The natural form is the best form, but it is very unstable and also the active ingredients are labile. The Royal jelly is immunomodulatory agent, stimulates cell growth and stimulates cell growth in the brain.

Nutrition has been a concern of mankind since ancient times. An old Ayurvedic proverb states “When the diet is bad, medicine is not helpful. When the diet is correct, medicine is not necessary”. Researches on health, disease and longevity clearly shows that people who follow mainly a whole-food plant-based diet, have significantly better long-term health results. It has been shown that this kind of diet make people feel well nourished, full of vitality able to have a long, happy and healthy life. Therefore, we sought to find a balanced diet that would fulfil the body`s complete needs. Api-nutrition promotes combining a healthy diet with daily bee products. Raw bee products provide essential nutrients, antioxidants, vitamins, pre/probiotics, and even telomerase, the “longevity enzyme.” Recognized as functional foods, they contribute positively to health

beyond basic nutrition.

Bee products strengthen immunity, support beneficial gut bacteria, aid tissue regeneration, and protect overall health. When used properly, they help maintain and improve health, quality of life, and longevity. This presentation will introduce the basics of api-nutrition and related findings

Keywords: Api-Nutrition, Bee Products, Functional Food, Health

Investigating the changes of blood and tissue factors in the injection of bee venom and melittin on the knee cartilage of male rats

Erkek Sıçanların Diz Kıkırdağına Arı Zehri ve Melittin Enjeksiyonunun Kan ve Doku Faktörlerindeki Değişiklikler Üzerindeki Etkilerinin Araştırılması

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Abstract

Background: The use of honey and other bee products goes back thousands of years. So that even its therapeutic benefits are mentioned in the holy book of Quran and holy books such as Veda (Holy book of Indians), Bible (Holy book of Christians). Bee venom consists of at least 18 pharmacologically active compounds including enzymes such as phospholipases, peptide and amino acid compounds such as melittin, which has anti-inflammatory properties.

Objective: In this study, the hematological and histological effects of bee venom and melittin were compared.

Methods: Isolation of melittin from bee venom was performed by linear gradient method with HPLC-RP. The procedure was performed by intra-articular injection of 1mg/kg of bee venom and melittin separately on rats. One month after the injection, the results of hematology factors, including hemoglobin, hematocrit, white blood cells, red blood cells, and platelets, as well as immunological factors IL6 and TNFa, were evaluated in comparison with the control group. Also, tissue TNFa expression was investigated by immunohistochemistry method.

Results: The findings of the present study did not show significant differences in hematology factors. The findings of the present study did not show significant differences in hematology factors. The results of histological studies showed an increase in cartilage thickness in the group receiving the poison, and the number of chondrocytes in both groups showed a significant decrease. Also, the reduction of collagen fibers and disorganization of the ground substance was confirmed in Schiff's periodic acid staining and Masson's trichrome in the group receiving melittin. Conclusion: The results of this study showed that the hematological and histological changes of intra-articular injection of bee venom can have the least joint damage compared to melittin injection under the same conditions. These results show that bee venom can be a new therapeutic approach of natural substances.

Keywords: Bee venom, HPLC, IL6, melittin, TNFa

Bee Products for Children

Çocuklar için Arı Ürünleri

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Abstract

Children's needs are very specific and their response to a health condition is significantly faster than adults. Nowdays, foods are increasingly poor in nutrients and most often contaminated with chemicals. That means we need to pay more atention to the nutrition of the child. Bee products are lately attracting the attention of the consumers, but also of the researchers due to their marvelous characteristics: significant effects on human health and nutrition. For example, raw pollen and bee bread due to their complex composition are accepted as superfoods. Raw honey not only replace sugar in daily diet, but offers a variety of phytonutrients that can play important roles for maintaining a good health: enzymes, probiotics, antioxidants, etc. Propolis has very good antimicrobial and anti-inflammatory properties. Royal jelly and apilarnil are very good for body and brain development, for premature babies, immune problems, etc. Introducing bee products in children's diet helps to maintain a good state of health and harmonious development. Their taste is well accepted and appreciated by kids, which is important for a good compliance. The use of bee products has shown very good effects in boosting immunity: children who start in kindergarten or school are protected from recurrent infectious. This presentation will show some of our experience introducing bee products as part of the diet and remedies for common issues that infants and toddlers might face.

Keywords: Apitherapy, Nutrition, Bee Products, Children

The study of the Lactuca L. genus in the flora of the Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti florasında Lactuca L. cinsinin incelenmesi

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Abstract. Species belonging to the genus Lactuca L. in the flora of Nakhchivan Autonomous Republic have been studied and the taxonomic spectrum of the species has been determined. Also, many literatures were studied, and detailed information about the genus and species was obtained. The distribution of species in the area was also studied and natural photographs were taken. Research in the Nakhchivan Autonomous Republic revealed that the Asteraceae Dumort. family is represented by 357 species belonging to 92 genera, and the Lactuca L. genus (lettuce) is represented by 7 species. Due to the abundance of natural resources in the Lactuca genus, the aromatic compounds contained in their roots and stems are promising for future use as pharmaceuticals and flavoring agents in the food industry.

Key words: Lactuca, Asteraceae, taxonomic spectrum, natural resources, flora

Introduction. The Nakhchivan Autonomous Republic stands out among other botanical and geographical regions of the Republic of Azerbaijan for its floristic diversity. Thanks to the research of T.H. Talibov, the floristic diversity of the Nakhchivan Autonomous Republic was first identified, comprising 2,742 species classified in 773 genera, 110 of which were considered rare. In this list, the family Asteraceae Dumort.-Asteraceae includes 339 species belonging to 90 genera, of which 7 species are considered rare plants [Talibov et al., 2021]. In general, in the flora of Azerbaijan there are 551 species of Asteraceae belonging to 137 genera, of which 20 species belonging to 11 genera are cultivated, and 8 species belong to the genus Lactuca L. [Talibov 2003].

Materials and methods. The genus Lactuca L., native to the Nakhchivan Autonomous Republic, was used as the research material. The current status of this species, which is expected to be of economic importance, was studied in the region. During the research, classical and modern botanical-floristic, systematic, taxonomic changes, ecological, phytocenological and resource provisions were used [Talibov 2010; De Vries 1997].

Discussion. When compiling the taxonomic spectrum of the flora of the Nakhchivan Autonomous Republic (higher spore plants, gymnosperms and angiosperms), it was established that there are 2835 species belonging to 874 genera in the territory. After studying some taxa and cultivated flora, it was noted that in the territory

of the Nakhchivan Autonomous Republic, there are 337 species of the Asteraceae Dumort family belonging to 89 genera [Talibov, 2008; Noumedem, 2017].

Genus: Lactuca L.

1. Lactuca georgica Grossh.
2. L. orientalis Boiss.
3. *L. sativa L.
4. L. serriola L.
5. L. takhtadzhanii Sosn.
6. L. undulata Ledeb.
7. L. viminea (L.) Presl
8. L. wilhelmsiana Fisch. & C.A.Mey. ex DC.

Lactuca is a genus of perennial or annual herbaceous plants belonging to the family Asteraceae. The most well-known species of this genus is Lactuca sativa, which we know in our everyday life as "lettuce". Among these species, Lactuca takhtadzhanii Sosn. - Takhtadzhanii's was considered a rare plant in 1978 and was listed in the Red Data Books of the former USSR [Talibov 2001] and the Republic of Azerbaijan [Talibov 2003].

The biodiversity of the flora was represented by 3018 species belonging to 910 genera, of which the Asteraceae family included 357 species belonging to 92 genera [Talibov, 2008; Curtis, 2006]. Thus, as a result of the latest final classification of the Asteraceae family Dumort. - The genus Lactuca L. includes 7 species [Talibov 2010].

Genus: Lactuca L.

1. Subgen.1. Mulgedium (Cass.) Babc., Stebbins et J.A.Jenkins

1. Lactuca tatarica (L.) C.A. Mey.
2. L. wilhelmsiana Fisch. & C.A. Mey. ex DC.

2. Subgen. 2. Lactuca

Sect.1. Lactuca

3. L. serriola L.
4. *L. sativa L.
5. L. saligna L.
6. L. georgica Grossh.

Sect.2. Micranthae Boiss.

7. L. undulata Ledeb.

Lactuca takhtadzhanii Sosn., listed in the Red Data Books of the former USSR and Azerbaijan, also belongs to the genus Cephalorhynchus Boiss as Cephalorhynchus takhtadzhanii (Sosn.) Cyprus. The shape of the leaves and seeds of this species also indicates that it does not belong to the genus Lactuca L. Differences are also observed in the seed material of the species (Figure 1) [Kim, 2016].

According to the new classification, as can be seen from the taxonomic spectrum, in the genus Scariola F.W.Schmidt - Scariola is combined with Scariola orientalis (Boiss.) Sojak Lactuca viminea (L.) Presl and L. orientalis Boiss., in the genus Streptorhamphus Bunge with the species Streptorhamphus crambifolium Bunge is combined Lactuca crambifolia (Bunge) Boiss. and with the species Streptorhamphus tuberosus (Jacq.) Grossh. is combined the species L. petraea Fisch. & C.A. Mey. ex DC. as a synonym (Figure 2.) [Lebeda, et al., 2006; Pink, 1993].

Figure 1. Lactuca serriola

Due to the abundance of natural resources of species belonging to the genus Lactuca (Fig. 3), it is advisable in the future to use the bioactive substances contained in the tissues of the roots and stems in the pharmaceutical and food industry as a flavoring agent.

Figure 2. Seeds of some species Lactuca and Cephalorhynchus 1. Cephalorrhynchus takhtadzhanii; 2. Lactuca tatarica; 3. L. georgica; 4. L. saligna.

Figure 3. Formation of the species Lactuca serriola

Thus, as a result of recent research in the territory of the Nakhchivan Autonomous Republic, the family Asteraceae Dumort.- Compositae was represented by 357 species belonging to 92 genera, and the genus Lactuca L. includes 7 species in this taxonomic spectrum.

Result. Research in the Nakhchivan Autonomous Republic revealed that the Asteraceae Dumort. family is represented by 357 species belonging to 92 genera, while the genus Lactuca L. is represented by 7 species. The distribution of species in the area was also studied. Due to the abundance of natural resources in the species belonging to the genus Lactuca, the aromatic compounds contained in their roots and stems are promising for future use as pharmaceuticals and flavoring agents in the food industry.

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Protective and Anti-Anemic Effects of an Optimized Mixture of Moroccan Ziziphus lotus Honey and Bee Pollen against Phenylhydrazine-Induced Hemolytic Anemia in Wistar Rats

Wistar Sıçanlarında Fenilhidrazin ile İndüklenen Hemolitik Anemiye Karşı, Fas Menşeli Ziziphus lotus *Balı ve Arı Poleninin Optimize Edilmiş Karışımının Koruyucu ve Anti-Anemik Etkileri*

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Abstract

Natural bee products are increasingly investigated for their therapeutic potential due to their rich antioxidant composition. *Ziziphus lotus* honey and bee pollen are traditional Moroccan products known for their nutritional and pharmacological properties. This study aimed to design and optimize a synergistic honey-pollen mixture and to evaluate its protective and anti-anemic effects against phenylhydrazine-induced hemolytic anemia in Wistar rats. For this reason, a mixture design was established using *Design Expert*® software, combining *Ziziphus lotus* honey and bee pollen as two natural matrices. Eight formulations were generated and analyzed for total phenolic content (TPC), total flavonoid content (TFC), total antioxidant capacity (TAC), and DPPH radical scavenging activity. The optimal mixture, characterized by the highest TPC, TFC, and TAC values with the lowest DPPH, was selected for in vivo evaluation. Hemolytic anemia was induced by intraperitoneal injection of phenylhydrazine (60 mg/kg) on days 1 and 3. Rats were divided into seven groups and treated orally for 21 days with honey (1 g/kg), bee pollen (200 mg/kg), two mixture doses (200 mg/kg and 400 mg/kg), or Fe (III) polymaltose complex (4 mg/kg) as reference. The two other groups were served as normal (non anemic rats) and control (anemic rats) groups, and were gavaged with distilled water. The optimized mixture significantly improved hematological indices, including hemoglobin, hematocrit, and red blood cell counts ($p < 0.05$). Osmotic fragility assays confirmed enhanced erythrocyte resistance to NaCl-induced hemolysis. Both mixture doses exhibited comparable efficacy to the Fe (III) complex. The optimized honey-bee pollen mixture demonstrated remarkable antioxidant and anti-anemic properties, supporting its potential use as a natural bioactive formulation for anemia management.

Keywords : *Ziziphus lotus* honey, Bee pollen, Phenylhydrazine, Anemia, Antioxidants, Osmotic fragility, Mixture design.

Beyond the Label: Botanical Origin and Chemical Purity of Ziziphus Honey for Therapeutic Use

Etiketin Ötesinde: Tedavi Amaçlı Kullanım İçin Ziziphus Balının Botanik Kökeni ve Kimyasal Saflığı

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Abstract

Apitherapy depends on honey that is true to its plant source and free of harmful chemicals. Increasing adulteration puts patients at risk and can weaken the intended therapeutic effects. The objective of this study was the evaluation, authenticity and clinical suitability of *Ziziphus* honey sold in Lahore, Pakistan. Nine retail samples (S1–S9) were analyzed. Pollen was extracted by acetolysis, slides were examined under a microscope, and each sample was classified as unifloral (≥45% one pollen type) or multifloral. In parallel, GC–MS was used to profile major compounds and screen for likely adulterants/contaminants. Pollen data was identified four unifloral samples (S4, S5, S6, S9) and five multifloral samples (S1, S2, S3, S7, S8), supporting the stated botanical sources. GC–MS detected diethyl phthalate in all samples; S9 also contained 1,2-benzenedicarboxylic acid, diundecyl ester. These plasticizers are incompatible with genuine honey and indicate contamination or adulteration. Chemical profiles also showed varied amounts of alcohols, aldehydes, acids, and esters. Sample S1 carried the heaviest plasticizer load, whereas some samples had fewer plasticizers and relatively higher levels of potentially beneficial esters and acids. The presence of phthalates undermines safety and may interfere with honey's bioactive components, reducing therapeutic reliability. While unifloral status can guide product selection, chemical purity is essential for clinical use. Combining melissopalynology with GC–MS is a practical quality gate for apitherapy-grade honey. Regular market surveillance, supplier audits, and certification are recommended to protect consumers and uphold standards across bee products.

Keywords: Apitherapy; Honey Authenticity; Melissopalynology; GC-MS; Phthalates; *Ziziphus* Honey; Quality Assurance; Lahore, Pakistan.

Honey Bee Pollen Biodiversity and Nature Based Solutions for Health Security via Apitherapy in Asia

Asya'da Apiterapi Aracılığıyla Sağlık Güvenliğine Yönelik Bal Arısı Polen Biyoçeşitliliği ve Doğa Temelli Çözümler

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Abstract

Asian Northern Hemisphere region is one of the important and richest hotspot of bee floral biodiversity. In this region China -Pakistan hosted diverse ranges of honey bee flora in Himalaya, Karakoram and Kohindukush with long chain of mountain supporting with cultural communities. Currently a project China Pakistan Economic Corridor is consider to bring revolutionary changes to the research sector particularly by the application of honey bee based plant diversity. The experts from both countries have started number of international projects on plant resources using modern technologies including digitization of floral diversity, conservation of wild natural plant resources, conservation of trans-border indigenous knowledge and exchange of ideas by institutions through smart technology to cope 15th SDGs in order to conserve honey bee based plant diversity under fast climatic changes. This study contributes to a deeper understanding of the interplay between the built environment, biodiversity, and the SDGs, allowing key industry actors and policymakers to prioritize bee diversity and bee flora in SDG-related policies and programs.

In order to do this, we have compiled data on apiaries and bee flora that is currently available on the connections between biodiversity and economic growth, concentrating on changes in climate and land use. Finally, we demonstrate how scenario planning for significant policy instruments such as the convention on biological diversity can aid in shifting national and international goals away from growth and toward biodiversity protection. This project supported to develop modern bee pollen Herbaria and Botanic garden to protect endemic and endangered species in this part of Northern Hemisphere of Asia. Quaid I Azam university Botanic garden and Herbarium initiated projects with Institute of Botany Beijing, Gansu Province, Chengdu institute of Biology, and number of other institutions in China cooperating to support Pakistani researchers and experts in the field of bee floral biodiversity, honey bee and honey industry, plant documentation, collection and conservation in line with global efforts for protection. This initiative may further leads to trained post graduate students, scientists, pollination biologists, palynologists, bee biologists, taxonomists, biodiversity experts, horticulturists, melissopalynology experts, plant botanists, traditional health practitioners

and layman regarding the equal sharing benefits of honey bee industry and health benefits with sustainable way to provide Apitherapeutics application for nature based solutions to treat common day ailments.

Keywords: Bee Floral Biodiversity**,** Apitherapy and Sustainable Development**,** Nature-Based Solutions

Analysis of the Antioxidant Potential of Plants Used in Traditional Medicine

Geleneksel Tıpta Kullanılan Bitkilerin Antioksidan Potansiyellerinin Analizi

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Abstract

The study presents data on the total content of polyphenolic compounds obtained from aqueous and aqueous-ethanolic extracts of leaves of certain plants growing in the Almaty region of the Republic of Kazakhstan. It is shown that almost all the studied plants possess antioxidant properties to a greater or lesser extent. The use of aqueous-ethanolic extracts led to a significant increase in the yield of polyphenolic compounds, enabling the extraction of a wide range of biologically active substances. The use of a triple herbal phytomixture increases the resistance of erythrocytes to peroxide and osmotic hemolysis, enhances erythrocyte membrane resistance, reduces membrane permeability, and stabilizes red blood cell membranes. The obtained results correlate with the high polyphenol content in the triple phytomixture and substantiate its use as a membrane-stabilizing and antioxidant agent for applications in oxidative damage of erythrocyte membranes.

Keywords: Antioxidant, Phytomixture, Membrane, Free Radicals, Resistance, Hemolysis

➢ 1.INTRODUCTION

The use of medicinal herbs in traditional and folk medicine is currently particularly relevant, which is due to the significant advantages of plants compared to chemical pharmaceutical preparations. Over the past decade, considerable attention has been paid to the study of plant metabolites as effective antioxidants. Medicinal products with antioxidant activity (AOA) are widely used in medicine to inhibit lipid peroxidation processes [1].

Studies show that plant raw materials contain a wide range of biologically active compounds, including polyphenols, flavonoids, ascorbic acid, and tocopherols, which exhibit pronounced antioxidant properties [2,3]. It is known that the antioxidant activity of substances of plant origin largely determines the medicinal value of a plant. Antioxidants present in plants play an important role in protecting the body against oxidative stress caused by free radicals [4]. Recently, researchers' attention has been increasingly focused on natural sources of antioxidants, including medicinal plants [3]. In this regard, there is a need to identify the most promising plants with a high potential content of biologically active substances.

Kazakhstan possesses unique reserves of diverse plant species with medicinal properties, a significant proportion of which are promising for studies of biological activity. In this regard, research aimed at the isolation of new biologically active polyphenols from local plant raw materials is of particular importance. Therefore, the development and implementation of phytoproducts into production, as well as the rational use of the region's plant resources, are highly relevant [1].

Despite the widespread use of rosehip, sea buckthorn, Fragaria vesca L., and Rhodiola rosea in folk medicine, their combined antioxidant properties within phytomixtures require more in-depth investigation. Although each component exhibits pronounced antioxidant activity due to a high content of vitamins (especially C and E) and other biologically active compounds (flavonoids, carotenoids), their synergistic effects in mixtures remain insufficiently studied [3].

It is known that the antioxidant activity (AOA) of substances of plant origin largely determines the medicinal value of a plant [4,5]. The antioxidant activity of plant raw materials plays an important role in the development of natural cell membrane stabilizers. These compounds are capable of effectively inhibiting oxidative processes, thereby preventing the accumulation of free radicals and lipid peroxidation products [6]. Oxygen free radicals and free-radical oxidative reactions are known to play a significant role in protein and lipid damage, as well as in the formation and accumulation of lipid peroxidation products in the pathology of aging of various organs [7].

To maintain public health under the influence of adverse environmental factors, increasing the body's resistance through biologically active substances isolated from plant raw materials with pronounced membrane-stabilizing and antioxidant effects is of paramount importance. The flora of Kazakhstan is widely represented by plants containing flavonoids. Natural flavonoids are potential antioxidants, and considerable attention is therefore paid to the antioxidant properties of polyphenol-containing products.

Free radical oxidative reactions are considered important factors involved in the phenomenon of biological aging. They can damage intracellular components such as DNA, proteins, and membrane lipids, which may lead to mutagenesis, growth inhibition, and cell necrosis [8].

Since free radical lipid peroxidation of membranes increases with age and the activity of endogenous antioxidants changes, the use of exogenous antioxidants may be beneficial for maintaining health. Enhancing the body's resistance through natural biologically active compounds is of great importance for health preservation. Antioxidant substances can be used at different ages without harm to the body. Effective

geroprotective agents include preparations that reduce the risk of developing chronic diseases and increase life expectancy [9].

Membranes are one of the essential components of a living cell, ensuring the normal functioning of its elements. In studies of biological membranes, erythrocytes are often used as a model reflecting the condition of membranes throughout the body [9]. Research with preparations derived from plants growing in the territory of the Republic of Kazakhstan, which possess antioxidant and membrane-protective properties, may serve as a means to improve human health.

It is assumed that the possible mechanism of the protective action of plant preparations is due to the suppression of free radicals and the antioxidant activity of flavonoids present in these extracts.

The aim of this study is to investigate the antioxidant activity of certain plants and, based on the preparation of a phytoproduct, to assess their effect on changes in the resistance of erythrocyte membranes.

➢ 2.MATERIALS and METHOD/METHODS ETC

The experiments were aimed at studying the effects of aqueous-ethanolic extracts of leaves, sea buckthorn, rosehip, Fragaria vesca L., and Rhodiola rosea during the autumn period. A 50% ethanol solution was used to prepare the extracts, with a ratio of dry matter to extractant of 1:10. Extraction was carried out for 20 hours. At the end of the extraction period, the extracts were filtered to remove large particles. The prepared phytochemical extracts were stored at 4 °C.

Determination of soluble polyphenol content was carried out using the Folin–Ciocalteu method. This method is based on the reaction of polyphenolic compounds with the Folin–Ciocalteu reagent [11].

Experiments were conducted on 20 adult 12-month-old male rats weighing 180–200 g.

Isolation of erythrocytes: Erythrocytes were obtained by centrifuging the blood for 10 minutes at 1000 g. The plasma was removed, and the erythrocytes were washed twice with a medium containing 150 mM NaCl and 5 mM Na_2HPO_4 (pH 7.4).

Peroxide resistance (PGE) was determined according to the method [12]. Osmotic resistance of erythrocytes (ORE) was measured by incubating the cells for 20 minutes at 37 °C in hypotonic sodium chloride solutions (0.35–0.5 g/100 mL). The erythrocytes were then sedimented by centrifugation, and the hemoglobin concentration in the supernatant was measured. The optical density of the supernatant was

recorded at a wavelength of 540 nm. The level of cell hemolysis was calculated as a percentage relative to 100% hemolysis induced by a 0.1 g/100 mL Na_2CO_3 solution.

Statistical data analysis: The results were statistically processed using Microsoft Excel. Changes in the measured parameters were considered significant according to the Fisher–Student criterion at $p \leq 0.05$.

➢ 3.RESULTS and DISCUSSION

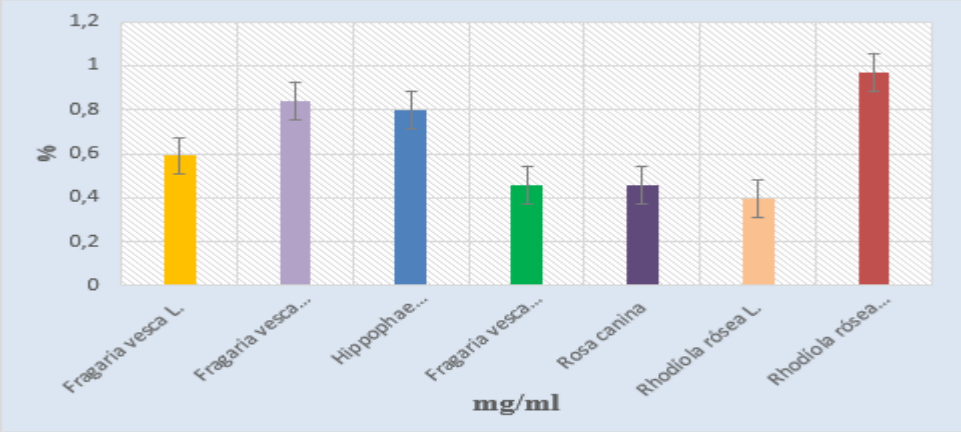
A comparative analysis was conducted on the effectiveness of two types of solvents—aqueous and 50% aqueous-ethanolic—to determine the optimal conditions for extracting biologically active compounds from plant raw materials. The obtained data allow for the assessment of the potential of each of the studied plant species (Rosa canina, Hippophae rhamnoides L., Fragaria vesca L., Rhodiola rosea L.) as sources of polyphenols.

Table 1. Antioxidant activity values of aqueous and aqueous-alcoholic plant extracts

№	Name of the extract	AOA mg/ml Water Extract	AOA mg/ml Water-ethanol extract (50%)
1	**Rosa canina**	0,4152	0,5902
2	**Hippophae Rhamnoides L.**	0,4902	0,6487
3	**Fragaria vesca L.**	0,2011	0,4585
4	**Rhodíola rósea L.**	0,2365	0,3961

The study showed that all samples were characterized by a high content of polyphenols, ranging from 20.11% to 64.87%. The use of aqueous-ethanolic extracts in all cases led to a significant increase in the yield of polyphenolic compounds compared to aqueous extraction, confirming the effectiveness of the mixed solvent for extracting a wide range of biologically active substances. It is likely that ethanol solutions extract antioxidant compounds from.

The highest polyphenol concentration was recorded in the aqueous-ethanolic extract of Hippophae rhamnoides (64.87%). A high content was also observed in the aqueous-ethanolic extract of Rosa canina (Rosa canina) at 59.02%. Fragaria vesca L. and Rhodiola rosea showed comparatively lower values (20.11% and 23.65%, respectively), indicating a moderate level of polyphenol content; however, when using the aqueous-ethanolic mixture, their levels also reached relatively high values (45.85% and 39.61%).



On the x-axis: content of polyphenolic compounds, mg/mL GAE; on the y-axis: concentration of plant extract ($p \leq 0.005$)

Figure 1. Polyphenolic composition of combined plant extracts of plant leaves

Thus, the results of the study highlight the high biochemical value of Hippophae rhamnoides and Rosa canina as sources of polyphenolic compounds and also confirm the effectiveness of using an aqueous-ethanolic solvent for their extraction.

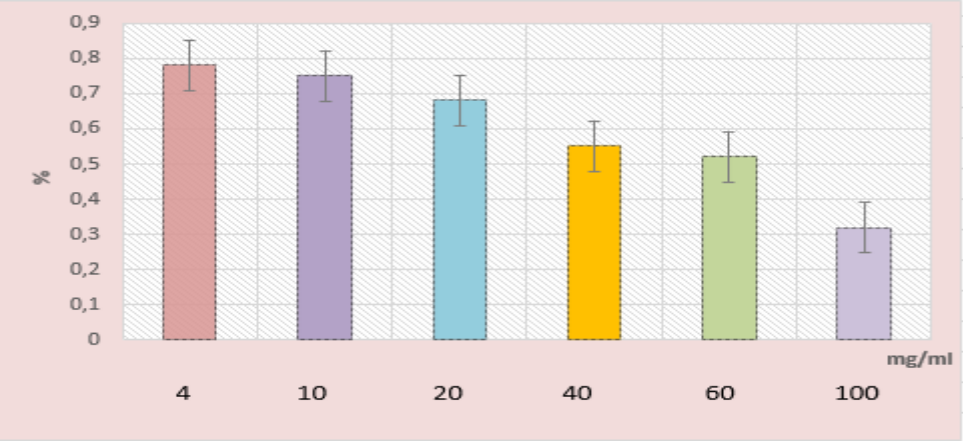
The total content of polyphenolic compounds in alcoholic leaf extracts and their combinations, expressed as gallic acid equivalents (mg/mL) at a dry matter concentration of 1 mg/mL, ranged from 0.40 to 0.97 mg/mL. The highest value was recorded for the triple phytomixture (Rhodiola rosea + Rosa canina + Fragaria vesca L.) at 0.97 mg/mL, which exceeds the mixture of Fragaria vesca L. + Rhodiola rosea by 15.6% (0.84 mg/mL), sea buckthorn by 21.6% (0.80 mg/mL), Fragaria vesca L. by 28.7% (0.59 mg/mL GAE), the Fragaria vesca L. + Rosa canina mixture by 111.6% (0.46 mg/mL), Rosa canina by 111.9% (0.46 mg/mL), and Rhodiola rosea by 145.3% (0.40 mg/mL).

The mixture of Fragaria vesca L. + Rhodiola rosea, ranking second, surpasses sea buckthorn by 5.2%, Fragaria vesca L. by 42.3%, the Fragaria vesca L. + Rosa canina mixture by 82.9%, Rosa canina by 83.1%, and Rhodiola rosea by 112.1%. Sea buckthorn, in turn, showed a higher polyphenol content compared to Fragaria vesca L. by 35.4%, the Fragaria vesca L. + Rosa canina mixture by 74.0%, Rosa canina by 74.2%, and Rhodiola rosea by 101.6%.

The combined extracts demonstrate pronounced synergism: the triple mixture increases polyphenol content by 64.6% compared to Fragaria vesca L. and by 87% compared to Rhodiola rosea. The double mixture of Fragaria vesca L. + Rhodiola rosea increases the level by 42.3% relative to Fragaria vesca L.. In contrast,

the addition of Rosa canina to Fragaria vesca L. leads to a decrease of 22.2%, indicating an antagonistic effect in this combination.

Thus, the triple and double (Fragaria vesca L. + Rhodiola rosea) combinations form the top group (>0.83 mg/mL GAE), significantly outperforming the individual extracts. Sea buckthorn maintains a high position among the single-component samples, whereas Rosa canina and its mixture with Fragaria vesca L., as well as Rhodiola rosea, belong to the middle class (<0.46 mg/mL GAE). These results justify the use of multi-component phytomixtures including Rhodiola rosea and Fragaria vesca L. for the maximal extraction of polyphenolic antioxidants.



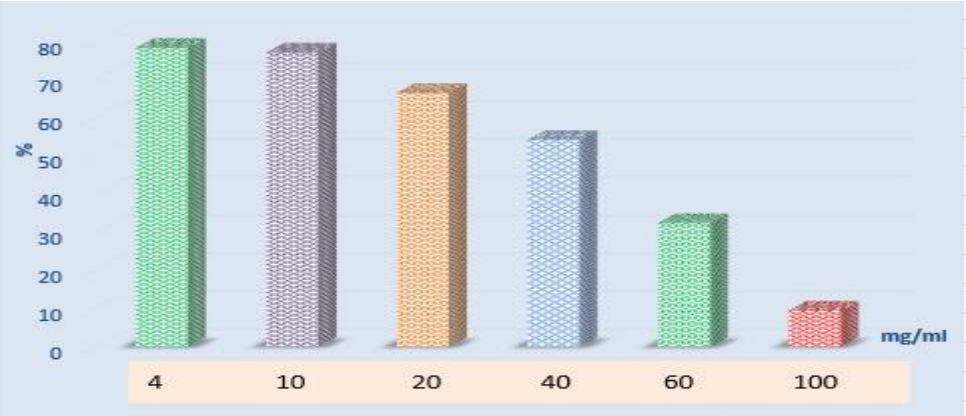
On the x-axis: extract concentration, mg/mL; on the y-axis: degree of erythrocyte osmotic hemolysis ($p \leq 0.005$)

Figure 2. Effect of the alcoholic extract of the phytomixture (Rhodíola rósea L.+Rosa canina+Fragaria vesca L.) on peroxide-induced hemolysis of animal erythrocytes

The diagram shows the effect of the alcoholic extract of the triple mixture (Rhodíola rósea L.+Rosa canina+Fragaria vesca L.), which has the highest polyphenol content (0.97 mg/mL), on peroxide-induced hemolysis of erythrocytes by H_2O_2. The effect of the triple phytomixture extract concentration on erythrocyte peroxide hemolysis is clearly dose-dependent. As the extract concentration increased from 4 to 100 mg/mL, the degree of erythrocyte hemolysis gradually decreased from 0.52 to 0.2. The phytomixture enhances erythrocyte peroxide resistance and reduces erythrocyte membrane hemolysis under in vitro conditions.

The high anti-hemolytic activity correlates with the maximum polyphenol content in the extracts of the triple phytomixture and confirms its strong antioxidant potential under in vitro conditions. The optimal concentration range is 60–100 mg/mL, at which hemolysis inhibition reaches 64.1–72.0%, respectively.

These data indicate the high polyphenol content in the triple mixture and substantiate its use as a membrane-stabilizing and antioxidant agent in protecting erythrocytes from oxidative damage. H_2O_2 contains oxygen in its molecule and, in the presence of reactive oxygen species in the medium, can act as an additional source of aggressive O_2 forms, which lead to damage of cellular biomolecules.



On the x-axis: Extract concentration, mg/mL; on the y-axis: degree of osmotic hemolysis ($p \leq 0.005$)

Figure 3. Effect of the triple phytomixture on erythrocyte osmotic hemolysis

As shown in Figure 3, the extract of the triple phytomixture is maximally effective in the osmotic resistance model, reducing hemolysis by 88.0% at 100 mg/mL. The critical effective range is 40–60 mg/mL, where resistance reaches 40.2%. The high efficacy correlates with the polyphenol richness and synergism of the components, positioning the phytomixture as a powerful natural osmoprotective agent with potential applications in the correction of hemolytic anemias and osmotic stress.

➢ 4.CONCLUSION

1. Aqueous-ethanolic (50%) extracts of Rosa canina, sea buckthorn, Fragaria vesca L. and Rhodiola rosea exhibit stronger antioxidant activity compared to their aqueous infusions.

2. All studied plants possess antioxidant activity to varying degrees. The highest content of polyphenolic compounds, expressed as gallic acid equivalents, was found in extracts of sea buckthorn and Rosa canina.

3. Combined extracts demonstrate a pronounced antioxidant effect, significantly surpassing that of individual extracts.

4. The extract of the triple phytomixture was most effective in models of osmotic and peroxide resistance, reducing hemolysis and increasing the resistance of animal erythrocyte membranes.

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Application of Pharmaceutical Preparations Derived from Beekeeping Products Produced in the Nakhchivan Autonomous Republic in Respiratory Diseases

Nakhçıvan Özerk Cumhuriyeti Koşullarında Üretilen Arıcılık Ürünlerinden Hazırlanan İlaç Preperatlarının Solunum Sistemi Hastalıklarında Kullanımı

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Abstract

The main aim of the conducted research was to evaluate the chemical composition, antioxidant, and antimicrobial activity of beekeeping products (honey, propolis, royal jelly, and bee pollen) collected under the ecological conditions of the Nakhchivan Autonomous Republic, and to determine their scientific basis for therapeutic use in respiratory system diseases. The study was carried out during 2023–2024 in the laboratories of the Faculty of Medicine and the University Clinic of Nakhchivan State University. Samples were collected from the Shahbuz and Ordubad regions, and their storage and analyses were performed in accordance with the national standard AZS 305:2017. The total phenolic content was determined by the Folin–Ciocalteu method (mg GAE/g), flavonoids by the $AlCl_3$ method (mg QE/g), and antioxidant activity by the DPPH method. Chemical profiles were determined by GC-MS (Agilent 7890B/5977A), and the main bioactive components were identified. Antimicrobial activity was assessed by the agar diffusion method against Staphylococcus aureus (ATCC 25923), Klebsiella pneumoniae (ATCC 13883), and Candida albicans (ATCC 10231). In the clinical part, a 14-day trial was conducted on 30 volunteers (15 with chronic bronchitis, 10 with pharyngitis, and 5 with post-viral cough) using honey, propolis extract, royal jelly–honey mixtures, and propolis aerosol; cough frequency, throat pain (VAS), CRP, ESR, and other parameters were evaluated.

Chemical analyses showed that beekeeping products from Nakhchivan have a high phenolic and flavonoid content: total phenol in propolis was 320 ± 25 mg GAE/g and flavonoid 110 ± 9 mg QE/g; in honey, phenol content was 250–400 mg GAE/g. In the DPPH test, the samples demonstrated 82–89% antioxidant activity. GC-MS analysis identified bioactive compounds such as caffeic acid, pinocembrin, kaempferol, ferulic acid, coumarin, and hesperetin. In antimicrobial tests, inhibition zones were 18–26 mm for S. aureus, 14–20 mm for K. pneumoniae, and 16–22 mm for C. albicans. After 14 days of clinical application, 60% of participants showed a reduction in cough frequency, 70% experienced decreased throat pain, CRP levels decreased by approximately 35%, and ESR by 20–25%. No serious side effects or severe allergic reactions were recorded.

The specific flora of Nakhchivan contributes to the high bioactivity of beekeeping products and the effectiveness of their formulations against respiratory pathogens. Laboratory and clinical results confirm the

antioxidant, antimicrobial, and anti-inflammatory effects of these products, showing their potential as promising natural agents for the prevention and adjunctive treatment of respiratory diseases. At the same time, the synergistic effect may be significant in managing microorganisms with increasing antibiotic resistance. In future studies, it is advisable to optimize dosage, conduct long-term safety (pharmacokinetic and toxicological) studies, and clarify molecular mechanisms. The clinical trials carried out will allow a more precise evaluation of the therapeutic potential of these products.

Keywords: Beekeeping Products, Propolis, Honey, Royal Jelly, Antioxidant, Antimicrobial, Respiratory System, Nakhchivan.

Naxçıvan Muxtar Respublikası Şəraitində Arı Vərəmumun Antımikrob Xüsusıyyətləri

Nahçıvan Özerk Cumhuriyeti Koşullarında Arı Propolisinin Antimikrobiyal Özellikleri

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Abstract

Vərəmum təmasda olduğu əşyalar və hava vasitəsilə mikroblarla yoluxur. Vərəmum mikroba qarşı tam təmiz olmasa da onun daxilindəki bioloji fəal maddələr hesabına öz-özünə təmizlənmə prosesi gedir.

2022-ci ilin payızında Arazboyu düzənlik, orta dağlıq və Zəngəzur dağlıq ərazilərindən götürülmüş vərəmum nümunələrinin antimikrob xassələrini sınaqdan keçirmək üçün mikrobları geniş istifadə olunan qidalı mühitə yerləşdirdik. Bunun üçün ət bulyonlu aqara 18-21 0C hərarətdə 0,03 qram vərəmum qırıntılarının nümunələri qatıldı. Nəzarət qrupunda hazırlanmış ət bulyonlu aqara isə vərəmum nümunələri qatılmadı. Bir gündən sonra aparılmış müşahidə zamanı müəyyən olundu ki, vərəmum qırıntıları olan qida mühitində mikroblar yetişmədi. Nəzarət qrupunun qida mühitində isə havadan oraya düşən mikroblar əvvəlcə bulyonu bulanıq şəklə saldılar və sonra isə mikroblar koloniya şəklində görünməyə başladılar.

Aparılmış təcrübə göstərir ki, Arazboyu düzənlik, orta dağlıq və Zəngəzur dağlıq ərazilərindən götürülmüş vərəmum nümunələrinin hamısı dezinfeksiya edicilik qabiliyyətinə malikdirlər.

Müxtəlif xəstəliklərin törədilməsində böyük rolu olan stafilokokklar təbiətdə geniş miqdarda yayılmışlar. Vərəmumun antimikrob fəallığını müəyyənləşdirmək üçün yüksək həssaslığa malik olan qızılı stafilokokkun ştammından (etalon ştammı -209) istifadə etdik.

Mikrobioloji və fiziki-kimyəvi metodlar vasitəsilə müxtəlif ərazilərdən götürülmüş vərəmum nümunələrinin fəallığı bir sıra qida mühitlərində yoxlanıldı.

Aparılmış təcrübələr göstərir ki, mikrob kulturaları bütün zonalardan götürülmüş nümunələrə qarşı həssas olmuşdur. Lakin, nümunələrin fəallığı bir-birinlə müqayisədə fərqli olmuşdur. Orta dağlıq və Zəngəzur dağlıq bölgələrindən götürülmüş vərəmum nümunələrinin mikrobəleyhi təsiri Arazboyu düzənlik nümunələri ilə müqayisədə bir qədər fəal olmuşdur.

Aqarda kağız diskdən istifadə etməklə diffuziya metodu ilə aparılmış təcrübələrdə vərəmum nümunələrinin təsirilə ləngimə zonası orta dağlıq ərazidə 13,1 mm, Zəngəzur dağlıq ərazidə 12,6 mm olmuşdur. Arazboyu düzənlik ərazidə isə zəif fəal (8,6-9,2 mm) ləngimə zonası müşahidə olunmuşdur.

Vərəmumun antimikrob fəallığını miqdarca müəyyənləşdirmək məqsədilə yetişdirmə metodlarından istifadə edilmişdir. Bu məqsədlə ət peptonlu aqarda vərəmumun 10%-li spirtli cövhərindən istifadə edilmişdir. Vərəmumun spirtli cövhərinin bakteriostatik norması mikrob kulturasında 0,09-2,7 mq/ml arasında olmuşdur.

Vərəmumun və uyğun bitki mənbəyinin antimikrob xassəsi müəyyənləşdirilərkən orta dağlıq ərazisində qovaq mənşəli vərəmumun yüksək antimikrob xassəsi ilə fərqlənməsi müşahidə olunmuşdur. Onun bakteriostatik qarışığının minimal norması 0,08-0,332 mq/ml olduğu halda, Arazboyu düzənlik ərazidə bu norma 0,56-dan 2,6 mq/ml arasında dəyişmişdir.

Sentyabr və may aylarında müxtəlif bölgələrdən götürülmüş vərəmum nümunələrinin fəallığının bakteriostatik qarışığının minimal norması 0,07-0,5 mq/mol arasında dəyişmiş və bu göstərici iyun ayı (0,31-1,23 mq/ml) ilə müqayisədə aşağı olmuşdur.

Bakteriosit norma müvafiq olaraq 6 dəfə bakteriostatik qarışığı üstələyir. Apardığımız təcrübələrdən görünür ki, vərəmumun spirtli (700-li) cövhərinin antimikrob fəallığı müxtəlif bölgələrdən və mövsümdən asılı olub bakteriostatik qarışığın minimal norması 0,08-2,6 mq/ml arasında dəyişir. Buradan görünür ki, bakteriostatik qarışığın minimal normasının dəyişkənliyi (5 yetişdirmədə) fəal maddələrin miqdarı yoxlanılmış nümunələrdən asılı olaraq bir-birindən fərqlənirlər.

Keywords: Vərəmum, mikrob, antimikrob, bakteriostatik

Phytocoenological Characteristics and Conservation of Rare Species Belonging to the Family Apiaceae Lindl. Distributed in Hasan Aliyev Zangazur National Park

Hasan Aliyev Zengezur Milli Parkı'nda yayılış gösteren Apiaceae familyasına (Apiaceae Lindl.) ait nadir türlerin fitosenolojik özellikleri ve muhafazaları

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Abstract

Zangazur National Park is one of the most important natural and ecological complexes of Azerbaijan, where numerous endemic and relict elements of the flora of the South Caucasus are preserved. The flora of this area, particularly the family Apiaceae Lindl., is of great ecological and phytogeographical importance. The orographic complexity of the Zangazur Range, the mosaic nature of the climate, the diversity of soils, and the high level of endemism have contributed to the formation of unique plant communities in this region. In this study, the bioecological, phenological, and phytocoenological characteristics of several rare species belonging to the Apiaceae family were investigated, including *Heracleum albovii* Mandenova (Albov's hogweed), *Prangos acaulis* (DC.) Bornm. (Stemless prangos), *Cachrys microcarpa* M. Bieb. (Small-fruited cachrys), *Ferula szovitsiana* DC. (Szovits' giant fennel), *Eryngium wanaturii* Woronow (Wanatur eryngo), *Grammosciadum platycarpum* (Boiss. et Hausskn.) Schischk. (Black-fruited grammosciadum), and *Dorema glabrum* Fisch. & C.A. Mey. (Glabrous dorema). The research was carried out between 2021 and 2024 in the Hasan Aliyev Zangazur National Park. For each species, up to ten populations were selected, and bioecological and phytocoenological indicators were determined. Phytocoenological studies were conducted according to the Braun-Blanquet (1964) methodology, recording dominance, coverage, and accompanying species within each 10×10 m plot. Phenological observations included the stages of flowering, fruiting, and seed formation. The studied species were mainly distributed at altitudes of 1500–3200 m, growing on mountain-meadow and brown soils. While *Heracleum albovii* and *Ferula szovitsiana* have relatively wide distribution ranges, *Eryngium wanaturii* and *Dorema glabrum* were recorded only in very limited areas. The obtained results indicate that the rare Apiaceae species in Zangazur National Park are fragmented and confined to restricted habitats. *Heracleum albovii* and *Dorema glabrum* were identified as the most sensitive species to anthropogenic impacts; overgrazing, road construction, and climate change significantly hinder their population regeneration. The populations of *Prangos acaulis* and *Ferula szovitsiana* are declining due to the collection of their aromatic resins and essential oils. Ethnobotanical surveys (based on local community interviews and traditional practices) revealed that many of these species are still used in folk medicine:

Heracleum albovii for treating colds, rheumatism, and subcutaneous inflammations; *Ferula szovitsiana* for respiratory and digestive disorders; *Dorema glabrum* as an anti-inflammatory agent; *Prangos acaulis* as animal feed and aromatic additive. These findings demonstrate that the loss of such species would result not only in ecological consequences but also in cultural and pharmacological losses.

Keywords: Zangazur, *Prangos acaulis*, *Heracleum albovii*, *Dorema glabrum*, rare species.

History Of The Study Of Free-Living İnfusoria And Amoebas İn Freshwater Basins Of The Nakhchivan Autonomous Republic

Nakhçıvan Özerk Cumhuriyeti Tatlı Su Havzalarında Serbest Yaşayan İnfuzorya ve Amiplerin İncelenme Tarihi

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Abstract

Man's exploration of the microscopic world to understand the diversity of the living world was an important stage in the development of science. With the invention of the microscope, man was able to observe for the first time creatures that are invisible to the naked eye but show signs of life characteristic of living organisms. Among protozoa, or simple unicellular organisms, infusoria and amoebas are considered one of the important components of the biosphere. They play an important role in the circulation of substances in aquatic ecosystems, in the decomposition of organic residues, and in the assessment of ecological processes as bioindicators. Infusoria and amoebas, most of which are bacteriophages, contribute to the biological purification of the environment by destroying a large number of bacteria, including pathogenic bacteria.

Ciliates are the most valuable indicators of the state of activated sludge and the degree of water pollution in biological wastewater treatment plants (A. Rogerson, 1980; N.N. Banina, 1981, 1983, 1984; N.V. Mamaev, 1989; N.N.R. Banina; N.N.190; Pratt, 2000; A.D. Zhirkova, 2004; Shadrin, 2004), as well as soils (Yu.G. Geltser, 1986; I.Kh. Alekperov, 1991; A.S. Yakovlev, 1991; Yu.A. Krayushkina, L.I.; 2004, 2006, 2008, etc.). Free-living protozoa distributed in the reservoirs of the autonomous republic have not been sufficiently studied. Scientific research work on free-living protozoa of various types of reservoirs located in various physical and geographical zones of the autonomous republic began in the 80s of the 20th century and was reflected in the first monograph for this region, “Ciliates of the reservoirs of the autonomous works are of a general nature and include a large element to familiarize readers with a group of protozoa that has not been studied before for the autonomous republic.

Thus, the research conducted by Professor I.Kh. Alekperov on this group of protozoa in the reservoirs and watercourses republic” (S. F. Likhachev, 1996)

Despite the research work of I.Kh. Alekperov on the territory of the autonomous republic, his

of the territories of the autonomous republic in recent decades remains insufficient. Therefore, any research conducted on infusoria in the autonomous republic is of extremely great scientific importance.

Keywords: İnfusoria, Amoeba, Free-Living, Water Body, Species

Study of Some Rare Tree, Shrub and Herb Species of Khizi District

Khizi İlçesindeki Bazı Nadir Ağaç, Çalı ve Otsu Bitki Türlerinin İncelenmesi

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Abstract

The crucial role of research in protecting the gene pool, restoring ecological balance, and preserving biodiversity, which are the main factors in studying the impact of global climate change on biodiversity, a pressing problem of the modern era, is enormous.

The territory of the Khizi-Absheron economic region of Azerbaijan is distinguished by its large forest biodiversity, landscape and ecosystem diversity: it is rich in forests, steppe (steppe), bozdags, subalpine and alpine ecosystems. From this point of view, studies have been conducted to determine the location of rare wild tree, shrub and herb species growing in the territories of the Khizi region, to study their ecological conditions, current status, degree of protection, etc.

In the Khizi region, the area (altitude) where the following species of forest dendroflora grow, Pyrus salsifolia Pall., P.vsevolodii Heideman , P. raddeana Woronov, Rosa komaroviii Sosn., Cotoneaster saxatilis Poyark, Prunus microcarpa C.A.Mey., Populus transcaucasica Jam.ex Grossh., .Iris caucasica Hoffm., Scilla hohenackari Fisch.et.,C/A.Mey. Muscari negelectum Guss., Ophrys caucasica Voronov ex Gossh., Orchis purpurea Huds., Orchis mascula (L.) L.and others, have been determined, photographed, herbarium and planting materials have been collected.

Based on the summarized results of the conducted research and referring to literature sources, 13 rare and medicinally important tree, shrub and herb species belonging to 5 families and 10 genera were identified in the forest areas of the Khizi region.

Keywords: Biodiversity, Gene Pool, Ecological Balance, Landscape, Ecosystem, Forests

Tropilaelaps – A New Threat to Beekeeping in Azerbaijan and Ways to Prevent it

Tropilaelaps – Azərbaycan Arıçılığında Yeni Bir Təhdid və Bununla Mübarizə Yolları

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Abstract

Tropilelapsois is an invasive disease of honeybee brood caused by mites belonging to the genus *Tropilaelaps* spp. In recent years, cases of tropilelapsois have been recorded in some beekeeping enterprises of the Republic of Azerbaijan. Currently, four species of the genus *Tropilaelaps* are recognized. Each species is associated with the Asian giant honeybee Apis dorsata. Two species (*T. clareae* and *T. mercedesae*) damage Apis mellifera honeybee populations. The other two species (*T. koenigerum* and *T. thaii*) are considered harmless to *Apis mellifera*, according to researchers. The detection and spread of tropilelapsois in Azerbaijan is raising alarm among beekeeping communities and public associations. Previously, it was believed that the long broodless period during winter provided effective protection against the spread of this mite. However, the situation is changing due to climate warming and drought. The uncontrolled import of bee colonies and packages from countries where tropilelapsois occurs also causes losses in apiaries. The danger of the invasion is further compounded by the fact that veterinarians, amateur and professional beekeepers have not previously dealt with this disease, cannot properly identify it, and therefore have limited capacity to confirm the diagnosis and implement treatment-preventive measures. Tropilelapsois has been included in the "List of contagious animal diseases subject to quarantine and restriction measures" under the name "bee mite Tropilaelaps" and is listed in the section of bee diseases.

The necessary measures aimed at preventing the spread of tropilelapsois in Azerbaijan include:

- Strict adherence to quarantine measures when purchasing bee colonies, bee packages, and queen bees, especially when importing them from neighboring countries. If quarantine rules are not followed, the import of bees from countries affected by tropilelapsois should be completely prohibited.
- Relevant laboratories of the Veterinary and Food Safety Agency must be provided with normative-methodical documents to confirm the diagnosis.
- The biology of Tropilaelaps spp. mite populations in Azerbaijan should be studied, and methods of treatment and prevention of this disease should be developed.
- The residue levels of medicines used against Tropilaelaps spp. mites in beekeeping products should be determined.

Keywords: Azerbaijan, Tropilelapsois, Beekeeping, Diagnosis, Prevention

The Impact of Helminthiasis on Livestock Productivity in the Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti'nde helmintiyazis hastalığının hayvan verimliliği üzerindeki etkisi

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Abstract

The study investigates the prevalence of helminth infections in livestock under the conditions of the Nakhchivan Autonomous Republic, their causative agents, mechanisms of impact, and negative effects on agricultural productivity. Helminths (nematodes, trematodes, and cestodes) are among the most widespread parasitic organisms in livestock, causing significant damage to their physiological functions and productivity indicators. Observations and laboratory analyses revealed that helminths, once inside the host organism, mainly affect the digestive organs - the gastrointestinal tract, liver, and bile ducts. As a result, metabolic disorders occur, nutrient absorption weakens, and anemia and general weakness are observed. Helminth infections suppress the immune system, making animals more susceptible to other infectious diseases. In chronic cases, reproductive system functions are disrupted, fertility decreases, and milk, meat, wool, and egg productivity decline both quantitatively and qualitatively. The results showed that in infected animals, milk yield decreased by 20-40%, body weight by 25-30%, and wool production by 15-25%. Moreover, the condemnation and disposal of damaged internal organs, particularly the liver and lungs, lead to significant economic losses on farms. The findings confirm the widespread occurrence of helminth infections among livestock and their considerable negative impact on productivity. Therefore, the study of helminthiasis, along with the development and strengthening of preventive and control measures, is of great scientific and practical importance for improving the quality and quantity of livestock production in the Nakhchivan Autonomous Republic.

Keywords: Helminthiasis, Nematodes, Trematodes, Cestodes, Animals, Productivity

First Aid for Bee Stings: Safe and Effective Assistance Measures

Arı Sokması Sırasında İlk Yardım: Güvenli ve Etkili Müdahale Yöntemleri

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Abstract

Although a bee sting is a common occurrence in daily life, it can sometimes cause serious allergic reactions. This article explains the importance of proper first aid measures in the event of a bee sting. The most common symptoms after a bee sting include pain, swelling, and redness. However, in some cases, life-threatening conditions such as anaphylaxis, a severe allergic reaction, may occur. The article describes the first aid process step by step, including checking the sting site, removing the bee stinger, cleaning the wound, applying cold compresses, and using appropriate medications. In addition, in cases where an anaphylactic reaction develops, the administration of an epinephrine injection and immediate access to emergency medical care are of vital importance. This paper demonstrates how timely intervention during a bee sting can help save lives.

Keywords: Bee Sting, First Aid, Allergic Reaction, Anaphylaxis, Epinephrine, Emergency Care.

POSTER PRESENTATION PAPERS

Uşaq Xəstəliklərində Arı Çiçək Tozunun (Pollenin) Tətbiqi Və Terapevtik Perspektivləri

The Application And Therapeutic Perspectives Of Bee Pollen In Pediatric Diseases

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Abstract

Bee pollen is a bee-collected, plant-derived product with high nutritional density and a complex profile of bioactive compounds. It contains proteins and free amino acids, essential fatty acids, minerals, vitamins, enzymes, and polyphenols such as flavonoids, while its exact composition varies with botanical and geographical origin and with post-harvest handling. Because pediatric practice frequently encounters nutritional inadequacy, recurrent respiratory infections, functional gastrointestinal complaints, and slow convalescence after acute illnesses, bee pollen has been proposed as an adjunct nutritional and supportive intervention. This paper provides a narrative overview of the chemical characteristics of bee pollen, summarizes the main pathways through which it may influence child health (nutrient repletion, antioxidant defense, and immunomodulation), and discusses practical considerations and safety limitations for pediatric use.

Materials were identified through a targeted search of major biomedical databases and recent review papers, complemented by key methodological publications on pollen standardization and quality control. The evidence base is dominated by compositional studies and adult or mixed-age clinical observations, with fewer controlled trials specifically designed for children. Across available reports, bee pollen supplementation is most consistently associated with improved appetite and weight gain in undernourished individuals, support of iron intake and a potential reduction in anemia risk, and an overall improvement in subjective well-being during recovery. Mechanistic data suggest that phenolic compounds contribute to antioxidant activity and may modulate inflammatory signaling, which could partly explain reported benefits in recurrent upper respiratory tract infections and some functional digestive disorders. However, clinical heterogeneity and variability of pollen products limit the strength of conclusions.

Safety remains the critical boundary for pediatric application. Bee pollen can trigger hypersensitivity reactions, particularly in children with atopy, allergic rhinitis, asthma, or known pollen/bee-product allergy. Therefore, patient selection, cautious dose escalation, and clinical supervision are necessary. Bee pollen should not be used in infants under 1 year of age and must not replace evidence-based therapy; it should be considered only as a complementary measure within a broader nutritional and medical plan. In conclusion,

bee pollen is a promising supportive option in pediatrics, but well-designed, product-standardized, pediatric randomized trials are required to clarify efficacy, optimal dosing, and risk profiles In addition, microbiological quality (including moisture content and storage conditions) and possible contamination with environmental residues are relevant for children, who may be more vulnerable to gastrointestinal adverse effects. Product selection from reputable producers, appropriate storage, and clear labeling are therefore essential prerequisites for clinical use..

Keywords: Apitherapy; Bee pollen; Pediatrics; Immunity; Nutrition; Child health

1. INTRODUCTION

Bee pollen (also referred to as flower pollen collected by honeybees) is a granular product formed when bees pack pollen grains with nectar and salivary secretions. It has attracted interest as a functional food because it combines macronutrients with micronutrients and diverse phytochemicals. Analytical studies show that the nutritional and phenolic profile of bee pollen depends strongly on botanical source, season, and regional ecology; therefore, standardization and quality control are essential for research and clinical translation (Campos et al., 2008; Morais et al., 2011).

In pediatrics, clinicians frequently manage nutritional deficiencies, poor appetite, iron deficiency anemia, and recurrent respiratory infections. Families also seek natural adjuncts that may support recovery and immune function. Bee pollen has been proposed as a complementary product in these settings due to its protein content, micronutrients, and antioxidant potential (Komosinska-Vassev et al., 2015; Khalifa et al., 2020). At the same time, the risk of allergic reactions—especially in atopic children—requires careful assessment before use (Denisow & Denisow-Pietrzyk, 2016). The aim of this paper is to summarize the composition of bee pollen, discuss potential pediatric applications, and highlight safety considerations and research gaps.

2. MATERIALS AND METHODS

This article is a narrative review. A focused literature search was performed using combinations of the terms “bee pollen”, “pediatrics/children”, “nutrition”, “immunity”, “respiratory infection”, “gastrointestinal”, and “allergy”. Priority was given to recent peer-reviewed reviews and methodological papers on pollen composition and standardization, as well as clinical and observational reports describing therapeutic use of bee pollen or closely related bee products.

Included sources were screened to extract information on (i) chemical composition and variability of bee pollen, (ii) biological activities relevant to child health, (iii) reported clinical applications (nutritional support, immune support, gastrointestinal effects), and (iv) contraindications and adverse effects. Because controlled pediatric trials are limited, mechanistic and adult/mixed-age data were used to inform plausible pathways while clearly emphasizing pediatric safety boundaries.

3. RESULTS AND DISCUSSION

3.1. Composition and biological properties

Bee pollen typically provides proteins and amino acids, carbohydrates, lipids, vitamins (including A, C, E and B-complex), and minerals such as iron, zinc, and selenium. It also contains phenolic acids and flavonoids that contribute to antioxidant activity and may influence inflammatory pathways (Komosinska-Vassev et al., 2015; Khalifa et al., 2020). Because composition varies widely, laboratory characterization and adherence to analytical standards are important when comparing studies or selecting products for clinical contexts (Campos et al., 2008).

3.2. Nutritional deficiencies, appetite, and growth support

Nutritional inadequacy and selective eating are common pediatric challenges. The protein fraction and micronutrient content of bee pollen provide a rationale for its use as a dietary adjunct. Clinical observations have reported increased appetite, weight gain, and improved general condition during supplementation, which may be relevant in undernutrition or convalescence (Denisow & Denisow-Pietrzyk, 2016; Khalifa et al., 2020). Iron contribution may support strategies aimed at reducing anemia risk, although it should not be considered a stand-alone treatment for confirmed iron deficiency.

3.3. Immune modulation and recurrent respiratory infections

Bee pollen has been described as having immunomodulatory and antimicrobial properties, largely attributed to polyphenols and other bioactive constituents (Komosinska-Vassev et al., 2015; Khalifa et al., 2020). In pediatric practice, it is most often suggested as an adjunct in children with frequent upper respiratory tract infections. However, robust pediatric randomized evidence is scarce, and benefits reported in clinical practice should be interpreted cautiously. Broader evidence on bee products (e.g., honey, propolis, royal jelly) supports the plausibility of anti-inflammatory and antioxidant effects, but these cannot be directly extrapolated to standardized pediatric outcomes (Pasupuleti et al., 2017).

3.4. Gastrointestinal effects

A balanced gut microbiota contributes to child growth and immune maturation. Some sources suggest that bee pollen may exhibit prebiotic-like effects and support digestive function, potentially helping functional gastrointestinal complaints. Nevertheless, product quality and microbiological safety are important, because pollen can carry environmental microorganisms and its stability depends on moisture and storage (Morais et al., 2011).

3.5. Allergy risk and contraindications

The most important limitation of bee pollen in children is hypersensitivity. Reported reactions include urticaria, pruritus, angioedema, wheezing, and, rarely, severe systemic reactions. Risk is higher in children with a history of atopy, allergic rhinitis, asthma, or known pollen/bee-product allergy (Denisow & Denisow-Pietrzyk, 2016). For these patients, bee pollen should generally be avoided unless allergy evaluation and medical supervision are available.

3.6. Practical considerations and product-related limitations

Bee pollen should not be given to infants under 1 year of age. If used in older children, dosing should be individualized by a pediatrician and introduced gradually. Because fermentation and processing can alter bioactivity and safety, clinicians should consider product form and evidence supporting the specific preparation (Mărgăoan et al., 2019). Finally, evidence from animal supplementation studies suggests biological activity, but translation to pediatric dosing and outcomes requires caution (Attia et al., 2014). In Azerbaijan, apitherapy is discussed as a complementary approach, yet standardized clinical protocols and large-scale pediatric studies remain limited (Azeri, 2019; Aliyev & Quliyeva, 2021).

4. CONCLUSION

Bee pollen is a nutrient-dense natural product with antioxidant and potentially immunomodulatory properties. In pediatrics it may be considered as a complementary dietary support in selected cases of poor appetite, nutritional inadequacy, and recurrent infections, but the evidence base is limited by product variability and a shortage of well-designed pediatric trials. Allergy risk is the major safety concern; therefore, careful patient selection and medical supervision are essential, and use in infants under 1 year should be avoided. Future research should focus on standardized products, clearly defined pediatric outcomes, and rigorous safety monitoring.

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Biodegradation of NSAIDs by Stutzerimonas stutzeri Fad2: A Sustainable Biotechnological Strategy

NSAID'lerin Stutzerimonas stutzeri Fad2 Tarafından Biyobozunumu: Sürdürülebilir Bir Biyoteknolojik Yaklaşım

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Abstract

The misuse of pharmaceuticals represents a common and significant public health issue worldwide, with more severe implications in developing and under developed countries. Aspirin (acetylsalicylic acid), a non-steroidal anti-inflammatory drug (NSAID), has emerged as an environmental contaminant due to its widespread and uncontrolled use, posing a serious threat to aquatic ecosystems (Spina et al., 2013). Similarly, ibuprofen (2-methyl-4-[2-methylpropyl] phenylacetic acid), one of the most frequently used NSAIDs globally, is commonly prescribed for its analgesic and anti-inflammatory properties; however, its environmental residues pose notable ecotoxicological risks. Another widely used non-steroidal analgesic, ketoprofen (C16H14O3), has also been identified as a compound with potential threats to ecosystems, thereby necessitating eco-pharmacovigilance (Wang et al., 2018).

In this study, *Stutzerimonas stutzeri* Fad2 was employed to evaluate the biodegradability of selected NSAIDs. During the experimental phase, the drugs were added at a final concentration of 100 mg/L to MSM medium supplemented with 1 g/L glucose as an additional carbon source. Following incubation at 37 °C, samples were subjected to HPLC analysis. The results revealed that aspirin, ibuprofen, and ketoprofen were significantly degraded by *Stutzerimonas stutzeri* Fad2.

In conclusion, the findings demonstrate the potential of this bacterium as a biological tool to mitigate NSAID-induced environmental pollution. This approach offers a promising biotechnological strategy to reduce the adverse impacts of pharmaceutical waste on ecosystems.

Keywords: Aspirin, ibuprofen, ketoprofen, *Stutzerimonas stutzeri* Fad2, biodegradation, HPLC

Genetic Diversity Study of Lentil (Lens Culinaris) Accessions Using Rapd Markers

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Abstract

Lentil, one of the earliest domesticated members of the Fabaceae family, occupies an important place in the human diet due to its high protein digestibility rate (86%). In line with the priority directions set by programs aimed at the development of the lentil gene pool, particular importance is attached in our country to the preliminary evaluation of genotypes of different origins, the selection and multiplication of accessions better adapted to local soil–climatic conditions and resistant to stress factors, as well as their ex situ conservation. The differentiation of genotypes is essential for the effective implementation of these processes and also provides a foundation for more reliable seed preservation in gene banks and the efficient use of genetic resources in breeding programs. In this study, 30 cultivated lentil accessions introduced from ICARDA were used. Field characterization of lentil genotypes was carried out under controlled experimental conditions (irrigated). The sowing scheme consisted of a 45 cm inter-row spacing, a row length of 2 m, and 5 cm between plants. Seeds were sown at a depth of 5–7 cm in moist soil. After full maturity, 10 plants were uprooted from each accession and subjected to structural analysis based on nine major yield traits (plant height, number of fertile branches, number of pods per plant, number of seeds per plant, 100-seed weight, number of seeds per pod, and pod width and length), followed by comparative evaluation. Plant height ranged from 28 to 63 cm, the number of fertile branches from 2 to 3, the height of the first pod from 16 to 29 cm, the number of pods per plant from 35 to 95, 100-seed weight from 6.0 to 9.8 g, and yield per square meter from 87.2 to 461.1 g. For molecular analysis, 3 g of fresh leaf material was collected from each genotype, ground into powder using liquid nitrogen, and stored in tubes for DNA extraction. As a result, 36 bands were amplified using 10 RAPD primers, of which 27 were polymorphic. The band sizes ranged between 200 and 650 bp, with a genetic diversity index value of 0.67. Based on marker analysis, cluster analysis revealed four main clusters and 12 sub-clusters according to genetic similarity. Genotypically, Flip 20110-36 and Flip 2011-34, Flip 2011-32 and 10942, as well as 10932 and Flip 2011-29, were evaluated as the most genetically distant, while Flip 2011-35 and Flip 2011-37, Flip 2011-48 and Flip 2011-54, and 10932 and 10937 were identified as the closest genotypes.

Keywords: lentil, polymorphism, cluster, ISSR marker, yield components

Medicinal Significance of Rosa canina L. Species in the Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti'nde Rosa canina L. Türünün Tıbbi Önemi

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Abstract

The Nakhchivan Autonomous Republic is an exceptionally rich and inexhaustible natural reservoir of medicinal plants. Preserving this unique biological resource, enhancing its diversity and reserve potential, and ensuring its proper, efficient, and sustainable utilization are of considerable scientific and practical importance. Among the numerous medicinal plants distributed in the regional flora, *Rosa canina L*. (dog rose) holds a prominent position and has been widely used in traditional medicine for centuries.

In modern times, due to the side effects of synthetic drugs and the difficulties of adaptation in the human organism, the study and application of biologically active, plant-derived natural compounds have become increasingly relevant. The fruits and other organs of *Rosa canina* are rich in biologically active compounds, including ascorbic acid, flavonoids, phenolic compounds, and carotenoids. These constituents play a significant role in strengthening the human immune system, restoring metabolic balance, and preventing various diseases.

Therefore, investigating the distribution, phytochemical composition, and medicinal significance of *Rosa canina L*. in the flora of Nakhchivan is crucial both for the efficient use of natural resources and for the scientific development of traditional medicine. The species serves not only as a natural source of medicinal raw materials but also as a valuable dietary supplement. Its fruits, leaves, and flowers are abundant in bioactive compounds. Phytochemical studies have shown that R. canina fruits contain high levels of ascorbic acid, flavonoids (quercetin, rutin), phenolic compounds, carotenoids, and organic acids, which exhibit strong antioxidant, anti-inflammatory, immunostimulatory, and capillary-strengthening effects.

In apitherapy, the combined use of *Rosa canina* extracts with bee products (honey, propolis, royal jelly) enhances the body's resistance to oxidative stress, accelerates tissue regeneration, and regulates immune responses through additive effects. In particular, the application of dog rose fruit extract dissolved in honey increases the bioavailability of vitamin C and flavonoids, contributing to the prevention of respiratory and cardiovascular diseases.

The traditional use of this species by the local population (for colds, anemia, liver, and kidney disorders) confirms its pharmacological potential.

Consequently, the phytochemical composition and biological activity of *Rosa canina L.*, especially in combination with bee products, open new possibilities for additive effects in apitherapy. Further comprehensive studies in this area could provide a scientific basis for the development of natural, biologically active preparations.

Keywords: *Rosa canina* L., Apitherapy, Phytochemical Composition, Biological Activity, Medicinal Plants

Medicinal Significance of Satureja macrantha *C.A.Mey. (Lamiaceae Lindl.) Species Distributed in the Territory of Nakhchivan Autonomous Republic*

Nahçıvan Özerk Cumhuriyeti'nde Yayılış Gösteren Satureja macrantha *C.A. Mey. (Lamiaceae Lindl.) Türünün Tıbbi Önemi*

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Abstract

Satureja macrantha C.A.Mey., a perennial, essential oil-bearing plant belonging to the family *Lamiaceae Lindl*., is mainly distributed in dry xerophytic soils and screes on rocky mountain slopes. This species holds considerable importance not only from a floristic perspective but also due to its biologically active compounds, which confer significant pharmacological and medicinal value. Particularly, the essential oils of this plant exhibit antibacterial, anti-inflammatory, and antioxidant properties, indicating its potential for the prevention and treatment of various diseases.

The main objective of this study was to investigate the bioecological characteristics, traditional medicinal uses, and pharmacological significance of Satureja macrantha in the Nakhchivan Autonomous Republic. The research incorporated both field observations and laboratory analyses, alongside the collection of ethnobotanical data from the local population.

Results revealed that the biologically active substances in Satureja macrantha possess antibacterial, antioxidant, and anti-inflammatory effects. In traditional medicine, the plant is primarily used for treating colds, coughs, gastrointestinal disorders, and skin infections. Locals commonly apply the plant as an infusion or ointment.

The findings suggest that Satureja macrantha has a high pharmacological potential, offering broad opportunities for inclusion in medicinal formulations. The biological activity of its essential oils positions the species as a natural antiseptic and anti-inflammatory agent. Additionally, it is imperative to study the conservation and cultivation potential of this species as a genetic resource.

In conclusion, Satureja macrantha C.A.Mey. represents a promising species in the fields of alternative medicine and pharmacology. Future in-depth pharmacological and clinical studies on this plant could provide a basis for its practical medical application.

Keywords: Satureja Macrantha, Medicinal Plants, Ethnobotany, Pharmacological Effect, Traditional Medicine.

The healing properties of processed products from some indigenous grape varieties of the Nakhchivan Autonomous Republic of Azerbaijan

Azərbaycanın Naxçıvan Muxtar Respublikasının bəzi aborigen üzüm sortlarının emal məhsullarının müalicəvi xüsusiyyətləri

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Abstract

The article outlines the benefits of treatment with folk remedies, especially treatment and moderate nutrition with technological products of grapes, such as sultanas, meviz and doshab (bekmez - grape honey). Kishmish and meviz are dried products of grapes, kishmish from varieties without family members, and meviz is also dry products only from varieties with seeds. For centuries, these products have been dried by different methods from native grape varieties of Azerbaijan. Doshab is a canning product, cooked by a special method, also from various grape varieties of Azerbaijan.

With high nutritional value and medicinal properties, these products are widely consumed both in Azerbaijan and abroad. On the basis of our scientific research, the organoleptic characteristics of dry products and doshab, which were made from some native grape varieties of the Nakhchivan Autonomous Republic of Azerbaijan, are given.

Keywords: plant, grape, variety, medicinal properties, technology, doshab, dried product, kishmish, meviz

INTRODUCTION

Grapes (fresh and dried) and a number of their processed products (kishmish, meviz, doshab, etc.) are used in folk medicine for various diseases [5]. The varietal composition of grapes in the Nakhchivan Autonomous Republic includes more than 200 varieties, and more than 40 of them are used for drying and for the production of other technological products [6].

Grapes with delicate berries are called table varieties and are highly valued in this respect [7, 8]. Undoubtedly, grapes grown in all regions of the world, especially table grapes, possess certain nutritional, dietary, and medicinal properties in one form or another. As is known, to ensure proper nutrition and human health, not only calories but also vitamins, other biologically active substances, mineral salts, organic acids, and other

components that regulate important physiological and biochemical processes must be balanced in the diet [12, 16]. From this point of view, the inclusion of fresh grapes with high nutritional value and medicinal properties, as well as industrial products made from them, in the human diet is of great importance. The modern era promotes treatment with natural remedies, especially medicinal plants, fruits and vegetables, as well as their processed products, since organisms are sufficiently "saturated" with chemical substances and diseases have become more resistant to them. In this regard, treatment with natural remedies is not only effective but also relevant, as they are easily accessible [14].

Thus, fully ripe grapes contain 65–85% water, up to 30% sugars (glucose, fructose, and a small amount of sucrose), 0.5–1.4% organic acids, and 0.15–0.90%. They also contain protein substances; 0.3–1.0% pectin substances; 0.3–0.5% potassium, calcium, phosphorus, iron, and other minerals; vitamin A (carotene) 0.02–0.12 mg; vitamin B_1 (thiamine) 0.25–1.25 mg; small amounts of vitamin B_2 (riboflavin); vitamin C (ascorbic acid) 4.3–12.2 mg per 100 g of fresh grapes; and very small amounts of vitamins B_6 and P (citrin). One kilogram of grapes contains 900 kcal. However, this value is 400 kcal in 1 kg of apples and 500 kcal in pears [13].

Hippocrates, his disciple Asclepiades, Pliny, and some Arab physicians in ancient times (Abu Bakr al-Razi, Avrellon), as well as Riverus in the Middle Ages, the great physician Abu Ali ibn Sina, and the prominent Azerbaijani physician of the 18th century, Muhammad Yusif Shirvani, provided valuable information in their works on the medicinal properties of grapes and dietetics [14].

MATERIALS and METHOD/METHODS ETC

For the study, meviz samples were prepared from the grape varieties Ag Aldara and Bandi, Duzali, Xanimi, Nakhshabi, Sari Aldara, Shahangiri, and Talibi. Doshab samples for the study were obtained from the grape varieties Ag Khalampur, Xatini, and Shakhtakhtı. All grape varieties are grown in the Botanical Garden of the Institute of Bioresources, and the relevant analyses were carried out in the "Biochemical Research" and "Horticulture, Vegetable Growing, and Viticulture" laboratories. Grape drying was carried out using the stabel method, which is currently considered the most effective by specialists [3, 4], as well as the methods of V.M. Guliyev and S.A. Najafov [1, 2, 11]. The method of obtaining doshab is as follows: doshab is prepared by boiling and concentrating the berry juice (traditional method).

The methods for determining sugar content, acidity, and moisture were carried out using the Bertrand method [9]. Color, clarity, bouquet, and product specificity were determined according to the method proposed by G. S. Morozova. Tasting, organoleptic, and other indicators were evaluated by us using the method proposed by G. S. Morozova, in accordance with the 100- and 10-point scoring systems [10].

Experimental part. Kishmish and meviz are very high-calorie food products and, under normal conditions, make it possible to use grapes throughout the year. Many scientists and researchers believe that the Nakhchivan Autonomous Republic is the region with the most favorable natural conditions for the production of kishmish and meviz not only in the Republic of Azerbaijan but also throughout the CIS countries (high-quality drying can be carried out in the open air using solar energy without any additional costs) [5].

In the Nakhchivan Autonomous Republic, meviz is traditionally prepared mainly from the Hanaqırna, Ag Aldara, and Nabi grape varieties. Expanding the range of grape varieties used for the production of meviz and doshab is a topical issue. In order to broaden the assortment of existing varieties, dried samples were prepared from the table and technical varieties “Duzali,” “Xanimi,” “Nakhshabi,” “Sari Aldara,” “Shahangiri,” and “Talibi,” and their chemical composition and organoleptic qualities were compared with dried products from standard varieties (Ag Aldara and Bandi).

The studied table and technical grape varieties, especially Duzali, Xanimi, Nakhshabi, and Shahangiri, are not inferior to, and in some cases even surpass, the standard Ag Aldara and Bandi varieties in terms of dry product yield, chemical composition, and organoleptic indicators. The expansion of these grape varieties will further increase meviz production in the autonomous republic (Table 1).

Table 1. Organoleptic evaluation of dried products made from studied underutilized grape varieties suitable for drying (using the 100-point system)

№	**Grape varieties**	**Evaluation criteria**							
		Color of the dried product	**Sweetness (%)**	**Acidity (g/dm³)**	**Clolor (1-20)**	**Taste and aroma (10-30)**	**Consistency of the pulp and skin (10-30)**	**Specific characteristics of the meviz type (1-20)**	**Total score**
1.	Ag Aldara (st, sort)	Light brown	65,26	1,89	18	20	23	18	79
2.	Bandi (st, sort)	Light yellow	67,52	1,72	13	21	24	19	78
3.	Duzali	Light yellow	69,43	1,67	18	24	24	20	86
4.	Xanimi	Light yellow	67,12	1,63	18	23	24	19	84
5.	Nakhshabi	Golden yellow	71,47	1.59	19	23	25	20	87

6.	Sari Aldara	Light yellow	64,57	1,82	18	22	23	20	83
7.	Shahangiri	Light yellow	72,16	1,74	18	22	24	19	83
8.	Talibi	Light yellow	65,62	1,76	18	21	23	19	81

Dried grapes (Figures A, B) are valuable food products with high taste, nutritional value, and certain medicinal properties. They contain easily digestible sugars (including glucose and fructose) – 65–80%, nitrogenous substances – 1.59–1.84%, and organic acids [15,16].

Doshab (grape molasses) is prepared as follows – berry juice is boiled and concentrated (traditional method). Samples of doshab were prepared from the Ag Kalampur, Xatini, and Shahtakhtı grape varieties and evaluated based on their organoleptic characteristics.

Table 2. Organoleptic evaluation of the doshab product (According to G.S. Morozova's 10-point system)

№	**Varieties**	**Product Name**	**Evaluation criteria**					
			Transparency (0.1–0.5)	**Color (0.1–0.5)**	**Bouquet (1.0–3.0)**	**Taste (1.0–5.0)**	**Product Specificity (0.1–1.0)**	**Total Score**
1.	Ag Kalampur	doshab	0,4	0,4	2,4	4,0	0,7	7,9
2.	Xatini	doshab	0,4	0,4	2,3	3,9	0,7	7,7
3.	Shahtakhtı	doshab	0,4	0,4	2,6	4,1	0,8	8,3

As seen from Table 2, the prefabricated products received quite high scores in terms of organoleptic qualities. This suggests that the less common grape varieties selected for doshab production can be considered very useful for this purpose. Grape doshab (bekmez – grape molasses) is one of the most popular processed products made from fresh grapes (Fig. B).

A.

B.

C.

Figure 1. Processed grape products: A – Kishmish (seedless dried product), B – Grape doshab,

C – Meviz (seeded dried product)

The biologically active substances in doshab include macro- and microelements, as well as vitamins from the B, P, Ca, Mn, B_5, and B_6 groups [16]. Meviz contains vitamins B, F, Ca, Mg, and K [16]. Both dried products and doshab are used for the treatment of many diseases and, in addition, are environmentally clean products.

CONCLUSION

In addition to the standard Ag Aldara and Bandi varieties used for dried product (meviz) production, it is advisable to use the less common grape varieties studied, especially Duzali, Xanimi, Naxshabi, and Şahangiri. The chemical composition and organoleptic qualities of the dried products from these varieties are superior, with scores of 8.6, 8.4, 8.7, and 8.7 respectively (based on a 10-point system). Increasing the cultivation of these less common grape varieties will enable the expansion of meviz production in the autonomous republic. These varieties can compete well with traditional drying varieties such as Hanaqirna (which ripen from early September to early December).

1. Doshab products made from the less common grape varieties Ag Kalampur, Xatini (Nakhchivan), and Shahtakhti received relatively high scores for their organoleptic qualities, with ratings of 7.7, 7.7, and 8.3 respectively on a 10-point scale. They can also compete with traditional varieties used for doshab production, such as the conventional white grape.

2. Thus, it can be concluded that the selected varieties studied for meviz and doshab production are very useful for their intended purpose, and the scale of their cultivation should be expanded.

3. Dried products and doshab can be stored and used throughout the year without loss, making them strategic products for the country's food security.

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Protein and Amino Acid Indicators of Synthetic Wheat Genotypes under Irrigated and Rainfed Conditions

Sulama ve Yağmurlama Koşullarında Sentetik Buğday Genotiplerinin Protein ve Amino Asit Göstergeleri

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Abstract

Synthetic wheat, which combines the genetic potential of the Aegilops L. genus - the closest relative of wheat - is widely used in the programs of leading breeding centers worldwide. This allows for a significant expansion of genotypic diversity and the development of new wheat forms resistant to biotic and abiotic stresses. In recent years, various research studies have been conducted in this direction in our country as well. The present study was conducted under irrigated conditions at the Absheron Regional Experimental Station and under drought conditions at the Jalilabad Regional Experimental Station. The research utilized 68 synthetic wheat genotypes and the variety "Akinci-84" (Azerbaijan) as a standard. In the samples, the content of total protein (Kjeldahl method), the essential amino acids lysine (S. Museyko and A. F. Sisoyeva method) and tryptophan (A. Ermakov and N. R. Yarosh method) were determined, and their yield potential (per 1 m²) was investigated. Based on three-year average data, under irrigated conditions, protein content ranged from 11.8% to 15.6%, lysine content from 1.50% to 2.48%, and tryptophan from 0.49% to 0.87%. Under drought conditions, however, protein varied from 9.1% to 18.7%, lysine from 0.96% to 2.78%, and tryptophan from 0.52% to 1.09%. The research established that, compared to the 'Akinci-84' variety, 15 synthetic wheat genotypes under irrigated conditions and 19 under drought conditions were distinguished by higher protein indicators. Under irrigated conditions, the highest result was recorded in the Japanese-origin genotype 65 J-16 (15.6%). Under drought conditions, however, the highest protein indicator was observed in the Japanese-origin genotype 62 J-12 (17.8%). In general, our findings, which align with several previous studies, demonstrated that protein content is frequently higher under drought conditions. This phenomenon can be attributed to the more intensive accumulation of carbohydrates during the grain-filling period under irrigation, which increases grain weight but consequently dilutes the protein concentration. The conducted research led to the identification of synthetic wheat genotypes distinguished by high biochemical parameters. These genotypes represent a promising source for breeding programs aimed at developing new varieties and forms with superior quality characteristics.

Keywords: Synthetic wheat, Protein, Amino acid, Lysine, Tryptophan

Mycological Monitoring of Some Medicinal Plants Distributing in the Gadabay Region

Gadabay Bölgesinde Rast Gelinen Bazı Tıbbi Bitkilerin Mikolojik Araşdırılması

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Abstract

Mycological monitoring of medicinal plants is carried out in many countries of the world, but local studies in this direction, especially the study of specific flora and mycoflora relationships in regions, are not widespread enough. Although the Gadabay region has rich vegetation, the species composition and distribution characteristics of microscopic fungi growing on medicinal plants growing in this area have not been systematically studied so far. Therefore, the study of the mycological composition of some medicinal plants growing in natural conditions in the Gadabay region is relevant both from a scientific and practical point of view. The results of the study can contribute to improving the sanitary and safety indicators of these plants, the formation of proper collection and storage technologies, and, in general, to ensuring safer use in folk medicine and pharmacology. The main objective of the study is to study the microscopic fungal (mycoflora) species growing on some medicinal plants (*Urtica dioica* L., *Mentha longifolia* (L.) L., *Stellaria media* L., *Alcea rosea* L., *Rosa laevigata* Michx., *Rumex acetosa* L., *Thymus collinus* M. Bieb., *Hypericum peforatum* L., C*ephalaria gigantea* (Ledeb.) Bobrov) distributing in the natural conditions of the Gadabay region and widely used in folk medicine, to determine their systematic composition and to evaluate the results obtained on a scientific basis. The research work was carried out based on mycological methods and approaches appropriate to the purpose of the study, taking samples from some medicinal plants growing in the Gadabay region.

As a result of the conducted studies, it was determined that a rich and diverse mycobiota is formed on medicinal plants growing in the Gadabay region. More than 15 species of micromycetes were discovered on the studied plants and they were systematically attributed to different taxonomic groups. The anamorphs of fungi belonging to the Ascomycota *phylum* are numerically superior than those belonging to other taxonomic groups. They account for 66% of the total fungi recorded during the studies. 34% belong to the *Zygomycota phylum*. The most common fungal genera were: *Alternaria*, *Rhizopus*, *Fusarium*, *Penicillium*, *Aspergillus*, *Mucor*, etc. Many of these species are phytopathogenic and saprotrophic. Plant-fungal relationships have been observed in various ecolotrophic types: parasitism, saprotrophy, and rarely mutualism. The dominance of pathogenic micromycetes has increased, especially in weakened and mechanically damaged plant organs. The study showed that microorganisms that affect the therapeutic potential of medicinal plants are formed in accordance with their biochemical composition and environmental conditions. Changes in the composition of

mycobiota are closely related to the age of the plant and environmental factors. Microbiological monitoring may play an important role in the future in terms of hygienic and technological control in the industrial use of these plants. In particular, biosafety measures are recommended to reduce the risk of fungal contamination during the stages of harvesting and drying of plants.

Keywords: Mycobiota, Fungal Contamination, Medicinal Plant

Ecogeographic analysis of the genus Carex L. distributed in Azerbaijan

Azerbaycan'da dağılım gösteren Carex L. cinsinin ekocoğrafik analizi

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Özet

Azerbaycan coğrafyası ağırlıklı olarak dağlık alanlardan oluşmaktadır. Ülkenin kuzeyinde Büyük Kafkaslar, güneyinde ise Küçük Kafkaslar yer almakta olup bu durum farklı dağ peyzajlarının oluşmasına olanak sağlamaktadır. Azerbaycan Cumhuriyeti oldukça zengin bir floraya sahiptir ve bölgede 4.500'den fazla yüksek bitki türü bulunmaktadır. Azerbaycan florasında, Cyperaceae Juss. familyasına ait 14 cinse bağlı 115 takson yayılış göstermektedir. *Carex* L., Cyperaceae Juss. familyasının en büyük cinsi olup Azerbaycan'da 64 takson ile temsil edilmektedir. Bunların 52'si tür, 10'u alttür ve 2'si varyete düzeyindedir. Modern nomenklatüre göre *Elyna* Schrad. ve *Cobresia* Will. cinslerine ait türler de *Carex* L. cinsi içerisinde değerlendirilmiştir.

Carex L. cinsine ait taksonların su rejimi açısından incelenmesi sonucunda, Azerbaycan'da bulunan 64 taksonun 43'ünün (%67) mezofit, 7'sinin (%11) higromezofit, 8'inin (%13) higrofit ve 6'sının (%9) kserofit olduğu belirlenmiştir. Işık rejimine göre bitkiler iki gruba ayrılmaktadır: heliyofitler ve skiyofitler. Buna göre, 64 taksonun 47'si (%73) ışık seven (helyofit) bitkilerden oluşmaktadır. İncelenen cinsin 17 türü (%27) ise skiyofit olup ağırlıklı olarak gölgeli ormanlık alanlarda ve çalılıklarda yayılış göstermektedir.

Yürütülen bilimsel araştırmalar sonucunda, türlerin yayılış gösterdiği peyzajlar ile toprak tipleri arasında güçlü bir ilişki bulunduğu ve bu faktörlerin birlikte belirli bir ekosistem oluşturduğu ortaya konulmuştur. Bu doğrultuda, Azerbaycan'da *Carex* L. türlerinin bulunduğu peyzaj tiplerini gösteren bir Coğrafi Bilgi Sistemleri (CBS) haritası hazırlanmıştır.

Anahtar Kelimeler: Azerbaycan, *Carex* L., ekocoğrafya, peyzajlar, CBS

Abstract

The geography in Azerbaijan is dominated by the mountains. With the Greater Caucasus in the northern part of the country and the Lesser Caucasus in the southern part, there are a variety of mountain landscapes. The Republic of Azerbaijan has a very rich flora. There are more than 4,500 species of higher plants here. In the flora of Azerbaijan, 115 taxa, united in 14 genera belonging to the family *Cyperacea* Juss., are widespread. *Carex* L. is the largest genus of the family *Cyperaceae* Juss., represented in Azerbaijan by 64 taxa. Currently, 52 of them are species, 10 are subspecies, and 2 are variations. According to modern nomenclature, species belonging to genera such as *Elyna* Schrad. and *Cobresia* Will. have also been included in the genus *Carex* L. When analyzing the water regime of representatives of the genus *Carex* L., it was found that 43 (67%) of the

64 taxa found in Azerbaijan are mesophytes, 7 (11%) are hygromesophytes, 8 are hygrophytes (13%), and 6 (9%) are xerophytes. According to the light regime, plants are divided into two groups: heliophytes and sciophytes. Thus, 47 out of 64 species (73%) are light-loving plants. 17 species (27%) of the genus we studied are sciophytes and are mainly distributed in shady forests and thickets. When conducting scientific research, it was determined that the landscapes and soil types in which species are distributed are interconnected and these factors form a certain ecosystem as a whole. Based on the above, a GIS map of the landscape types where Carex L. species are found in Azerbaijan has been prepared.

Keywords: Azerbaijan, *Carex* L., Ecogeography, Landscapes, GIS

1.INTRODUCTION

The principal geomorphological structures of the Azerbaijan Republic - Greater Caucasus, Lesser Caucasus (with Garabagh plateau), and Talysh mountains surround the Kur-Araz lowland in the north, west, and southeast. The geography in Azerbaijan is dominated by the mountains. With the Greater Caucasus in the northern part of the country and the Lesser Caucasus in the southern part, there are a variety of mountain landscapes. Azerbaijan is located between 38° and 41° north latitudes, and 44° and 50° east longitudes (Bayramov et al. 2023). The Republic of Azerbaijan has a very rich flora. There are more than 4,500 species of higher plants here. The flora of Azerbaijan is much richer in the number of species than the flora of the other republics of the South Caucasus. Sixty-six per cent of the species growing in the whole Caucasus can be found in Azerbaijan (https://gsaz.az/en/articles/view/95/Vegetation-Azerbajcan).

Currently, 115 taxa, united in 14 genera, belonging to the *Cyperacea* Juss. family, are distributed in the flora of Azerbaijan. The most extensive genus of the genus is *Carex* L. in terms of taxon composition. More than 2000 individuals of the *Carex* L. genus are distributed all over the world. This indicator is 107 for the Caucasus, and 64 for Azerbaijan (Flora of Azerbaijan. 1952). The *Carex* L. genus is represented in Azerbaijan by 64 taxa, of which 52 are species, 10 are subspecies, and 2 are variations. According to modern nomenclature, species belonging to genera such as *Elyna* Schrad. and *Cobresia* Will. have also been included in the Carex L. genus (https://www.worldfloraonline.org/search?query=Carex+L).

Ecogeography focuses on studying the relationship between ecological factors and geographical phenomena. It aims to understand the patterns and dynamics of ecosystems through space and time. This support the occurrence, reproduction and survival of many living biomass. Different Ecological zones were distributed geographically around the world during the past centuries. Ecogeographical studies provide information on ecological region; adaption, genetic resources, habitat, distributions and land cover. (Masaad M.E. 2023).

Ecological and geographical factors play a crucial role on the distribution, existence, and persistence of plants. Thus, ecological factors include vegetation cover, climate, water regime, species distribution characteristics, existing ecosystems, and geographical factors include soil types, distribution areas, landscapes, anthropogenic

impacts, etc.

The study of landscape is a core topic of geography. It is seen as a unique synthesis between the natural and cultural characteristics of a region. This synthesis embraces geo-ecological relations, spatial patterns and aesthetical properties (Antrop M. 2000).

Since the natural conditions of the Republic of Azerbaijan are complex, the landscapes developed on its territory are also characterized by their diversity. Landscapes are divided into mountainous and plain landscapes. Within these, a number of landscape types and subtypes are distinguished (Budagov B.A). When studying the ecological state of landscapes, first of all, changes in landscapes as a result of the impact of human economic activity should be investigated. It is the nature of anthropogenic impacts that is the main factor determining the ecological state of landscapes (Dashdiyev R. 2010).

GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what thinks are like there). This provides a foundation for mapping and analysis that is used in science and helps users understand patterns, relationships, and geographic context (https://www.esri.com/en-us/what-is-gis/overview)

Coupled with ecological modelling, GIS can provide significantly increased opportunities for detailed environmental resource inventory and analysis and show considerate promise for extensive use in nature conservation (Vogiatzakis N.I. 2003).

2. MATERIALS and METHODS

2.1. Study area

The principal geomorphological structures of the Azerbaijan Republic - Greater Caucasus, Lesser Caucasus (with Garabagh plateau), and Talysh mountains surround the Kur-Araz lowland in the north, west, and southeast. The geography in Azerbaijan is dominated by the mountains. With the Greater Caucasus in the northern part of the country and the Lesser Caucasus in the southern part, there are a variety of mountain landscapes. Azerbaijan is located between 38° and 41° north latitudes, and 44° and 50° east longitudes [Imran Bayramov, Mansura Ismayilova, Matanat Mehdiyeva. Geography of Azerbaijan. Baku 2023.]. The highest point in Azerbaijan is Mount Bazarduzu in the Greater Caucasus, at 4,485 m (14,714ft), and the lowest point is - 28 m (-92 ft), in the Caspian Sea (Fig.1). The country is situated at the crossroads of Europe and Asia has a unique geopolitical and geographical position. Azerbaijan is characterized by a diverse landscape. There are two major forms of landscape -plains and mountains. Mountains cover 60% of the total area of the country (https://namazerbaijan.org/about-azerbaijan-geography).

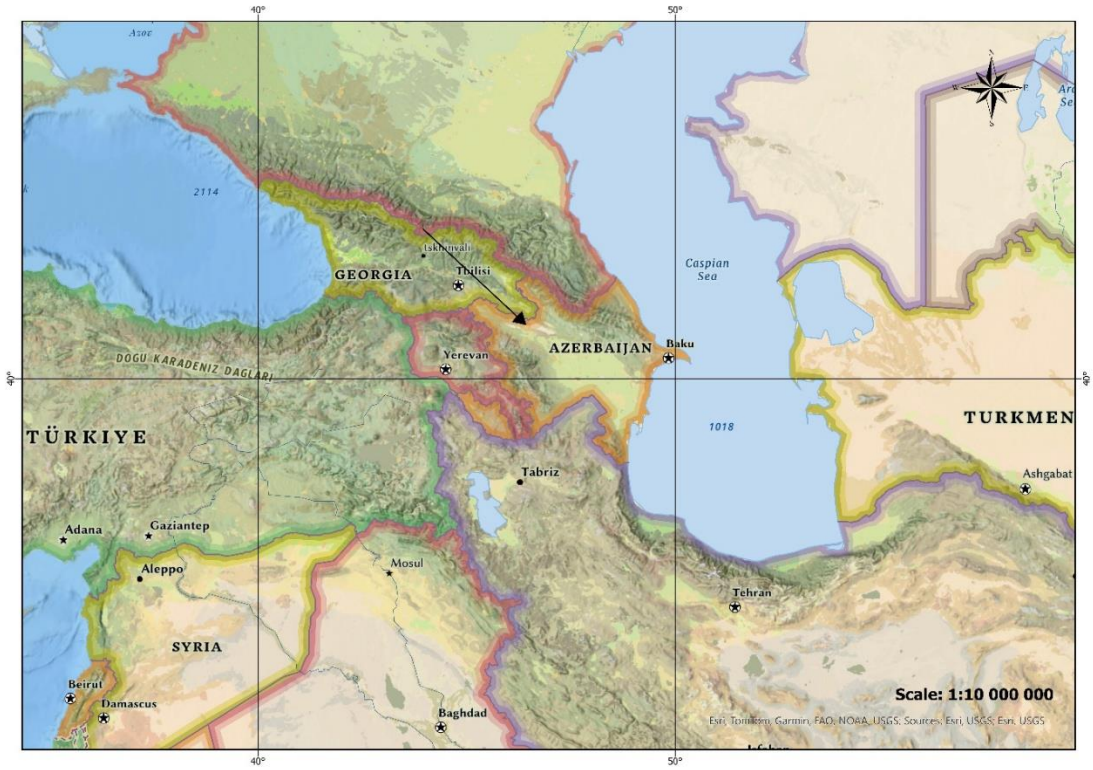

Fig.1. Location of Azerbaijan on the map

2.2. Semi-stationary and stationary investigations

During the research period, numerous short and long-term expeditions were carried out during the spring, summer, and fall seasons. The research was carried out mainly using semi-stationary and stationary methods, geobotanical records were made about the structure of phytocenoses. Within studies, expeditions were carried out to various regions of Azerbaijan, herbarium specimens were collected and individual formations were photographed.

General information was collected about the species of the genus *Carex* L. distributed in Azerbaijan. Based on this, a flora summary was prepared, and the information provided was compared based on classical and modern sources. Currently, 115 taxa, united in 14 genera, belonging to the *Cyperacea* Juss. family, are distributed in the flora of Azerbaijan. The most extensive genus of the genus is *Carex* L. in terms of taxon composition. More than 2000 individuals of the *Carex* L. genus are distributed all over the world. This indicator is 107 for the Caucasus, and 64 for Azerbaijan (Flora of Azerbaijan 1952). The *Carex* L. genus is represented in Azerbaijan by 64 taxa, of which 52 are species, 10 are subspecies, and 2 are variations. According to modern nomenclature, species belonging to genera such as *Elyna* Schrad. and *Cobresia* Will. have also been included in the *Carex L*. genus. (World Flora Online).

The flora summary of the species, flowering periods, main ecosystems were carried out based on the works “Flora of Azerbaijan” (V II, 1952), the landscape types of plants were based on the works “Azerbaijan National Encyclopedia., Landscapes” (Budagov B.A 2007), the soil types were based on the works “Physical

Geography of Azerbaijan" (Museyibov M.A. 1998) and "Fundamentals of Soil Science and Soil Geography" (Mammadov G.Sh. 2007), the water regime was based on the works "General Ecology" (Chernova N.M. 2004), and the light regime was based on the works "Ecology and Environmental Protection" (Mammadov G.Sh. 2005).

2.3. Geographic Information System-based methods

One of the areas of application of geographic information systems is the analysis of data obtained during environmental monitoring (Avkhadieva A.A., 2019). Since environmental safety is one of the main concepts of sustainable development, it includes scientifically based solutions of important issues such as the protection and restoration of natural ecosystems, as well as stabilization of the environment and improvement of quality, reduction of waste and harmful substances, environmental monitoring, and so on. The effectiveness of any environmental monitoring depends on the accuracy of collection, generalization, modeling and analysis of various data (Andreev, D.V., 2020).

Currently, there are many software products that implement the functions of geographic information systems, among which the most modern and widespread is the ArcGIS Pro software. ArcGIS Pro is a licensed functional, desktop geoinformation system. The program has extensive capabilities and supports numerous vector, raster formats and databases (Mikov S.I., 2023).

3. RESULTS and DISCUSSION

3.1. Ecogeographical analysis

When analyzing the water regime of representatives of the genus *Carex* L., it was found that 43 (67%) of the 64 taxa found in Azerbaijan are mesophytes, 7 (11%) are hygromesophytes, 8 are hygrophytes (13%), and 6 (9%) are xerophytes. Thus, mesophytes are species that are mainly distributed in meadows, forests and shrubs, in humid-sandy areas, in valleys, around rivers and water canals. These are considered the largest group in terms of percentage. Examples of mesophytes include *C.divisa* Huds., *C.remota* L., *C.dacica* Heuffl, etc. Hygromesophytes are species that occur not only in swamps, but also around rivers and channels, as well as rice plantations, and also in humid meadows. Examples of such species include *C. riparia* Curtis., *C. compacta* Lam (=*Carex vulpina* L.), *C.melanostachya* M., etc. The third group, which we analyze according to the water regime, is hygrophytes. Hygrophytes are species that are widespread mainly in swamps and rice plantations, examples of such species include *C. vesicaria* L., *C. caespitosa* L., etc. Among the species of the genus *Carex* L. distributed in Azerbaijan, the group with the lowest percentage according to the water regime is xerophytes. Xerophytes are species that are mainly found on stony-pebble slopes, dry slopes, and sandy-pebble dry areas. Examples of them include *C. supina* Wahlenb, *C. colchica* J.Gay, *C. pachystylis* J.Gay, etc. species (Fig.2.).

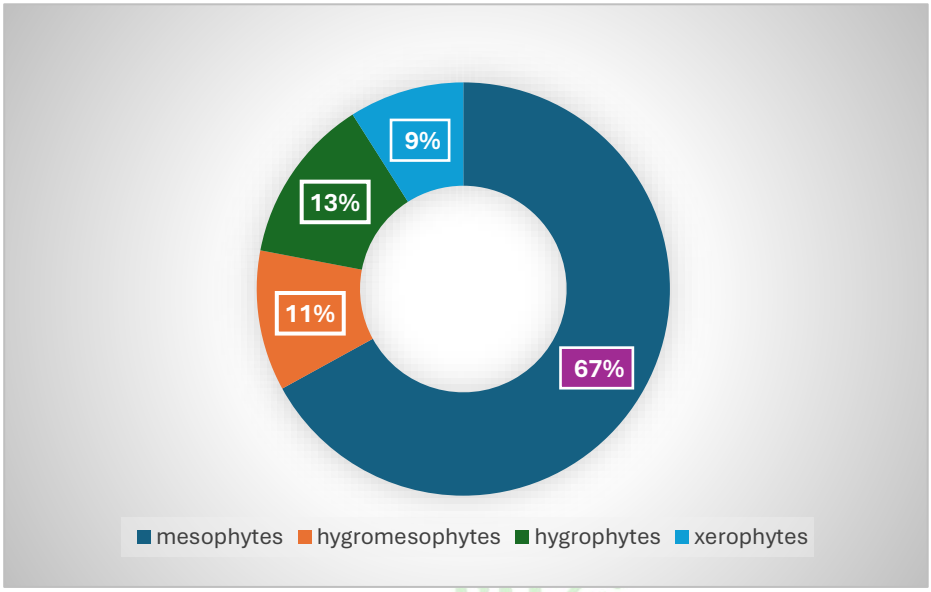

Fig.2. Water regime percentage indicator

According to the light regime, plants are divided into two groups: heliophytes and sciophytes. Light-loving plants or heliophytes include plants of open areas, constantly illuminated places (meadows, slopes, semi-desert areas). These plants are rarely encountered in the forest zone. Heliophytes predominate among the representatives of the *Carex* L. genus distributed in the territory of Azerbaijan. Thus, 47 out of 64 species (73%) are light-loving plants. Examples of this group include *C. vesicaria* L., *Carex diluta* M.Bieb., *C.colchica* J.Gay, etc. Shade-loving plants or sciophytes include plants of the lower tier of shady forests. These plants do not tolerate strong direct sunlight. 17 species (27%) of the genus we studied are sciophytes and are mainly distributed in shady forests and thickets. Examples of sciophyte species include *C.polyphlla* Kar.& Kir, *C.buekii* Wimm, *C.tomentosa* L.(Fig.3.).

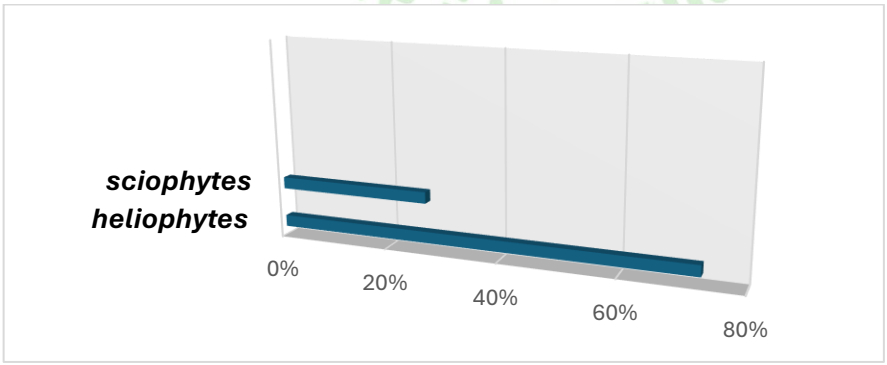

Fig.3. Light regime percentage indicator

3.2. Landscapes and soil types

When conducting scientific research, it was determined that the landscapes and soil types in which species are distributed are interconnected and these factors form a certain ecosystem as a whole. Thus;

1. Grassy mountain-meadow soils are characteristic of alpine and subalpine meadow-steppe landscapes of the high mountains, and the species found in this specific environment are usually species adapted to the ecosystem of alpine and subalpine meadows. Examples of such species include *Elyna schoenoides* C.A.Mey. (= *Carex deasyi* (C.B.Clarke) O.Yano & S.R.Zhang, *Carex humilis* (C. A. M.) L. Serg, (=*Carex alatauensis* S.R.Zhang), *Carex canescens* L., *Carex oreophila* C.A.Mey. etc.
2. The soils characteristic of the broad-leaved forest and post-forest meadow-shrub landscape of the middle highlands are brown mountain-forest, sedimentary-carbonate mountain-forest, typical and washed mountain-forest soils, where the species distributed here are mainly adapted to humid-shady forests, shrubs, forest meadows and swampy meadows, and ecosystems characteristic of the surroundings of rivers and lakes. Examples of such species include *Carex digitata* L., *Carex brevicolis* D.C., *Carex pallescens* L. etc.
3. The soils characteristic of the mountain-xerophyte landscape of the middle highlands are mountain-chestnut and brown mountain-forest soils. The ecosystem created by these two factors is mainly dry-grassy valleys and stony-gravel-debris. In this ecosystem, it is possible to find *Carex pachystylis* J.Gay, *Carex stenophyllodies* V.I.Krecz (=*Carex stenophylla subsp. stenophylloides* (V.I.Krecz.) T.V.Egorova and other species.
4. In the steppe, partly forest-steppe landscape of the lowlands dark-chestnut, mountain gray-brown, brown mountain-forest soils are widespread. These elements form ecosystems consisting of swamps, humid areas, and shady forests. In such an environment, mainly *Carex phyllostachys* C.A.M. *C.micropodioides* V.I. Krecz (=*Carex pyrenaica subsp. micropodioides* (V.I.Krecz.) Chandjian and etc. species are widespread.
5. In the dry, sandy ecosystem of the semi-desert landscape of the lower mountain belt, on brown, light brown, gray-brown soils, species such as *Carex.colchica* J.Gay, *Carex divisa* Huds can be encountered.
6. In the broad-leaved forest landscape of the foothills, carbonate and typical brown mountain-forest and podzolized mountain-yellow soils are widespread. Examples of species found in ecosystems consisting of humid areas, forests, shrubs and swamps that create appropriate landscape-soil-climatic factors are *Carex cuprina* (Sándor ex Heuff.) Nendtv. ex *C.divulsa* Stokes and others.
7. In the forest-meadow landscapes of the plains, alluvial meadow-forest, alluvial meadow and meadow-forest soils, podzolic and gleypodol yellow soils are widespread. Here, ecosystems formed mainly by swampy meadows, moist-sandy, clayey-sandy, and moist river banks are formed. Examples of species widespread in such environments include *Cyperus badius* Poir. (=*C.longus subsp.badius* Desf. B&L), *Cyperus rotundus* L., *Acorellus pannonicus* (Jacq.) Palla (=*Cyperus pannonicus* Jacq.).

8. In the meadow-swamp type of semi-desert landscapes of the plains and intermontane plains, gray-meadow, gray, gray-brown soils are widespread. Examples of species found in marshy areas, marshy meadows, and damp, silty, sandy riverbanks include *Cyperus fuscus* L., *Cyperus glaber* L., *Pycreus globosus* Rchb.(=*Cyperus flavidus* Retz.) *Torulinium ferax* (Rich.) Ham. (=*Cyperus ferax* Rich.).

Based on the above, a GIS map of the landscape types where Carex L. species are found in Azerbaijan has been prepared [Fig.4].

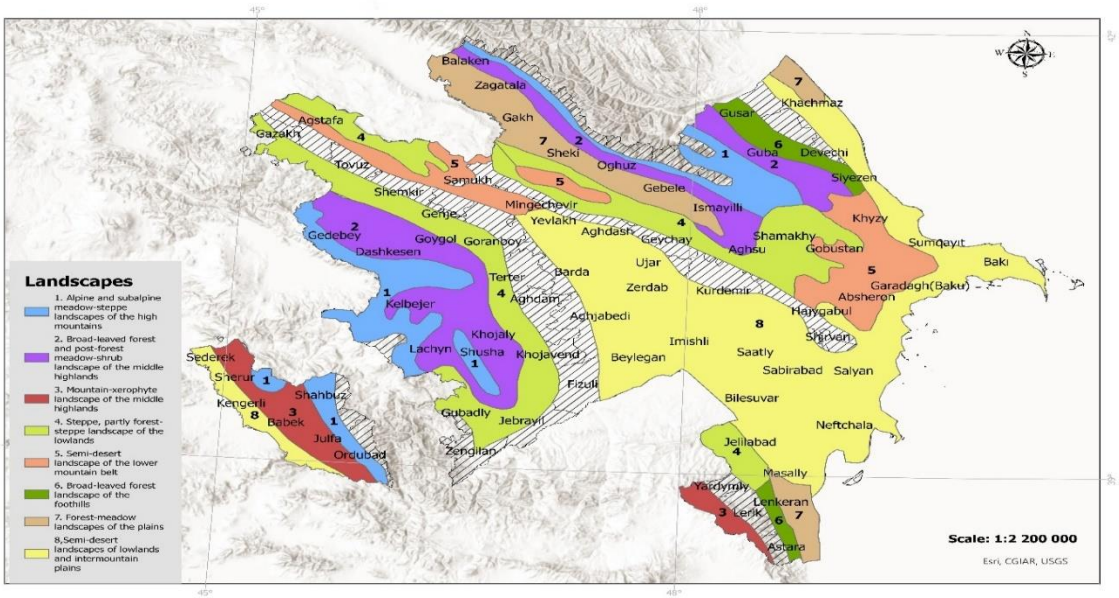

Fig. 4. Landscapes where Carex L. species are distributed

Landscape types where *Carex* L. species are not found are marked with white lines on the map.

4. CONCLUSION

When analyzing the water regime of representatives of the genus *Carex* L., it was found that 43 (67%) of the 64 taxa found in Azerbaijan are mesophytes, 7 (11%) are hygromesophytes, 8 are hygrophytes (13%), and 6 (9%) are xerophytes. Thus, mesophytes are species that are mainly distributed in meadows, forests and shrubs, in humid-sandy areas, in valleys, around rivers and water canals. Hygromesophytes are species that occur not only in swamps, but also around rivers and channels, as well as rice plantations, and also in humid meadows. Hygrophytes are species that are widespread mainly in swamps and rice plantationsşAmong the species of the genus *Carex* L. distributed in Azerbaijan, the group with the lowest percentage according to the water regime is xerophytes. Xerophytes are species that are mainly found on stony-pebble slopes, dry slopes, and sandy-pebble dry areas.

Light-loving plants or heliophytes include plants of open areas, constantly illuminated places (meadows, slopes, semi-desert areas). Heliophytes predominate among the representatives of the *Carex* L. genus

distributed in the territory of Azerbaijan. Thus, 47 out of 64 species (73%) are light-loving plants. Shade-loving plants or sciophytes include plants of the lower tier of shady forests. These plants do not tolerate strong direct sunlight. 17 species (27%) of the genus we studied are sciophytes and are mainly distributed in shady forests and thickets.

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Features of Anaplasmosis in Different Breeds of Sheep in the Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti'ndeki Farklı Koyun Irklarında Anaplazmozisin Özellikleri

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Abstract

The aim of the study was to investigate the course characteristics, clinical signs, and morphological and biochemical changes in the blood of sheep breeds raised under the conditions of the autonomous republic infected with Anaplasma, in order to develop complex treatment measures in the future. For this purpose, three groups of animals were formed, each consisting of 20 heads: the first group Balbas, the second – Mazekh, and the third – crossbreeds obtained from crossing these breeds with the Prekos breed. The animals were artificially infected with Anaplasma through blood and observed accordingly.

In Balbas and Mazekh breeds, the incubation period of the disease lasted 13–15 days, while in crossbreeds it lasted 14–19 days. The course of the disease varied depending on the breed. In Balbas and Mazekh sheep, body temperature rose to 40–41°C, the mucous membranes were initially pale, then became porcelain-like and yellowish. The animals showed loss of appetite, emaciation, diarrhea, increased respiration and pulse rate; the blood was diluted, and microscopic examination revealed 200–300 parasites per 100 visual fields. The disease lasted 40–50 days, and 30–35% of lambs under one year of age died.

In crossbreeds, clinical symptoms were milder. Body temperature reached 40–41°C, with slight yellowing of the mucous membranes, mild weight loss, and preserved appetite. Diarrhea was not recorded, and respiration and pulse rates changed only slightly. Microscopic examination revealed 15–30 parasites per 100 visual fields. The disease lasted 20–25 days and no mortality occurred.

No significant differences were observed between artificial and natural infections in terms of clinical signs. Hematological and biochemical analyses showed that in Balbas and Mazekh breeds, the number of erythrocytes and the amount of hemoglobin decreased by 47–48% and 43–47%, respectively, while leukocytes increased by 59–64%. In dead animals, erythrocytes and hemoglobin decreased by 70–75%. Marked neutrophilia was observed in the leukocyte formula.

During the acute stage of the disease, the total protein content decreased by 8–10% in Balbas and Mazekh breeds, and by 3–4% in crossbreeds. Albumin levels decreased by 8–9% (Balbas, Mazekh) and 1–2% (crossbreeds), while beta- and gamma-globulins increased by 7–9%. The amount of total nitrogen decreased

(by 11–15% in Balbas and Mazekh, and by 7–8% in crossbreeds), whereas residual nitrogen increased (by 49–50% and 27–30%, respectively). These changes are associated with the severe course of the disease and the disruption of protein metabolism in the organism.

Keywords: Sheep, Anaplasmosis, Blood parasites, Balbas, Mazekh, Prekos, Crossbreeds.

Growth and Nitrogen Metabolism of Amaranth (Amaranthus l.) in arid Conditions of the Kura-Araz Lowland of Azerbaijan

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Abstract

The specificity of the physiological and biochemical responses of amaranth plants (*Amaranthus* L.) under natural conditions, constantly or periodically exposed to certain environmental factors (mainly abiotic), was studied. The study focused on the roots, leaves, stems, and flowers (spikes) of *Amaranthus* plants adapted to areas near the regional centers along the busy highways of Tartar and Barda. For comparative analysis, samples of the same species were collected from the experimental plot of the Institute of Botany, located in the Karrar experimental site of Kurdamir district, where plants were provided with optimal conditions for normal growth and nutrition. Plant samples from all study regions were collected during the summer. Nitrogen content was quantified using a colorimetric method with Nessler's reagent on a photoelectrocolorimeter. Morphological parameters were determined using classical methods generally accepted in plant physiology.

It has been shown that under the influence of soil and climatic stressors, protective and adaptive metabolic mechanisms are activated in plants, contributing to the enhancement of synthetic processes in the roots. The increase in protein nitrogen content in the roots of experimental plants represents a species-specific adaptive strategy that ensures the resistance and survival of Amaranth under these environmental conditions.

It is concluded that amaranth, having demonstrated physiological adaptations to stressful conditions such as salinity and pollution, can be utilized for the restoration of degraded agricultural lands and the conservation of biodiversity in arid regions. Furthermore, its application may prove effective in the remediation of marginal soils in Kura-Araz Lowland.

Keywords: Amaranthus, nitrogen, stress, salinity, morphometric parameters.

Micro and Nano Lasers: Production of Nanomaterials and Their Applications in Medicine

Mikro və Nano-Lazerlər. Nanomateriallarin Istehsali və Tibbdə Tətbiqi

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Abstract

In recent years, micro and nano lasers have become one of the rapidly developing areas of optoelectronics and biomedicine. These lasers, characterized by high directivity, monochromaticity, and low energy consumption, have the potential to replace conventional laser technologies. The synthesis and structuring of nanomaterials — particularly quantum dots, nanowires, and two-dimensional materials — play a key role in the fabrication of micro and nano lasers. Through these technologies, laser sizes can be reduced to the nanometer scale, allowing light–matter interactions to be controlled at the level of new quantum effects. In biomedicine, micro and nano lasers are applied in intracellular imaging, biomolecule detection, photodynamic therapy, and precise diagnostics. Thus, nanomaterial-based laser technologies contribute both to the development of new-generation biomedical devices and to the more efficient management of optical information.

Keywords: laser, atom, laser induction, photon, semiconductor, molecule, dermatology, quantum lasers, biomolecule.

Xülasə

Son illərdə mikro və nano-lazerlər optoelektronika və biotibbin sürətlə inkişaf edən sahələrindən birinə çevrilmişdir. Bu lazerlər yüksək istiqamətlənmə, monoxromatiklik və aşağı enerji sərfiyyatı ilə fərqlənərək, ənənəvi lazer texnologiyalarını əvəz etmək potensialına malikdirlər. Nanomaterialların — xüsusilə kvant nöqtələrinin, nanotel və ikiölçülü materialların — sintezi və strukturlaşdırılması mikro və nano-lazerlərin istehsalında əsas rol oynayır. Bu texnologiyalar sayəsində lazerlərin ölçüləri nanometr miqyasına qədər azaldılaraq, işıq-maddə qarşılıqlı təsiri yeni kvant effektləri səviyyəsində idarə oluna bilir. Biotibbdə mikro və nano-lazerlər hüceyrədaxili görüntüləmə, biomolekulların aşkarlanması, fotodinamik terapiya və dəqiq diaqnostika kimi sahələrdə tətbiq olunur. Beləliklə, nanomaterial əsaslı lazer texnologiyaları həm yeni nəsil biotibbi cihazların yaradılmasına, həm də optik informasiyanın daha effektiv idarə edilməsinə şərait yaradır.

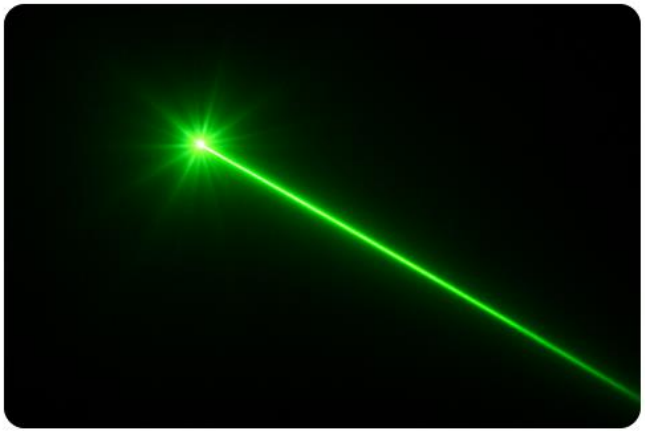
Açar sözlər: lazer,atom, lazer-induksiya, foton, yarımkeçirici, , molekul, dermatologiya, kvant lazerlər,biomolekul.

1. GİRİŞ

Son onilliklərdə lazer texnologiyalarının sürətli inkişafı nəticəsində optoelektronika və biotibb sahələrində fundamental dəyişikliklər baş vermişdir. Xüsusilə mikro və nano ölçülü lazer sistemlərinin yaradılması, həm enerji səmərəliliyi, həm də məkan dəqiqliyi baxımından mühüm irəliləyişlərə səbəb olmuşdur. Mikro və nano-lazerlər ölçülərinə görə ənənəvi lazerlərdən fərqlənir və onların aktiv mühiti, rezonator həcmi optik dalğa uzunluğuna yaxın miqyasda olur. Bu, kvant ölçülü təsirlərin və səth plazmon rezonansının iş prinsiplərində əsas rol oynamasına gətirib çıxarır.

Mikro və nano-lazerlərin inkişafı nanomaterialların sintezi və emalı proseslərinə yeni yanaşmalar gətirmişdir. Lazer ablyasiyası, lazer-induksiya olunmuş çökmə və lazer kimyəvi buxarlanma kimi üsullar vasitəsilə müxtəlif metal, yarımkeçirici və dielektrik nanohissəciklər yüksək dəqiqliklə əldə edilir. Bu üsulların üstünlüyü ondadır ki, onlar təmiz mühitdə, əlavə kimyəvi reagentlərdən istifadə etmədən nanomaterialların sintezini təmin edir.

Biotibb sahəsində mikro və nano-lazerlər yeni nəsil diaqnostik və terapevtik sistemlərin əsasını təşkil edir. Nanoölçülü lazer mənbələri hüceyrə səviyyəsində fotodinamik terapiya, biomolekulyar deteksiya və real vaxtlı bioimaging texnologiyalarında geniş tətbiq edilir. Bu sistemlər minimal invazivlik və yüksək həssaslıq təmin etməklə canlı orqanizmlərin tədqiqinə yeni imkanlar yaradır.



Şəkil 1: Lazer şüasının vizual görüntüsü

2. MIKRO VƏ NANO-LAZERLƏRIN FIZIKI PRINSIPLƏRI

Lazerin əsas iş prinsipi stimullaşdırılmış emissiya hadisəsinə əsaslanır. Bu proses, kvant mexanikasının fundamental qanunlarından biri olan enerji kvantlaşması ilə əlaqədardır. Atom və ya molekulun yüksək enerji səviyyəsindən (E_2) aşağı səviyyəyə (E_1) keçidi zamanı yayılan fotonun enerjisi

$h\nu=E_2-E_1$ ifadəsi ilə təyin olunur. Burada h– Plank sabiti, ν isə yayılan şüanın tezliyidir.

Ənənəvi lazerlərdə bu hadisə makroskopik miqyasda baş verir və rezonatorun uzunluğu optik dalğa uzunluğundan (λ) dəfələrlə böyük olur. Mikro və nano-lazerlərdə isə rezonatorun ölçüləri λ-ya yaxın və ya ondan kiçik olur. Bu hal, fotonların rezonator daxilində lokalizasiyasını və sıx elektromaqnit sahəsinin yaranmasını təmin edir.

Mikro-lazerlər, əsasən, mikrodisk, mikrosfera və ya mikrohalqa rezonatorları şəklində olur. Bu strukturlarda işıq “whispering gallery mode” (WGM) adlanan rejimdə hərəkət edir. Bu rejimdə fotonlar optik sərhədlər boyunca daxili tam əks olunma nəticəsində çoxsaylı dövrlər vurur və bu da güclü sahə lokalizasiyasına səbəb olur.

Belə rezonatorlarda enerji itkisi minimal olur və yüksək Q-faktoru (rezonans keyfiyyət əmsalı) təmin edilir. Mikro-lazerlərin üstünlüyü onların aşağı həcmli, az enerji tələb edən və inteqrasiya olunmuş optoelektron sistemlərə uyğun strukturlarda işləməsidir.

Nano-lazerlər, mikro-lazerlərin təkmilləşdirilmiş forması olub, plasmonik təsirlərə əsaslanır. Metal nanohissəciklərdə sərbəst elektronların optik sahə ilə qarşılıqlı təsiri nəticəsində səth plazmon rezonansı (Surface Plasmon Resonance – SPR) yaranır. Bu rezonans elektromaqnit dalğasının metal səthində lokalizasiyasını təmin edir və bu, işığın dalğa uzunluğundan daha kiçik ölçülü sahələrdə intensivləşməsinə gətirib çıxarır.

Nano-lazerlərdə optik sahənin lokalizasiyası səbəbindən Purcell effekti mühüm rol oynayır. Purcell effekti – foton sıxlığının artması nəticəsində spontan emissiyanın güclənməsidir. Bu, nanoölçülü rezonatorlarda lazer eşik enerjisini kəskin şəkildə azaldır və yüksək kvant səmərəliliyi yaradır.

Nano-lazerlərin aktiv mühitləri kimi yarımkeçirici kvant nöqtələri, perovskit nanokristalları və ya orqanik hibrid materiallar istifadə olunur. Onların spektral xassələri rezonatorun geometriyası və materialın dielektrik sabiti ilə tənzimlənir.

3. NANOMATERIALLARIN ISTEHSALINDA MIKRO VƏ NANO-LAZERLƏRIN TƏTBIQI

Nanomaterialların istehsalında lazer texnologiyalarının tətbiqi son illərdə ən çox tədqiq olunan istiqamətlərdən biridir. Lazerin yüksək enerji sıxlığı, istiqamətlənmiş şüa axını və qısa impuls müddəti sayəsində maddənin səthində lokal dəyişikliklər yaratmaq mümkündür. Bu proseslər nəticəsində atom və molekul səviyyəsində struktur yenidənqurmalar baş verir və nanoölçülü hissəciklər formalaşır.

Lazer ablyasiyası nanohissəciklərin alınmasında ən çox istifadə edilən üsullardan biridir. Bu metodda yüksək intensivlikli lazer impulsu hədəf materialın (metal, oksid, yarımkeçirici və s.) səthinə yönəldilir. Şüalanma nəticəsində materialın səthi lokal olaraq qızır, buxarlanır və plazma buludu əmələ gətirir. Soyuma prosesi zamanı buxarlanmış atomlar kondensasiya olunaraq nanohissəciklər əmələ gətirir. Lazer ablyasiyası prosesinin üstünlükləri vardır ki,bunlara aşağıdakıları missal gətirmək olar:

Kimyəvi reagentlərdən istifadə olunmur, çirklənmə riski minimaldır;nanohissəciklərin ölçüsünü lazer enerjisi, impuls müddəti və mühitin növü ilə tənzimləmək mümkündür;metal, keramika və yarımkeçirici materialların təmiz sintezini təmin edir.Bu üsulla qızıl (Au), gümüş (Ag), mis (Cu), TiO_2 və SiO_2 əsaslı nanohissəciklər geniş miqyasda sintez edilir.

Bütün bunlarla yanaşı lazer-induksiya olunmuş kimyəvi buxarlanma üsulu (Laser Chemical Vapor Deposition, CVD) nanostrukturlu təbəqələrin və nazik filmlərin alınmasında mühüm texnologiyadır. Bu üsulda lazer şüası qaz fazasında olan reaktivlərin parçalanmasını təmin edir və substrat səthində nazik bərk təbəqə əmələ gəlir.

Bu üsulla alınan təbəqələr çox yüksək homogenliyə, mexaniki möhkəmliyə və optik şəffaflığa malik olur. Xüsusilə, SiO_2, TiN, ZnO və qrafen əsaslı nanostrukturların formalaşmasında effektivdir.

Nanoölçülü strukturların formalaşmasında lazer-induksiya olunmuş çökmə (Laser-Induced Deposition) və lazer nanoyazma (Laser Direct Writing) üsulları da geniş tətbiq edilir. Bu texnologiyalar mikroelektronika və optik cihaz istehsalında istifadə olunur. Femtosaniyə impuls lazerləri vasitəsilə materialın səthində lokal ərimə və bərkimə prosesləri baş verir ki, bu da nanometr miqyasında strukturlaşdırmaya imkan yaradır. Bu üsulların bir çox üstünlükləri vardır. Bunlardan substratın temperaturuna minimal təsiri; təmiz və mexaniki sabit nanostrukturların alınması;inteqrasiya olunmuş optik komponentlərin birbaşa yazılması imkanıdır.Belə proseslərdə nano-lazerlərin tətbiqi, yüksək sahə sıxlığı və lokal enerji ötürülməsi hesabına nanohissəciklərin morfologiyasını idarə etməyə imkan verir.

4. BIOTIBBDƏ MIKRO VƏ NANO-LAZERLƏRIN TƏTBIQI

Nano-lazerlərin tətbiq olunduğu ən mühüm sahələrdən biri bioloji hüceyrə və toxumaların görüntülənməsidir. Nanoölçülü lazer mənbələri fluoresans mikroskopiya, Raman spektroskopiyası və konfokal görüntüləmə sistemlərində istifadə edilir.

Bu sistemlərdə lazer şüası bioloji nümunədə molekulyar səviyyədə işıq saçılmasına səbəb olur və alınan siqnalların spektral analizi hüceyrədaxili strukturların müəyyən edilməsini təmin edir. Nano-lazerlərin üstünlüyü ondan ibarətdir ki, onlar minimal enerji ilə yüksək intensivlik yaradır və bu da hüceyrə zədələnməsinin qarşısını alır.

Xüsusilə plasmonik nano-lazerlər, səth plazmon rezonansına əsaslanaraq, bioloji nümunələrdəki molekulyar dəyişikliklərə qarşı çox həssas olur. Bu, onları biosensor kimi istifadəyə yararlı edir.

Mikro və nano-lazerlər xərçəng hüceyrələrinin selektiv məhv edilməsində effektiv rol oynayır. Fotodinamik terapiya (PDT) zamanı nano-lazer şüası fotosensibilizator molekulları aktivləşdirir.Fotobiologiyada orqanizmin ultrabənövşəyi və görünən işığa qarşı həssaslığını artıran maddələr fotosensibilizatorlar adlanır (Cəfərov, 2008). Nəticədə oksigenin singlet forması yaranır və bu, hüceyrə membranlarını zədələyir. Hər iki üsulun üstünlüyü selektivlik, aşağı doza ilə yüksək effektivlik və minimal yan təsirlərdir. Beləliklə, mikro və nano-lazerlər hədəfli bioterapiya sahəsində mühüm alət kimi çıxış edir. Nano-lazerlərin daha bir tətbiq istiqaməti biosensor texnologiyalarıdır. Nano-rezonator əsasında qurulan lazerlər, biomolekulyar bağlanma hadisələri nəticəsində spektral dəyişikliklərə çox həssas reaksiya verir.

Belə biosensorlar aşağıdakı məqsədlərlə istifadə olunur:

- Qan və plazma nümunələrində biomarkerlərin (məsələn, xərçəng göstəriciləri) aşkarlanması;
- Virus və bakteriyaların real vaxtlı identifikasiyası; və s.

Nano-lazer biosensorları, klassik optik sensorlarla müqayisədə, miniatür ölçüləri və çox yüksək siqnal–səs nisbəti ilə fərqlənir. Nano-lazerlər həmçinin optogenetika sahəsində, yəni işıq vasitəsilə hüceyrə fəaliyyətinin idarə edilməsində istifadə edilir. Hüceyrə daxilinə yerləşdirilən biouyğun nano-lazer mənbələri neyron siqnallarını işıqla tənzimləməyə imkan verir. Bu, gələcəkdə sinir sisteminin xəstəliklərinin (Parkinson, Alzheimer və s.) müalicəsində yeni yanaşmaların əsasını təşkil edə bilər. Müasir biotibbin əsas məqsədi xəstəliklərin erkən mərhələdə diaqnostikası, hədəfli terapiya və real vaxtlı bioproseslərin monitorinqidir. Bu istiqamətdə mikro və nano-lazerlərin tətbiqi fundamental yeniliklərə səbəb olmuşdur. Nanoölçülü lazer sistemləri bioloji mühitlə yüksək uyğunluq (biokompatibilik), yüksək spektral seçicilik və minimal invazivlik

xüsusiyyətlərinə malikdir.Nano-lazerlərin tətbiqi lazer göz cərrahiyyəsində (LASIK) kornea düzəltmək üçün istifadə olunur.Bu yumşaq toxumaların və damarların kəsilməsi üçün minimal invaziv metodlar.Bunlarla yanaşı lazer spektroskopiyası ilə hüceyrələr və toxumalar analiz olunur. Xərçəngin ilkin mərhələdə aşkarlanması üçün istifadə edilir.

Fizioterapiya və dermatologiyada da nano-lazerlərin tətbiqi olduqca böyükdür.Lazer şüaları iltihabların müalicəsində və dəri problemlərində tətbiq olunur.

Lazerlər fizikanını yeni sahəsi sayılan qeyri-xətti optikada tətqiqatlar aparmaq üçün əsas alət hesab olunurlar. Adi işıq dəstələri üçün şəffaf olan maddələr işıq enerjisinin böyük sıxlıqlarında öz xassələrini dəyişirlər. Əks hadisə də müşahidə olunur. İşıq enerjisinin kiçik sıxlıqları üçün qeyri şəffaf olan maddələr böyük sıxlıqlarda şəffaflaşırlar (Hüseynəliyev, Qardaşbəyova & Sultanova, 2009).

Bu hadisələrin nəzəriyyəsinin inkişafı işığın öz - özünə fokuslanmasını qabaqcadan xəbər verə bilmişdir. Güclü işıq dalğalarının mühitdə yayılması detektə effekti, müxtəlif optik harmoniyaların generasiyası və mühitin sındırma əmsalının dəyişməsi ilə müşahidə olunur. Lazer şüası özünə-məxsus linza yaradır və bu işığın öz-özünə fokuslanması effektinə gətirib çıxarır.

Hazırda dünyanın bir çox laboratoriyalarında müxtəlif tezlik diapazonunda işləyən yeni tip kvant qurğuları yarat-maq və tətbiq etmək üçün kvant tezlik standartlarının, parametrik gücləndiricilərin, lazerlərin təkmilləşdirilməsi üzərində işlər aparılır. Submillimetrlik ($\boldsymbol{\lambda}$~1-0,1mkm) və ultrabənövşəyi ($\boldsymbol{\lambda}$~ 0,4mkm) diapazonlarda kvant generatorlarının və tezliyi idarə oluna bilən koherent işıq mənbələrinin yaradılması problemi çox aktual hesab olunur. Kristalların qeyri xətti optik xassələrinin istifadə olunması lazer şüasını fiksə olunmuş hər hansı tezlikli başqa bir şüaya çevirməklə yanaşı həm də tezliyi tədricən dəyişdirilən bilən şüaya çevirməyə imkan verir. Bütün bunlar son zamanlar qeyri-xətti optika sahəsində əldə olunan yeni nəticələrin və formalaşan yeni tədqiqat istiqamətlərinin tam olmayan bir siyahısını təşkil edir.

Rentgen şüalarının istifadə olunduğu qoloqrafik mikroskopda həndəsi böyütmə və dalğa böyütməsi hesabına yüksək böyütməyə nail olmaq mümkün olmuşdur (López-Carrasco, 2025). Belə ki, qoloqrafiya prinsipi istənilən elektromaqnit dalğa uzunluğu üçün ödənildiyindən qoloqram almaq üçün

$\boldsymbol{\lambda}$ = 10-4 mkm-dalğa uzunluğunda rentgen şüalarından, bərpa olunma etapında isə $\boldsymbol{\lambda}$ = 0,5 mkm görünən işıqdan istifadə etmək olar. Əgər həndəsi böyütmə 200 olarsa bu zaman mikroskopun tam böyütməsi

$$K=200 \cdot \frac{0{,}5 \cdot 110^{-4} sm}{10 sm^{-8}}=10^6$$

olacaqdır.

Lazer şüalarının yüksək monoxromatikliyi va istiqamətliliyi onu - dalğa uzunluğuna yaxın çox kiçik bir ölçüdə nöqtəyə fokuslamağa imkan verir. Belə kəskin fokuslanma hesabına lazer şüalarını toxumaların üzərinə yönəltmək mümkün olur (məsələn, göz toxumalarının) və lazer şüasının çox da böyük olmayan (~0,1 coul) intensivliklərində tələb olunan effektivliyi almaq olur. İşığa çox həssas olmayan və güclü şüalanma tələb edən böyük sahəli obyektlər üçün (məsələn, bədxassəli şişlər) -100÷1000 coul enerjili şüalanmasını tətbiq etmək mümkündür.

Oftalmologiyada 0,2-0,3 coul enerjili lazer şüalanması bütövlükdə gözə heç bir xətər yetirmədən bir sıra mürəkkəb əməliyyatları aparmağa imkan verir. Cərrahiyyədə kəsilməz rejimdə işləyən lazerin fokuslanmış şüası (gücü 100 vt-a qədər olan) çox iti və steril skalpeli əvəz edir. Xüsusilə, qanının qatılaşması çox aşağı olan xəstələrdə qanaxmanı dayandırmıq və yaraları bitişdirmək üçün lazerlərdən istifadə etmək çox perspektivlidir.

Tezliyin çox kiçik diapazonunda lazerin hər kvadrat santimetri 100 vt enerji şüalandır bilir. Müqayisə üçün qeyd edək ki, qızmış cismin 100 vt/sm² enerji şüalandırması üçün onu 10 12K temperaturadək qızdırmaq lazımdır. Bu kəmiyyətə lazerin effektiv temperaturu deyilir və bu kəmiyyət lazerin gücündən və onun spektrinin enindən asılıdır (Hüseynəliyev, Qardaşbəyova & Sultanova, 2009) Lazerlərin effektiv temperaturu o qədər böyükdür ki, lazer şüası üçün çətin əriyən maddə anlayışı mənasını itirir. Lazer şüası materialın verilmiş həcmini əridər yoxsa yox - bu yalnız lazerin gücündən və onun şüasının materiala təsir müddətindən asılıdr.

4. NƏTİCƏ

Lazer texnologiyası təhsil, tibb və rabitə sahələrində inqilabi dəyişikliklər yaratmaqla, elmin və texnologiyanın inkişafında mühüm rol oynamışdır. Onun koherent, monoxromatik və yüksək intensivlik kimi unikal xüsusiyyətləri sayəsində lazerlər həm nəzəri, həm də tətbiqi istiqamətlərdə geniş istifadə olunur.

Təhsil sahəsində lazerlər fizika və mühəndislik ixtisaslarında optik hadisələrin öyrənilməsi, laborator eksperimentlərin aparılması və vizual tədris vasitələrinin hazırlanmasında yeni imkanlar açmışdır. Tibb sahəsində lazer texnologiyası cərrahi əməliyyatlarda, oftalmologiyada, dermatologiyada və diş həkimliyində dəqiqliyi və pasiyent üçün minimal travmanı təmin etməklə böyük üstünlüklər qazandırmışdır. Rabitə sahəsində isə lazerlər optik lif texnologiyalarının əsasında dayanaraq, məlumat ötürülməsinin sürətini və etibarlılığını əhəmiyyətli dərəcədə artırmışdır.

Gələcəkdə lazer texnologiyasının daha səmərəli, enerjiyə qənaətcil və çoxfunksiyalı formalarının yaradılması gözlənilir. Xüsusilə kvant lazerlər, femtosaniyə impuls lazerləri və nano-lazer texnologiyaları kimi istiqamətlərdə aparılan tədqiqatlar bu sahədə yeni inqilabi tətbiqlərə yol açacaq. Beləliklə, lazerlər həm elmi tədqiqatların, həm də sənaye və gündəlik həyatın ayrılmaz bir hissəsinə çevrilməkdə davam edəcək.

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Seasonal Variation of Helminth Invasions in Turkeys

Hindilerde helmint istilasının mevsimsel değişimi

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Abstract

This article studied the seasonal variability of helminth invasions in Indian chickens, and the intensity and frequency of different parasite species' spread during various periods of the year were analyzed comparatively. According to the research results, the spread of helminth invasions has a seasonal nature and is observed with high intensity mainly in the summer and autumn months. During these periods, the increase in environmental temperature and humidity creates favorable conditions for the development of parasite eggs and larvae. During the winter and spring months, the level of infections was relatively low, which was associated with both climatic factors and the fact that chickens were kept more in enclosed conditions. During the study, mainly nematode and cestode types of helminths were found in chickens, and seasonal changes in their life cycles were noted.The article's results indicate that planning preventive measures against helminth infections according to seasons, particularly timely antiparasitic treatments in summer and autumn, is of significant importance for maintaining the health of chickens and increasing farm productivity. Additionally, the study identified a correlation between the sanitary conditions of the farm environment, feeding regimen, and age groups of the birds with the spread of helminth infestations. It has been found that birds kept in poorly disinfected areas and fed unevenly have a higher risk of infection. Young birds are more susceptible to helminth infections, which has been explained by the incomplete development of their immune system. Research results have shown that effective control of helminth infections is possible not only with drugs but also by creating proper zoohygienic conditions and regular veterinary supervision.

Keywords: Helminth infections, Seasonal variability, Parasitic infection, Bird health

Digger Wasps of The Tribe Nyssonini (Crabronidae: Bembicinae) of The Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti'nin Nyssonini (Crabronidae: Bembicinae) Kabilesinin Kazıcı Eşek Arıları

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Abstract

According to recent data, the world fauna of the tribe Nyssonini comprises 18 genera and 237 species. Within the Palaearctic region, 65 species belonging to 3 genera have been recorded. Among the countries neighboring our republic, 21 species representing 3 genera have been reported from Russia, and 22 species representing 3 genera from Turkey. The present study was carried out in 2018–2019 based on material collected from various areas of the Nakhchivan Autonomous Republic, as well as specimens preserved in the collections of the Institute of Biology and Soil Science, Far Eastern Branch of the Russian Academy of Sciences, the Institute of Zoology of the Ministry of Science and Education of the Republic of Azerbaijan, and private entomological collections. During the study years, investigations were conducted at 15 localities across 12 villages of 4 administrative districts of the autonomous republic. As a result, 13 species belonging to 2 genera of the tribe Nyssonini were identified: *Brachystegus scalaris* (Illiger, 1807); *Brachystegus incertus* (Radoszkowski, 1877); *Nysson barrei Radoszkowski*, 1893; *Nysson chevrieri* Kohl, 1879; *Nysson decemmaculatus* Spinola, 1807; *Nysson epeoliformis* F. Smith, 1856; *Nysson fulvipes* A. Costa, 1859; *Nysson guichardi* de Beaumont, 1967; *Nysson harveyi* de Beaumont, 1967; *Nysson interruptus* (Fabricius, 1798); *Nysson maculosus* (Gmelin, 1790); *Nysson militaris* Gerstaecker, 1867; *Nysson paralias* Standfuss, 2010. The distribution of the species worldwide, as well as their altitudinal ranges and landscape preferences, were determined. It was observed that most species showed a preference for the flowers of plants belonging to the families Asteraceae and Fabaceae. Among the identified taxa, *Brachystegus incertus* (Radoszkowski, 1877); Nysson chevrieri Kohl, 1879; *Nysson decemmaculatus* Spinola, 1807; *Nysson epeoliformis* F. Smith, 1856*; Nysson guichardi* de Beaumont, 1967; *Nysson harveyi* de Beaumont, 1967; *Nysson interruptus* (Fabricius, 1798) and *Nysson maculosus* (Gmelin, 1790) were found to be the most abundant and widespread species.

Keywords: Nakhchivan, Nyssonini, Brachystegus, Nysson, Genus.

The Role of Bee Products in Health and Their Effect on Viruses

Arı Məhsullarinin Sağlamliqda Rolu və Viruslara Təsiri

Роль Продуктов Пчеловодства В Здоровье И Их Влияние На Вирусы

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Abstract

Bee products have been widely used in traditional therapeutic practices for the treatment of various diseases and microbe-related infections. Apitherapy is a type of biotherapy that utilizes bees and their products as therapeutic or preventive agents to control the course of diseases. In modern times, apitherapy is recognized in many countries as a part of complementary and integrative medicine. The numerous bioactive components of bee products enhance immunity and exhibit antiviral activity, thereby strengthening the body's defense against infections and diseases. Consequently, the bioactive properties of bee products are employed to prevent or treat various illnesses. Since ancient times, bee products have been known for their diverse therapeutic properties. Although numerous studies have been conducted on bee products, there is still a need to evaluate their potential against pathogenic viruses. Existing research confirms the effectiveness of bee products in reducing viral activity. Due to this significant antiviral potential, bee products and their bioactive extracts can be effectively used as an alternative strategy for improving human health at both individual and public levels. In this regard, the article discusses the potential role of bee products, especially bee venom, in human health and their application as apitherapeutic agents in combating various infections. Research on this topic is systematically reviewed, and the results are subjected to scientific and theoretical analysis.

Keywords: bee, virus, combat, bioactive compounds.

Аннотация

Продукты пчеловодства широко используются в традиционной терапевтической практике для лечения различных заболеваний и инфекций, связанных с микроорганизмами. Апитерапия представляет собой вид биотерапии, при котором пчел и их продукты используют в качестве лечебных или профилактических средств для контроля течения заболеваний. В современное время апитерапия во многих странах признана частью комплементарной и интегративной медицины. Многочисленные биологически активные компоненты продуктов пчеловодства обладают противовирусной активностью и укрепляют иммунную систему, тем самым повышая защиту организма от инфекций и заболеваний. Поэтому биологически активные свойства пчелопродуктов применяются для профилактики и лечения различных болезней. С древних времен продукты пчеловодства известны

своими многочисленными лечебными свойствами. Несмотря на проведение большого количества исследований, существует необходимость в оценке их потенциала против патогенных вирусов. Существующие исследования подтверждают эффективность продуктов пчеловодства в снижении активности вирусов. Благодаря значительному противовирусному потенциалу, продукты пчеловодства и их биологически активные экстракты могут эффективно применяться в качестве альтернативной стратегии для улучшения здоровья человека как на индивидуальном, так и на общественном уровне. В данной статье рассматривается потенциальная роль продуктов пчеловодства, особенно пчелиного яда, в поддержании здоровья человека и их использование в качестве апитерапевтических средств в борьбе с различными инфекциями. Исследования по данной теме систематически изучаются, а полученные результаты подвергаются научно-теоретическому анализу.

Ключевые слова: пчела, вирус, борьба, биологически активные вещества.

Xülasə

Müxtəlif xəstəliklərin və mikroblarla əlaqəli infeksiyaların müalicəsində ənənəvi terapevtik praktikada arı məhsullarından geniş istifadə olunur. Arı müalicəsi xəstəliklərin gedişatını nəzarət altında saxlamaq məqsədilə arılardan və onların məhsullarından müalicəvi və ya profilaktik vasitə kimi istifadə olunan bioterapiya növüdür. Müasir dövrdə bir çox ölkələrdə apiterapiya tamamlayıcı və inteqrativ təbabətin bir bölməsi kimi qəbul edilir. Arı məhsullarının çoxsaylı bioaktiv komponentləri viruslara qarşı və immun sistemini gücləndirərək infeksiyalara və xəstəliklərə qarşı müdafiəni artırır. Ona görə də müxtəlif xəstəliklərin qarşısını almaq və ya müalicə etmək üçün arı məhsullarının bioaktiv xüsusiyyətlərindən istifadə edilir. Qədim zamanlardan bəri arı məhsulları bir sıra müalicəvi xüsusiyyətləri ilə tanınmışdır. Arı məhsulları ilə bağlı çoxsaylı araşdırmalar aparılsa da, onların patogen viruslara qarşı potensialının qiymətləndirilməsinə hələ də ehtiyac vardır. Mövcud araşdırmalar arı məhsullarının virusların azaldılmasında effektivliyini təsdiqləyir. Bu cür əhəmiyyətli antivirus potensialı sayəsində arı məhsulları və onların bioaktiv ekstraktları fərdi və ictimai səviyyədə insan sağlamlığının yaxşılaşdırılması üçün alternativ strategiya kimi effektiv şəkildə tətbiq oluna bilər. Bu mənada, məqalədə arı məhsullarının, xüsusilə də arı zəhərinin insan sağlamlığında və müxtəlif infeksiyalarla mübarizədə apiterapevtik vasitələr kimi potensial rolundan bəhs edilir. Mövzu ilə bağlı araşdırmalar sistemli şəkildə öyrənilir və nəticələr elmi-nəzəri təhlilə cəlb edilir.

Açar sözlər: arı, virüs, mübarizə, bioaktiv maddələr.

1. GİRİŞ

Arı məhsulları bioloji cəhətdən aktiv komponentlərlə zəngin qida mənbələridir. Bu məhsulların antioksidant, antiinflamatuar və immunomodulyator xüsusiyyətləri, onları virus infeksiyalarına qarşı potensial qoruyucu

vasitələrdən biri kimi göstərir. Müasir tibb və qida elmləri sahəsində aparılan tədqiqatlar göstərir ki, arı məhsulları yalnız enerji və qida dəyəri baxımından deyil, həm də orqanizmin infeksiyalara qarşı müqavimətinin artırılmasında mühüm rol oynayır. Araşdırmada arı məhsullarının bioloji təsirləri və müxtəlif virus infeksiyalarına qarşı potensial faydaları sistematik şəkildə təqdim edilir.

Son illərdə qlobal miqyasda virus infeksiyalarının, xüsusilə respirator və immunsistemə təsir edən xəstəliklərin yayılması, insan sağlamlığının qorunması məsələsini daha da aktuallaşdırmışdır. Təbii qida məhsulları və alternativ terapevtik vasitələrə maraq artmışdır. Arı məhsulları əsrlər boyu həm ənənəvi, həm də müasir tibbdə müxtəlif xəstəliklərin qarşısının alınmasında və müalicəsində istifadə edilmişdir. Onların tərkibindəki bioaktiv maddələr (flavonoidlər, fenolik birləşmələr, vitaminlər və minerallar) immun sistemini gücləndirərək viral infeksiyalara qarşı qoruyucu təsir göstərə bilir. Bu səbəbdən arı məhsullarının sağlamlıqdakı rolu və viruslara təsiri mövzusu müasir elmi tədqiqatlar üçün yüksək əhəmiyyət daşıyır.

2. METOD

Məqalədə mövzu ilə bağlı ədəbiyyat nəzərdən keçirilmiş, daha sonra arı məhsullarının tərkibi, müalicəvi xüsusiyyətləri və onların effektivliyini artırmaq üçün istifadə edilən yeni texnologiyalar təhlil olunmuşdur.

3. NƏTICƏLƏR VƏ MÜZAKIRƏ

Məlumatlar göstərir ki, arı terapiyası sahəsində elmi araşdırmalar və klinik sınaqlar daim inkişaf etməkdədir. Arı məhsullarının tərkibinin daha yaxşı öyrənilməsi onların tibbi müalicədə istifadəsinə marağı artırmışdır. Toplanan və ya sintez olunan arı məhsulları iltihabı azaltmaq, qan dövranını gücləndirmək və sağlam immunoloji cavab yaratmaqla şəfanı təşviq edir. Bundan əlavə, tədqiqatçılar ənənəvi istifadədə mövcud problemləri aradan qaldırmaq və bioyararlılığı yüksəltmək məqsədilə nanohissəciklər, skafoldlar, nanoliflər və digər innovativ yanaşmalar işləyib hazırlamışlar.

Hazırda bütün arı məhsullarının antiviral fəaliyyətinə dair elmi və klinik sübutlar mövcuddur. Məqalədə məqsəd arı məhsullarının antiviral fəaliyyətini və bu sahədə son tədqiqat inkişaflarını ətraflı şəkildə təqdim etməkdir. Arı məhsullarının və onların bioaktiv komponentlərinin antiviral və immunomodulyator təsirləri bir çox viral infeksiyalara qarşı perspektivli alternativ terapiya kimi ortaya çıxır. Arıların antivirus təsirləri iki növə ayrılır:

1. Birbaşa təsir. Bu təsir məhsulun virusla birbaşa mübarizəsi ilə bağlıdır.

2. Dolayı təsir. Dolayı təsir viruslara qarşı orqanizmin immunitetini artırmaqla mübarizə aparır. Orqanizmin immuniteti birbaşa müdafiəni stimullaşdırmaqla və ya dolayı yolla, məsələn, bağırsaq bakteriyalarının artımını sürətləndirməklə yüksələ bilər.

Xərçəng, autoimmun xəstəliklər, xroniki xəstəliklər, bakterial, göbələk və viral infeksiyalar kimi həyat üçün təhlükəli xəstəliklərin yayılması və insidens göstəriciləri bütün dünyada artmaqdadır. Bundan əlavə, bir sıra tədqiqatlarda, məsələn, C. Hajat, E. Stein. R.L. Siegel, K.D. Miller, H.E. Fuchs, A. Jemal və başqalarının araşdırmalarında, Ümumdünya Səhiyyə Təşkilatının 2021-ci ilə aid Qlobal antimikrob müqaviməti və istifadəsinə nəzarət sistemi (GLASS) hesabatında sintetik dərmanların insan sağlamlığına mənfi təsirləri və bu maddələrə qarşı dərman müqavimətinin artması səbəbindən mövcud farmasevtik preparatların hazırda ciddi böhranla qarşılaşması göstərilmişdir (Hajat & Stein, 2018, s.284-293; Siegel və b., 2022, s. 7-33; World Health Organization, 2021). R.A. Faqihi, E.A.-H. Taha "Alternativ tibb kimi apiterapiya: məqalə icmalı"nda yazırlar: "Bal arıları (Apis mellifera) müxtəlif bioaktiv komponentlərdən ibarət olan və əsrlər boyu müxtəlif sivilizasiyalar tərəfindən bir çox xəstəliklərin müalicəsində istifadə olunan məhsullar istehsal etdiklərinə görə "qızıl həşəratlar" adlandırılır" (Faqihi & Taha, 2022, s. 43-57). Beynəlxalq Arıçılar Federasiyasının redaktoru Doktor Stefan Stanqaçiu apiterapiyanı belə tərifləmişdir: "Apiterapiya — bəşəriyyətin və bütün heyvanlar aləminin rifahı naminə bal arısı və onun məhsulları vasitəsilə müalicə və holistik şəfa sənəti və elmi" (Royal (2011), s.8-19). Bal və digər arı məhsullarının müalicə məqsədilə istifadəsi qədim dövrlərə gedib çıxır. Arı məhsullarının müalicəvi faydaları müxtəlif dini mənbələrdə — İncil, Vedalar və Qurani-Kərimdə qeyd olunmuşdur (Lee və b., 2005, s. 79-84; Adewole, Ileke & Oluyede, 2013, s.235-240). Qurani-Kərimdə bütöv bir surə (Nəhl surəsi) arıların adı ilə bağlıdır. R. K. Qup¬ta və S. Stanqaçiunun "Apiterapiya: zəif səhiyyə sisteminə malik ölkələrdə arı və arı məhsulları vasitəsilə holistik (bütöv) müalicə" adlı əsərində xəstəliklərin müalicəsi üçün innovativ, təbii, ənənəvi və qeyri-sintetik dərman vasitələrinin kəşfi və hazırlanmasının vacibliyi və xalq təbabətinin hər zaman təbii inqrediyentlərdən (məhsul və qarışım) istifadə etməsi vurğulanmış və həmin vasitələrədn biri kimin apiterapiya təbii vasitələ kimi dəyərləndirilmişdir (Gupta & Stangaciu, 2014, s.413-446).

Çağdaş zamanımızda arı terapiyasının tərifi bir qədər də genişlənmiş və təkmilləşmişdir. Bu anlayışa yalnız arı məhsullarının istifadəsi deyil, həm də arı akupunkturası (bədənin müəyyən nöqtələrinə nazik iynələrin batırılması yolu ilə orqanizmin enerjisinin tarazlanmasını təmin edən və sağlamlığı dəstəkləyən bir terapiya metodu) və hətta arıların fəaliyyətinin təbii prinsiplərinə və arıçılıq təsərrüfatlarına əsaslanan metodların insan müalicəsində tətbiqi daxildir.

Araşdırmalar göstərir ki, apiterapiyanın dəqiq başlanğıcını müəyyənləşdirmək hələ də mümkün olmamışdır. Lakin bəzi araçşdırmalarda onu qədim Misir və Yunanıstanla əlaqələndirirlər. Çin təbabətində isə apiterapiyanın 3–5 min il əvvəl tətbiq olunduğu göstərilir (Rose, 1994, s.267). Qədim Hindistan və Misir mənbələrində balın yaraların sağaldılması üçün istifadəsi göstərilir. Tədqiqatlarda Ebers papirusunda (e.ə. 1550) balın xarici tətbiq üçün 147 reseptdə qeyd edildiyi, yunanlar və romalıların arı məhsullarından tibbi məqsədlərlə istifadə etməsi bildirilir. Dünyada "tibb elminin atası" sayılan qədim yunan həkimi Hippokrat

balın təsirlərini belə təsvir etmişdir: “O, istilik yaradır, yaraları və xoraları təmizləyir, dodaq xoralarını yumşaldır, qarbunkulları (bir neçə birləşmiş furunkulun (dəri qovuşaqlarında irin toplanması) əmələ gətirdiyi böyük iltihabi ocaqları) və irinli yaraları sağaldır” (Majno, 1975). Bal və arı zəhərinin tibbi dəyəri Hippokrat (e.ə. 460–370), Aristotel (e.ə. 384–332) və Qalen (e. 130–200) tərəfindən də qeyd olunmuşdur. Qalen saç tökülməsinə qarşı bal və arı zəhərinin istifadəsini tövsiyə etmişdir. Aristotel isə bal yeməyin sağlamlıq və canlılığı qoruduğunu bildirmişdir. Qədim Roma farmakopeyasında ən faydalı məhsul bal hesab olunurdu. Yunan filosofu Aristotel “Historia Animalium” (Heyvanların Tarixi) əsərində balın göz ağrılarında məlhəm kimi faydasından bəhs etmişdir.

N. Urtubey “Apitoxin: from bee venom to apitoxin for medical use” (“Apitoksin: arı zəhərindən tibbi istifadə üçün apitoksinə”) adlı kitabında arı zəhərinin müalicəvi təsirlərinin ilk dəfə 1868-ci ildə Lubarski və rusiyalı Lokumski tərəfindən yenidən gündəmə gətirildiyini qeyd etmişdir (Urtubey, 2005). Son illərdə bal arısı zəhəri autoimmun və xroniki xəstəliklərdən əziyyət çəkən pasiyentlərin müalicəsində həkimlər və sertifikatlı apiterapevtlər tərəfindən tətbiq edilməkdədir (Ahmed və b., 2018, s.198). Arı zəhəri (Apitoksin) sarımtıl rəngli, acı, kəskin, şəffaf və turşulu mayedir. O, arıların qarın boşluğunda yerləşən iki zəhər vəzisində sintez olunur və sancaq aparatı ilə əlaqəlidir. Zəhərin istehsalı arıların həyatının ilk iki həftəsində artır. Arılar üçün bu, mühüm müdafiə vasitəsidir. Sancmaq qabiliyyəti yalnız dişi arılara məxsusdur. Zəhər kisəsində təxminən 0,3 mq arı zəhəri istehsal olunur. Arı zəhəri havayla təmasda dərhal kristallaşır və quruyur. Onun tərkibindəki yüksək dərəcədə uçucu maddələrin bir hissəsi toplama zamanı sürətlə itirilir (Ali, 2012, s.69-83).

Arı zəhəri müxtəlif aktiv komponentlərdən ibarətdir:

1. Melittin, adolapin və apamin daxil olmaqla peptidlər, mast hüceyrələrinin deqranulyasiyaedici peptidi.
2. Fermentlər (hialuronidaza və fosfolipaza A2).

Bundan əlavə, histamin, norepinefrin və dopamin kimi qeyri-peptid molekullar da mövcuddur. Arı zəhərinin quru kütləsinin təqribən 50 %-ni təşkil edən melittin əsas komponentdir, onu isə təqribən 12 %-lik payla fosfolipaza A2 (PLA2) izləyir (Oršolić, 2012, s.173-194; Wehbe və b., 2019, p.2997).

Arı zəhərinin həm in vitro (canlı orqanizmdən kənarda), həm də in vivo (canlı orqanizmdə) tədqiqatlar arı zəhərinin çoxsaylı terapevtik təsirlərini sübut etmişdir. Bu təsirlər haqqında çox sayda araşdırmalar aparılmışdır. Həmibn təsirləri aşağıdakı kimi qruplaşdırmaq olar:

1. Arı zəhəri metastaz əleyhinə və antikanser təsir göstərir. Bu fikir N. Orşoliç və S. E. əl-Didamoni, R. İ. Amir, G. H. əl-Osaylinin tədqiqatlarında təsdiqini tapmışdır. (Oršolić, 2012, s. 173-194; El-Didamony və b., 2022, p.13213).

2. Arı zəhərinin iltihab əleyhinə və oynaq xəstəliklərinə qarşı (anti-artritik) təsiri vardır. Bu haqda bir sıra araşdırmaçılar, o cümlədən Omar Ahmed, Hassan Fahim, Ahmed Mahmud, Eman Ahmed təsdiq edirlər ki, arı zəhəri və hesperidin immunomodulyasiya və antioksidant müdafiə sisteminin gücləndirilməsi yolu ilə tam Freund adjuvantı (yəni peyvəndin və ya immunoloji tədqiqatın təsirini gücləndirən maddə) ilə induksiya olunmuş artriti effektiv şəkildə azaldır. (Ahmed və b., 2018, p. 198).

3. Arı zəhəti antimikrob təsir göstərə bilir. Bu, María Carpena, Nunyez-Estevez, Arturo Soria Lopez və Simal Qandaranın "Arı zəhəri: onun bioaktiv molekullarına və sağlamlığa tətbiqlərinə dair yenilənmiş icmal", Selim Didamoni, Mohamed Kalaba, Esmail əl-Fakharani, Mahmud H. Sultan və Mohamed Şarafın "Xitozan nanopartikullarına yüklənmiş arı zəhərinin antifunqal və antibiofilm fəaliyyəti: insanlarda göbələk patogenlərinə qarşı yeni yanaşma" adlı tədqiqatları dorulayır (Carpena və b., 2020, s. 3360; El-Didamony və b., 2022, s.244).

4. Arı zəhəri antioksidant və iltihab əleyhinə təsir göstərir. Bu haqda Syed Ali Hassan, Rami S. Alazragi, Naime Salemin "Arı zəhərinin sisteplatindən əmələ gəlmiş hepatotoksikliyin müalicəsində potensial terapevtik təsiri", María Karpena Rodríquez, Bernabe Nunez Estevez, Arturo Soria Lopez, Jesus Simal-Qandaranın "Arı zəhəri: onun bioaktiv molekullarına və sağlamlığa tətbiqlərinə dair yenilənmiş icmal " adlı tədqiqatları geniş məlumat verir (Hasan və b. (2021), s. 200-210; və b., 2020, s.3360

5. Arı zəhəri antimutagen (mutasiyaların (yəni genetik dəyişikliklərin) yaranmasının qarşısını alan və ya onların təsirini azaldan) və ağrıazaldıcı (antinoseptiv) təsirə malikdir. Belə ki, "Zəhər xəstənin vəziyyətini yaxşılaşdırır, tonus və iş qabiliyyətini artırır, yuxusuzluq, iştaha və qan-damar sisteminə müsbət təsir göstərir" (https://share.google/AfC8xyoqL9lSGqvUp).

6. Arı zəhərinin qaraciyəri zədələnmədən qoruyucu (anti-hepatotoksik) və hüceyrəqoruyucu (sitoprotektiv) təsirləri vardır. Bu təsir S.A. Hassan, R.S. Alazraqi və N.A. Salemin "Arı zəhərinin sisteplatindən əmələ gəlmiş hepatotoksikliyin müalicəsində potensial terapevtik təsiri" ilə bağlı araşdırmasında əsaslandırılmışdır (Hassan və b., 2021, s.200-210).

7. Arı zəhəri antiviral, neyroprotektiv təsirə malikdir (Carpena və b., 2020, s.3360).

8. Arı zəhəri radiasiyadan qoruyucu (radioprotektiv) təsir göstərə bilir. Bu təsir Luka Kornara, Miçele Biaçi, Cun Şiao, Bruno Burlandonun müəllifliyi ilə aparılan "Fərqli arı məhsullarından əldə olunan bioaktiv birləşmələrin terapevtik xüsusiyyətləri" adlı tədqiqatla sübut olunmuşdur. (Cornara və b., 2017, p.412).

4. NƏTİCƏ

Arı terapiyası sadə, əlçatan və istifadəsi asan bir müalicə vasitəsi olub, həm ənənəvi təbabətdə tətbiq olunur, həm də müxtəlif xəstəliklərin müalicəsində xüsusi potensiala malikdir. Lakin onun effektivliyini və

təhlükəsizliyini sübut etmək üçün əlavə tədqiqatlara ehtiyac vardır. Bundan başqa, praktikada tənzimləyici normaların olmaması hələ də problem olaraq qalır.

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Taxonomic Composition, Ecological Assessment and Potential for Use of Marine Algae Along the Neftchala Coast of the Caspian Sea (Azerbaijan)

Hazar Denizi'nin Neftçala Kıyısındaki (Azerbaycan) Deniz Yosunlarının Taksonomik Bileşimi, Ekolojik Değerlendirmesi ve Kullanım Potansiyeli

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Abstract

From January to September 2025, the coastal waters of Neftchala district (Azerbaijan, Caspian Sea) were the subject of the first taxonomic and ecological evaluation of macroalgae and cyanobacterial communities. A total of 26 taxa representing 11 families and 14 genera were identified, grouped into four phyla: Rhodophyta (2), Heterokontophyta (6), Cyanobacteria (8), and Chlorophyta (10 taxa). The predominant group consisted of green algae (38.4%), followed by red algae (7.7%), cyanobacteria (30.7%), and diatoms (23%). Between 24 and 26 taxa, species richness and diversity indices showed only slight spatial variation across sampling stations; a well-balanced algal assemblage was indicated by Shannon diversity (H′ = 3.171–3.232). Ikinci Mayak displayed lower values, indicating localized anthropogenic stress, whereas the Shirvanli station displayed the highest levels of richness and diversity. Lyngbya aestuarii, Planktolyngbya limnetica, Nitzschia palea, and Corallina officinalis were the primary causes of the high degree of dissimilarity (>90%) between sites, according to SIMPER analysis. Shirvanli supported a variety of epilithic, epipsammic, and planktonic taxa, whereas Ikinci Mayak was dominated by tolerant epilithic forms, according to ecological group analysis, which showed spatial differentiation. The saprobic index (2.59–2.62) revealed β–α-mesosaprobic conditions, indicating weak hydrodynamic circulation and moderate organic pollution most likely brought on by human inputs. The study emphasizes how human activity and local environmental heterogeneity affect the composition of algal communities along the southern Caspian coast. The acquired data offer a useful point of reference for upcoming coastal monitoring and bioindication research in the area.

Keywords: Anthropogenic Impact, Biodiversity, Caspian Sea, Marine Algae, Neftchala Coast

Zirinc (Berberis vulgaris L.) Bitkisinin Naxçıvan Florasında Yayılması, Kimyəvi Tərkibi və Farmakoloji Əhəmiyyəti

The Distribution, Chemical Composition, and Pharmacological Significance of the Barberry (Berberis vulgaris L.) Plant in the Flora of Nakhchivan

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Xülasə

Zirinc (Berberis vulgaris L.) Naxçıvan Muxtar Respublikasının dağlıq və dağətəyi bölgələrində təbii şəkildə yetişən çoxillik tikanlı kol bitkisidir. Tərkibindəki alkaloidlər (berberin, berbamin, palmatin), fenolik birləşmələr, flavonoidlər və C vitamini sayəsində bitki antioksidant, antimikrob, antidiabetik və hepatoprotektiv xüsusiyyətlərə malikdir. Naxçıvan şəraitində zirincin yayılma arealı, morfoloji xüsusiyyətləri, kimyəvi tərkibi və tibbi əhəmiyyəti geniş şəkildə araşdırılmalıdır. Dərman əhəmiyyətli bitkilərin qorunması üçün tədbirlər görülməlidir.

Açar sözlər: Zirinc, Berberis vulgaris, Naxçıvan florası, farmakologiya, alkaloidlər

Abstract

Barberry (Berberis vulgaris L.) is a perennial thorny shrub that naturally grows in the mountainous and foothill regions of the Nakhchivan Autonomous Republic. Due to the presence of alkaloids (berberine, berbamine, palmatine), phenolic compounds, flavonoids, and vitamin C, the plant possesses antioxidant, antimicrobial, antidiabetic, and hepatoprotective properties. In the conditions of Nakhchivan, the distribution area, morphological characteristics, chemical composition, and medicinal significance of barberry should be extensively studied. Measures should be taken to protect medicinally valuable plants.

Keywords: Barberry, Berberis vulgaris, Nakhchivan flora, pharmacology, alkaloids

Giriş

Naxçıvan Muxtar Respublikası Azərbaycanın endemik və dərman bitkiləri ilə zəngin floristik bölgələrindən biridir. Zirinc (Berberis L.) qədim və tibbi əhəmiyyəti olan bitkilərdən biridir. Naxçıvanın iqlimi və torpaq xüsusiyyətləri bu bitkinin optimal inkişafı üçün əlverişlidir. Zirinc (Berberis vulgaris)- Zirinckimilər fəsiləsindən olan kol bitkisi. Adi zirin düzənliklərdən tutmuş mərkəzi yüksək dağlıq ərazilərə kimi Azərbaycanın hər yerində geniş yayılmışdır (Elşad Q 2009). Yer üzündə 450 növü vardır ki, Azərbaycanda o cümlədən Naxçıvanda 7 növü yayılmışdır ki bunun 1 növü mədəni digər 6 növü yabanı halda mövcuddur. Naxçıvan MR-da Ordubad, Şahbuz, Culfa və Kəngərli rayonlarındakı dağ ətəyi kolluqlarda daha çox

yayılmışdı Zirinc 2–3 metr hündürlüyündə, tikanlı budaqlara malik kol bitkisidir (Tariyel T, Anvar İ 2014). Yarpaqları dişli kənarlı və uzunsovdur. Çiçəkləri sarı rəngdə, may–iyun aylarında açır. Meyvəsi qırmızı və turşməzə dadlıdır, sentyabr–oktyabrda yetişir. Ən çox yayılmış növ adi zirincdir (Berberis L).

- **Berberin:** antibakterial və ödqovucu təsir göstərir.
- **Berbamin:** iltihabəleyhinə və antineoplastik təsir.
- **Palmatin:** sinir sisteminə sakitləşdirici təsir.
- **Flavonoidlər:** antioksidant təsir.
- **Vitamin C və üzvi turşular:** immuniteti möhkəmləndirir.

Zirinc antimikrob, antiinflamatuar, antidiabetik və hepatoprotektiv təsirlərə malikdir. Meyvələri ənənəvi olaraq ödqovucu və qan təmizləyici vasitə kimi istifadə olunur (Fatma E 2021). Müasir tədqiqatlar göstərir ki, ekstraktları lipid metabolizmini tənzimləyir və ürək-damar xəstəliklərinin profilaktikasında faydalıdır. Bu bitkinin müxtəlif orqanlarında müxtəlif alkaloidlərə rast gəlinir ki, onlardan ən əsası berberindir. Bu alkaloid müxtəlif təsirlər göstərə bilər, o cümlədən antioksidant, antiinflamatuar, hipoqlikemik, hipotenziv və hipolipidemik fəaliyyətləri var. Kökü, qabığı, yarpaqları və meyvələri ənənəvi tibbdə antihistamin, antixolinergik, antinosiseptiv, iltihab əleyhinə, vazokonstriktor, ödqovucu, işlətmə və qızdırma salıcı kimi istifadə olunur (Mustafa A 2021). Zirinc torpağın eroziyaya qarşı qorunmasında mühüm rol oynayır. Dekorativ əhəmiyyətə malikdir və şəhər yaşıllaşdırılmasında istifadə olunur. Arılar üçün qiymətli nektar mənbəyidir.

Antimikrob və antibakterial təsir: Berberin, bakteriyaların çoxalmasını və bəzi patogen mikroorqanizmlərin fəaliyyətini əngəlləyir.

Həzm sisteminə faydası: Zirinc kökləri və meyvələri mədə-bağırsaq problemlərində (dispepsiya, qastrit, bağırsaq infeksiyaları) istifadə olunur.

Qan şəkərinin tənzimlənməsi: Tədqiqatlar göstərir ki, berberin insulinə həssaslığı artıraraq qanda şəkər səviyyəsinin sabitləşməsinə kömək edə bilər.

Ürək-damar sistemi üçün faydalı təsir: Bitkinin tərkibindəki flavonoidlər və alkaloidlər qan təzyiqini tənzimləyə, xolesterolu azalda və ürək-damar sağlamlığını dəstəkləyə bilər (Beyzanur B , Emine A 2023)..

Antioksidant təsir: Vitamin C və flavonoidlər sərbəst radikallara qarşı qoruyucu təsir göstərir, hüceyrələrin zədələnməsini azaldır (Beyzanur B , Emine A 2023).

Berberis vulgarisin ən məşhur təsirlərindən biri onun arıqlama faydalarıdır. Tərkibindəki berberin bədəndə yağ yığılmasını azaldır və maddələr mübadiləsini gücləndirərək arıqlamağa kömək edir. Piylənmə ilə mübarizədə yüksək effektli olan bu bitki yağ toxumalarında yığılan trigliseridləri parçalamağa kömək edir. O, həmçinin iştahı idarə etməyə kömək edir və həddindən artıq yemək istəyini azaldır. Zirincin kökü, gövdəsi

və meyvəsi müxtəlif tibbi məqsədlər üçün istifadə olunur. Onun əsas bioaktiv maddəsi berberindir, bu da antimikrobial və antiinflamatuar xüsusiyyətlərə malikdir. Eyni zamanda meyvələrindən hazırlanan şirələr və mürəbbələr iqtisadi əhəmiyyət daşıyır. Naxçıvan bölgəsi üçün ekoloji tədqiqatlar məhduddur, lakin bu bitkinin həm iqtisadi, həm də tibbi əhəmiyyəti nəzərə alınmalıdır. Gələcək tədqiqatlarda artırılması nəzərdə tutulur.

Nəticə

Zirinc (Berberis vulgaris L.) Naxçıvan florasında həm ekoloji, həm də farmakoloji baxımdan əhəmiyyətlidir. Onun biokimyəvi tərkibi tibbi və farmakoloji sənaye üçün perspektivli resursdur. Zirinc bitkisi xalq təbabətində də geniş istifadə edilir. Zirinc bitkisinin qorunmasının artırılması məqsədilə tədbirlər görülməlidir.

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Beyzanur BOSTANCI , Emine AKALIN An overview of the therapeutic potentials and safety profiles of Berberis species in Türkiye 2023

The Role of Gender and Language in Dyslexia

Dislekside Cinsiyet ve Dil Faktörü

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Abstract

Dyslexia is a neurodevelopmental disorder observed in children with normal or above-average intelligence, characterized by specific difficulties in reading, writing, and language processing. This study aims to examine dyslexia symptoms among primary school students in Azerbaijan, focusing on the roles of gender and language of instruction. Conducted as a cross-sectional field study, data were collected from Azerbaijani and Russian sections of various schools. Results showed that dyslexia symptoms were more prevalent among male students and those studying in Russian-language programs, where orthographic and phonological complexity may hinder reading acquisition. Additionally, findings indicate that early reading difficulties are often temporary adaptation challenges rather than persistent disorders; as students adapt to the learning environment, dyslexia-like symptoms decrease by approximately 80% by grades 3–4. The study highlights the importance of early observation, educational and psychological interventions, and nutritional support (notably zinc and omega-3) in managing dyslexia. Increasing awareness among teachers and families, and implementing individualized educational programs, can enhance learning outcomes and support children's cognitive development in Azerbaijan.

Keywords: Dyslexia, Neurodevelopmental Disorder, Education Language, Adaptation, Azerbaijan, Early Intervention

The forest-meadow Vegetation Distributed across the Territory of the Julfa District

Culfa İlçesi Topraklarına Dağılmış Orman-Çayır Bitki Örtüsü

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Abstract

The geographical location, climate and soil characteristics, vegetation cover, and biological diversity of the forest-meadow ecosystems of the Julfa (Culfa) district have been comprehensively analyzed on a scientific basis. The conducted research has determined that the forest-meadow zones formed in the mountainous and foothill areas of the Julfa district have developed as a result of the interaction between the morphological structure of the relief, climatic conditions, hydrological factors, and soil types. These ecosystems play an important ecological role not only in maintaining the stability of the natural environment but also in supporting the development of sectors such as agriculture and beekeeping. The forest-meadow landscapes represent one of the principal sources of the bioecological diversity of the Julfa district. As the altitude increases, the composition of plant species changes, clearly reflecting the manifestation of vertical zonality. Moreover, these ecosystems play a significant role in preventing soil erosion, regulating the water balance, stabilizing the microclimatic conditions, and maintaining the carbon cycle. At the same time, the conservation and sustainable management of the forest-meadow areas of the Julfa district are regarded as one of the key directions for ensuring regional ecological security and the efficient utilization of natural resources.

Keywords: Forest-Meadow Ecosystem, Vegetation Cover, Biodiversity, Ecological Stability

The Anthelmintic Effect of Preparative Forms of Tansy (Tanacetum vulgare l.) against Avitellinosis in Sheep

Dağ Tarhununun (Tanacetum vulgare L.) Kullanıma Hazır Formlarının Koyunlardaki Avitellinosis Hastalığına Karşı Anthelmintik Etkisi

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Abstract

Avitellinosis is a helminthic disease caused by species belonging to the ***Avitellinidae*** family and Avitellina centripunctata (A centripunctata) in ruminant animals. Since *Avitellina* species are biohelminths, certain species of soil insects belonging to the class Insecta and the order Collembola (such as *Drepanura*, *Willwosia*, and *Lepidocyrtus*) serve as intermediate hosts in their development. Tansy (*Tanacerum vulgare L.*) is a common medicinal plant used in medicine since ancient times. Forty animals divided into 4 equal groups. Group 1 was given 5 g of herbal plant meal for 3 days; Group 2 was given 5 ml/kg of herbal infusion; Group 3 was given decoction at a dose of 5 ml/kg. All medicinal forms were given twice a day with an interval of 12 hours for 3 days. Group 4 was maintained as the control group. 5 days after the application of the plant, fecal samples were taken from the rectum of the animals. According to the results of fecal examination, the effectiveness of treatment in the group receiving plant meal was 60%; 40% effectiveness in the group receiving infusion and 50% in the group receiving decoction. The animals of the control group had 100% infection.

Keywords: Avitellina, Medicinal Plant, Herbal Flour, Infusion, Decoction.

Algal Biodiversity of Continental Water Bodies in Ismayilli District and Their Biotechnological Potential Related to Apitherapy

İsmayıllı İlçesinin Karasal Su Havzalarının Yosun Biyoçeşitliliği ve Apiterapi ile İlişkilendirilebilen Biyoteknolojik Potansiyeli

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Abstract

The continental water bodies of the Ismayilli District possess significant ecological and socio-economic importance, constituting the main freshwater resources of the region and ensuring the sustainability of local ecosystems. This study presents the results of algofloristic investigations conducted in various springs and rivers of the Ismayilli District. The main aim of the research is to determine the species composition, ecological distribution, and biotechnological potential of phytoplankton communities inhabiting these water bodies. Samples were collected in May, July, and September of 2024, and both planktonic and benthic (periphytic) forms were recorded at each sampling site. The main physico-chemical parameters of water—temperature, pH, electrical conductivity, and turbidity—were measured in situ, and samples were preserved in 4% formalin solution. Laboratory analyses were performed using an Amplival light microscope, and taxonomic identification was based on the AlgaeBase database.

In total, 52 taxa were identified, belonging to the divisions *Charophyta* (8), *Chlorophyta* (12), *Cyanobacteria* (11), *Euglenophyta* (6), and *Heterokontophyta* (15). Within the overall algal composition, *Heterokontophyta* (28.8%) and *Chlorophyta* (23.1%) were dominant. The most common species included *Anabaena saaremaaensis* (Skuja), *Dolichospermum circinale* (Rabenhorst ex Bornet & Flahault) Wacklin, Hoffmann & Komárek, *Spirulina subsalsa* (Oersted ex Gomont), *Chlorella vulgaris* (Beijerinck), *Cladophora glomerata* (Linnaeus) Kützing, and *Euglena viridis* (O.F. Müller) Ehrenberg. Seasonal observations revealed that diatoms reached their maximum density during summer, whereas cyanobacteria were more active in spring. Species distribution showed a strong correlation with water temperature, light intensity and trophic conditions.The biotechnological and applied potential of the algal taxa was also assessed. *Spirulina subsalsa* and *Chlorella vulgaris* demonstrated promising properties for use as dietary supplements and in apitherapy due to their high protein and antioxidant content. *Cyanobacterial* representatives enhance ecosystem productivity through biological nitrogen fixation, while *Charophyta* and *Chlorophyta* can be utilized in biofiltration and water

purification systems. Members of *Heterokontophyta* and *Euglenophyta* possess potential applications in biosensors, bioreactors, and bioenergy technologies.

Thus, the algal diversity identified in the continental waters of the Ismayilli District is of great importance both as a bioindicator and as a biotechnological resource. These findings provide a valuable scientific basis for assessing the ecological status of regional waters and for the development of nature-based biotechnological applications.

Keywords: Ismayilli District; algae; bioindicator; biotechnological resource

➢ 1.INTRODUCTION

The continental water bodies of the Ismayilli region hold significant ecological and socio-economic importance. These aquatic systems not only constitute the region's primary freshwater reserves but also serve as vital components ensuring the sustainability of ecosystems. Since continental waters are highly sensitive to anthropogenic influences, their ecological condition is regarded as one of the main indicators of environmental health (Bellinger & Sigee, 2015). Moreover, these water bodies possess economic value due to their role in agriculture, fisheries, tourism, and recreation. Springs located in mountainous and forested areas represent strategically important sources of clean drinking water. From an ecological perspective, the protection of these waters plays a crucial role in maintaining biodiversity (Wehr et al., 2015). Furthermore, these aquatic ecosystems contribute to preventing erosion, preserving soil fertility, regulating the carbon cycle, and supporting oxygen production—making them an essential part of ecosystem services (Muxtarova & Muradova, 2021).

Due to their species richness and ecological sensitivity, algal communities are considered reliable bioindicators for assessing the ecological status of aquatic environments (Sharma et al., 2020). Therefore, studying algal biodiversity holds significant scientific and practical value for both the conservation of biological diversity and the sustainable management of freshwater ecosystems.

Algae are not only indicators of environmental quality but also important biological resources with substantial biotechnological potential (Smith & Bidigare, 2022). Their species composition and biomass parameters are used to determine the trophic state of water bodies, while also finding application in biotechnology, food production, cosmetics, and pharmacology (Şirin et al., 2019). Rich in proteins, vitamins, and minerals, algae are valuable raw materials for both animal feed and human nutrition. Additionally, algal pigments, antioxidants, and antibacterial compounds are bioactive components of considerable biotechnological significance (Singh & Sharma, 2021). The rapid growth rate and high biomass productivity of algae make them promising candidates for alternative energy production, particularly biofuel generation (Zimba & Gama,

2019). Their bioremediation capabilities also enhance their use in purifying polluted waters and absorbing heavy metals (Falasco et al., 2009).

Thus, algae possess dual importance as both ecological indicators and biotechnological resources. In this context, the study of algal species composition, ecological distribution, and bioindicator properties in the continental water bodies of the Ismayilli region is a relevant scientific task, contributing to the assessment of regional ecological conditions and the identification of potential applications of these organisms. In recent years, the integration of apitherapy—the medical and preventive use of bee products—with the bioactive compounds of algae has gained growing scientific interest (Yıldız et al., 2020). This study evaluates the biodiversity indicators of algal species recorded in certain springs and rivers of the Ismayilli region and explores their potential biotechnological significance in relation to apitherapy.

➢ 2.MATERIALS and METHOD/METHODS ETC

Algal samples were collected during May, July, and September of 2024. At each sampling site, both planktonic and benthic (periphytic) forms were observed. The samples were collected in sterile glass flasks, hermetically sealed, and preserved with a 4% formalin solution. All collected materials were properly labeled, and the precise geographical coordinates (GPS) of each site were recorded. Water temperature was measured in the field using a mercury thermometer, while pH values were determined with a portable pH meter (Aboal & Puig, 2005).

In the laboratory phase, the samples were examined using an Amplival-type light microscope (Carl Zeiss-Jena). Prior to microscopic analysis, all samples underwent standard cleaning and mounting procedures. Taxonomic identification was carried out following modern systematic approaches, with species names and classifications standardized according to the AlgaeBase database (Guiry & Guiry, 2025).

For morphological identification, key floristic references were used, including Coesel & Meesters (2007), Dillard (1991), Hindák (2008), Lenzenweger (1996–1999), John et al. (2021), Prescott (1973), Uherkovich (1995), and Wołowski & Hindák (2005).

Additionally, literature data on the biotechnological potential of algae were reviewed during the laboratory stage. Particular attention was given to recent scientific studies concerning bioactive compound synthesis, antioxidant and antimicrobial properties of various algal groups, as well as their applications in apitherapy and nature-based biotechnological products (Singh & Sharma, 2021; Smith & Bidigare, 2022). The findings from these studies emphasized that algae serve not only as ecological indicators but also as valuable biotechnological resources.

3.RESULTS and DISCUSSION

The algal flora identified from the studied continental water bodies comprises a total of 52 taxa. These include representatives of the following divisions: *Charophyta* (8 taxa), *Chlorophyta* (12 taxa), *Cyanobacteria* (11 taxa), *Euglenophyta* (6 taxa), and *Heterokontophyta* (15 taxa). Accordingly, the proportional composition of the algal community is as follows: Charophyta–approximately 15.4%, Chlorophyta– 23.1%, Cyanobacteria– 21.2%, Euglenophyta– 11.5%, and Heterokontophyta– 28.8% of the total identified taxa.

The floristic list of algal species recorded in the investigated water bodies is presented in Table 1.

Table 1. List of algal species identified in the sampled water bodies.

Taxa		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
ivision	***CYANOBACTERIA***																	
Class	***Cyanophyceaeae***																	
Order	***Nostocales***																	
Family	***Aphanizomenonace***																	
	Anabaena saaremaaensis Skuja	+			+		+	+			+		+	+		+		
	Anabaena sp.Bory ex Bornet & Flahault	+		+					+	+				+			+	
	Dolichospermum circinale (Rabenhorst ex Bornet & Flahault) Wacklin, Hoffmann & Komárek		+			+						+	+		+		+	+
Family	***Nostocaceae***																	
	Nostoc communeVaucher ex Bornet & Flahault	+	+			+	+				+				+	+		
Order	***Spirulinales***																	
Family	***Spirulinaceae***																	
	Spirulina Turpin ex Gomont			+	+			+	+	+			+	+	+		+	
	Spirulina subsalsaOersted ex Gomont			+	+		+				+		+			+		+
Order	***Oscillatoriales***																	
Family	***Oscillatoriaceae***																	

	Phormidium Kützing ex Gomont	+					+				+							+			
	Oscillatoria limosa C.Agardh ex Gomont	+		+			+				+							+			
	Oscillatoria sp	+		+				+					+								
Order	***Leptolyngbyales***																				
Family	***Leptolyngbyaceae***																				
	Leptolyngbya aeruginea (Kützing ex Hansgirg) Komárek		+		+			+					+								+
Order	***Chroococcidiopsidales***																				
Family	***Gloeocapsaceae***																				
	Gloeocapsa alpine Nägeli	+		+			+			+	+			+	+			+			
Division	***CHLOROPHYTA***																				
Class	***Ulvophyceae***																				
Order	***Cladophorales***																				
Family	***Cladophoraceae***																				
	Chaetomorpha tortuosa (Dillwyn) Kleen		+				+			+											
	Cladophora glomerata (L innaeus) Kützing		+				+			+								+			
	Cladophora pulvinata (K. I.Meyer) K.I.Meyer		+				+			+								+			
Family	***Ulotrichaceae***																				
	Ulothrix Kützing						+			+				+							
Family	***Pithophoraceae***																				
	Pithophora roettleri (Roth) Wittrock	+			+						+										+
Class	***Chlorophyceae***																				
Order	***Oedogoniales***																				
Family	***Oedogoniaceae***																				
	Oedogonium Link ex Hirn		+		+			+				+					+				+
Order	***Volvocales***																				
Family	***Chlamydomonadaceae***																				
	Chlamydomonas sp. Ehrenberg	+		+		+	+	+	+		+	+	+		+			+			+

Order	***Sphaeropleales***																	
Family	***Scenedesmaceae***																	
	Scenedesmus quadricauda(Turpin) Brébisson		+						+			+				+		
Order	***Sphaeropleales***																	
Family	***Hydrodictyaceae***																	
	Pediastrum boryanum(Turpin) Meneghini			+							+				+		+	
Class	***Trebouxiophyceae***																	
Order	***Chlorellales***																	
Family	***Chlorellaceae***																	
	Chlorella vulgaris Beijerinck	+	+		+			+		+		+			+		+	
Class	***Zygnematophyceae***																	
Order	***Zygnematales***																	
Family	***Zygnemataceae***																	
	Zygnemasp.C.Agardh			+			+		+		+			+		+		
Class	***Zygnematophyceae***																	
Order	***Desmidiales***																	
Family	***Desmidiaceae***																	
	Cosmarium botrytisMeneghini ex Ralfs		+		+	+						+			+			
Division	***CHAROPHYTA***																	
Class	***Charophyceae***																	
Order	***Charales***																	
Family	***Characeae***																	
	Chara vulgaris Linnaeus	+						+	+			+	+			+		
	Chara contraria A.Braun ex Kützing			+			+		+		+				+			
	Chara globularis Thuiller			+			+											
	Chara hispida Linnaeus										+			+				+

	Nitella flexilis(Linnaeus) C.Agardh				+				+					+			+						+
	Nitella opaca(C.Agardh ex Bruzelius) C.Agardh			+				+				+				+					+		
	Tolypella nidifica(O.F.Müller) A.Braun		+			+					+						+						
Class	***Zygnematophyceae***																						
Order	***Spirogyrales***																						
Family	***Spirogyraceae***																						
	Spirogyra Link	+	+			+			+	+			+	+	+						+		
Division	***Heterokontophyta***																						
Class	***Bacillariophyceae***																						
Order	***Naviculales***																						
Family	***Naviculaceae***																						
	Navicula radiosa Kützing	+			+						+			+	+			+	+				
	Navicula cryptocephala Kützing	+								+		+			+	+					+		
	Navicula bryophila J.B.Petersen	+					+		+				+	+	+			+			+		
	Navicula trivialis Lange-Bertalot	+				+		+							+	+				+	+		
	Navicula capitatoradiata H.Germain ex Gasse	+		+		+										+	+		+				
	Navicula mutica *Kützingsp*	+	+				+	+				+			+			+			+		
Family	*Pinnulariaceae*																						
	Pinnularia viridis (Nitzsch) Ehrenberg 1843	+		+		+	+			+	+				+	+			+				
Order	*Achnanthales*		+					+			+	+	+				+						
Family	*Achnanthidiaceae*																						
	Achnanthidium minutissimum (Kützing) Czarnecki	+	+			+				+	+	+				+	+				+		
Order	*Cymbellales*																						
Family	*Gomphonemataceae*																						

	Gomphonema parvulum (kützing) kützing	+	+			+				+	+	+			+	+			+		
	Gomphonema sp.	+													+						
Family	*Cymbellaceae*																				
	Cymbella tumida (Brébisson) Van Heurck			+													+			+	
Order	*Fragilariales*																				
Family	*Fragilariaceae*																				
	Synedra ulna (Nitzsch) Ehrenberg 1832		+				+					+				+					+
Order	*Surirellales*																				
Family	*Surirellaceae*																				
	Surirella angusta Kützing	+		+			+					+					+	+			
Order	*Bacillariales*																				
Family	*Bacillariaceae*																				
	Nitzschia amphibia grunow	+													+	+	+	+	+		
	Nitzschia palea (kützing) w.smith	+				+	+	+								+			+		
Division	*Euglenophyta*																				
Class	*Euglenophyceae*																				
Order	*Euglenales*																				
Family	*Euglenaceae*																				
	Euglena viridis O.F.Müller) Ehrenberg			+				+							+						+
	Phacus longicauda (Ehrenberg) Dujardin		+							+									+		
	Trachelomonas volvocina (Ehrenberg) Ehrenberg	+					+					+			+		+				
	Trachelomonas hispida (Perty) F.Stein			+						+						+					+

Euglena acus (O.F.Müller) Ehrenberg					+				+			+				
Euglena sp	+		+				+				+					

* 1.Basqal River, 2.Dambulu Spring, 3.Haji Jabi Spring, 4.Goshabulag (Twin Spring), 5. Papaqqi Spring, 6.Mijjon, 7.Tandireki Spring, 8.Pir Spring, 9.Su Bashi (Water Source), 10.Shahid Spring, 11.Goshabulag (Sulut), 12.Sulut Spring, 13.Mucu River, 14.Mucu Spring, 15.Dayirmi Spring, 16. Shykshireki Spring, 17. Taghlabyan Spring

In the investigated continental water bodies, the phytoplankton community was composed of representatives from the *Cyanobacteria*, *Chlorophyta* and *Heterokontophyta* divisions. Within *Cyanobacteri*a, species belonging to the families *Aphanizomenonaceae* and *Nostocaceae*—including *Anabaena saaremaaensis*, *Dolichospermum circinale* and *Nostoc commune*—were widely distributed across various sampling stations. Representatives of the family *Spirulinaceae*, particularly *Spirulina* and *S. subsalsa*, were active during the summer months, while species belonging to *Oscillatoriaceae* and *Leptolyngbyaceae* exhibited relatively low abundance.

The division *Chlorophyta* comprised the classes *Ulvophyceae*, *Chlorophyceae* and *Trebouxiophyceae*, with identified species such as *Cladophora glomerata*, *Oedogonium*, and *Chlorella vulgaris*. Members of *Charophyta* (*Chara, Nitella)* were observed only at selected stations, whereas *Heterokontophyta* was mainly represented by *Bacillariophyceae* (diatoms), which dominated the community. Representatives of *Euglenophyta*, including *Euglena viridis*, *Phacus longicauda*, and *Trachelomonas*, were recorded only at specific sites. The taxonomic composition of these species is closely associated with the ecological status and seasonal conditions of the studied water bodies. At the same time, algae exhibit considerable biotechnological potential. *Spirulina subsalsa* and *Chlorella vulgaris*, due to their high protein and antioxidant content, are valuable for use in nutritional supplements, while *Cyanobacteria* contribute to ecosystem balance through biological nitrogen fixation. Representatives of *Charophyta* and *Chlorophyta* are applicable in biofiltration and water purification systems, whereas *Heterokontophyta* species have potential uses in biosensor and bioreactor technologies. Members of *Euglenophyta*, due to their lipid and carbohydrate reserves, are promising for bioenergy and biomass production. Extracts derived from microalgae can serve as bioactive components in apitherapy, cosmetics, and the pharmaceutical industry (Singh & Sharma, 2021; Smith & Bidigare, 2022).

Thus, the algal communities inhabiting the continental waters of the Ismayilli region hold significant ecological and biotechnological importance, providing a valuable foundation for future scientific research.

4.CONCLUSION

The conducted research indicates that the phytoplankton community formed within the continental water bodies of the Ismayilli region is characterized by high taxonomic diversity. The distribution and abundance of various species are closely related to the ecological status of the water bodies, seasonal dynamics, and their physicochemical parameters.

At the same time, the studied algae possess great significance not only as bioindicators but also as biotechnological resources. *Spirulina subsalsa* and *Chlorella vulgaris* can be valued as sources of nutritional supplements and antioxidants. Representatives of *Cyanobacteria* contribute to enhanced ecosystem productivity through biological nitrogen fixation, while *Charophyta* and *Chlorophyta* species show potential for use in biofiltration and water purification systems. Members of *Euglenophyta* and *Heterokontophyta* demonstrate promising applications in bioenergy, biomass production, and bioreactor technologies (Singh & Sharma, 2021; Smith & Bidigare, 2022)..

In conclusion, the continental waters of the Ismayilli region serve as an important subject for research in both ecological assessment and biotechnological applications, providing a reliable foundation for future scientific studies and the development of nature-based innovative products.

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Diversity of Algae in the Freshwater Ecosystems of Kalbajar District and Their Potential for Biotechnological Applications

Kelbecer Tatlı Su Ekosistemlerinde Yosun Çeşitliliği ve Biyoteknolojik Kullanım Olanakları

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Abstract

Kalbajar District, situated in the mountainous region of Karabakh, Azerbaijan, is characterized by its abundant natural resources, diverse climatic conditions, and distinct landscape features. The district's topography and hydroecological characteristics provide favorable conditions for the development of diverse ecosystems. Rivers, springs, and lakes in Kalbajar play a key role in maintaining the regional water balance and act as critical habitats that support rich biological diversity. These freshwater ecosystems are important not only as water sources but also as complex ecological systems hosting a variety of flora and microorganisms. Among these, phytoplankton and algae are essential components that contribute to ecosystem stability and ecological balance. Based on Balashova's classification, the predominant algal groups in Kalbajar's water bodies belong to the divisions *Heterokontophyta* and *Cyanophyta*, with *Heterokontophyta* species being most abundant. The diversity and ecological functions of these groups underscore their significant biotechnological potential. A comprehensive understanding of their natural distribution, species composition, and bioactive properties is fundamental for advancing algal biotechnology. Consequently, the study of Kalbajar's freshwater ecosystems, which are rich in hydroecological features, is of both scientific and practical importance. The algae found in these waters not only play a pivotal role in sustaining ecological stability but also represent promising biological resources for future biotechnological applications. Recent progress in biotechnology has markedly increased interest in algae, which, despite their simple structure, are multifunctional microorganisms capable of photosynthesis. They have wide-ranging applications in natural ecosystems as well as in industrial and technological sectors. Algae are utilized in the production of biofuels, nutritional supplements, bioactive compounds, pharmaceuticals, and cosmetic products, reflecting their broad biotechnological relevance. Algal biotechnology is increasingly recognized as an integral component of sustainable development and ecological management, providing solutions to challenges in industry, environmental conservation, and public health. However, research on the biotechnological potential of algae in Azerbaijan particularly in mountainous regions remains limited. Therefore, exploring the biological and technological properties of algal species in

the aquatic ecosystems of Kalbajar District represents a timely and essential area of study. The primary aim of this research is to assess the biotechnological potential and bioactive characteristics of these algae, thereby establishing a scientific basis for their potential future applications.

Keywords: Kalbajar District, Freshwater algae, Biotechnological potential, Aquatic ecosystems, Biodiversity

Taxonomic Spectrum Of Melliferous Plants In Azerbaijan

Türkçe Bildiri Başlığı Azerbaycanda Yayılan Balveren Bitkilerin Taksonomik Spektrumu

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Abstract

Melliferous plants, the primary source of honey and its derivatives, which are widely used as food, medicinal, health-improving, and other products, also possess numerous other beneficial properties – they provide fruit and berry fruits, medicinal, aromatic, forage, ornamental, and dyeing benefits, among other benefits. In Azerbaijan, melliferous plants are widespread throughout the country, growing from the lowlands to the alpine zone, in various vegetation types. Azerbaijan's melliferous flora possesses considerable and sought-after socio-economic potential; however, unfortunately, it remains understudied.

Our taxonomic analysis revealed that of the more than 5,000 plant species in Azerbaijan's flora, at least 610 species, grouped into 2 divisions, 3 classes, 29 orders, 80 families, and 312 genera, possess nectar-producing properties. The overwhelming majority of these species - 609 (99.8%) - belong to the Magnoliophyta division, and only 1 species (Taxus baccata L.) belongs to the Pinophyta division (0.2%). Of these nectar-producing plants, 48 species are cultivated.

In the class Magnoliopsida, the families Lamiaceae Lindl. (29 genera, 70 species), Fabaceae Lindl. (33 g, 70 s), Rosaceae Juss. (26 g, 60 s), Asteraceae Dumort. (32 g, 53 s) stand out in terms of the number of melliferous plant species, containing a total of 252 (41.4%) species belonging to 119 (38.1%) genera of this class. The species of melliferous plants that belong to these families and genera are widespread in forest and meadow communities, often acting as dominants of these communities: Salvia verticillata L., Prunella vulgaris L., Lathyrus silvestris L., Dorycnium intermedium, Geum urbanum, Crataegus kyrtostyla, Achillea millefolium, Pojarkovia pojarkovae (Schischk.) Greuter etc. Large families containing 12–23 species of melliferous plants include the families Salicaceae, Boraginaceae (12 species each), Apiaceae (18), Malvaceae (19), Brassicacea, Caprifoliaceae (21 each), and Ranunculaceae (23), which together contain 126 (20.7%) species from 60 genera. Among the species of these families there are also dominants of cenoses, such as Populus x hybrida M. Bieb., Salix caprea L., Echium vulgare L., Symphytum caucasicum M.Bieb., Daucus carota L., Pimpinella affinis Ledeb., Lavatera thuringiaca L., Tilia dasystyla subsp. caucasica (V. Engl.) Pigott and others. Most of the families include from 2 to 9 species which is 43 (7.05%), a significantly smaller number (23-3.8%) of families are represented by one genus and one species.

In the class Liliopsida, the most represented families are Amarilidaceae J. St.-Hil. (2g, 8s) and Orchidaceae Juss. (2g, 5s), and the least represented are Asparagaceae Juss. (3g, 4s), Colchicaceae DC. (1g, 3s) and Liliaceae Juss. (2g, 3s).

Distribution of melliferous plants by genera showed that the most representative in terms of species are 21 genera, containing from 5 to 10 species - Trifolium (10), Salix, Sorbus (9 each), Lathyrus (8), Allium, Rosa, Melilotus and Salvia (7 each), Acer, Brassica, Tamarix, Nepeta, Scabiosa and Centaurea (6 each), Ulmus, Rubus, Geranium, Lonicera, Scrophularia, Satureja, and Stachys (5 each). Most families are represented by single-species genera - 178 (29.2%) (Taxus, Phragmites, Alisma, Arum, Castanea, Capparis, Cleome, Philadelphus, Chrysosplenium, etc.). Genera containing 2-4 species are significantly fewer – 113 (18.5%) (Fraxinus, Myosotis, Thymus, Sonchus, Gentiana, etc.).

Research in this area is ongoing, and new species are expected to be added to the list of melliferous plants.

Keywords: Taxonomy, Nectar, Honey

Acupuncture and Dry Needling in the Treatment of Musculoskeletal and Neurological Disorders: Mechanisms, Applications, and Clinical Efficacy

Kas-İskelet ve Nörolojik Bozuklukların Tedavisinde Akupunktur ve Kuru İğneleme: Mekanizmalar, Uygulamalar ve Klinik Etkinlik

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Abstract

Acupuncture and dry needling are two minimally invasive therapeutic techniques widely used in the management of musculoskeletal and neurological disorders. While acupuncture is rooted in Traditional Chinese Medicine and focuses on restoring energy balance through stimulation of specific meridian points, dry needling is a modern neurophysiological approach targeting trigger points to alleviate muscle pain and dysfunction. This review explores the mechanisms of action, clinical applications, treatment protocols, and efficacy of these modalities, highlighting their complementary roles in enhancing patient outcomes.

Keywords: Apitherapy, Nature, Nutrition, Phytotherapy, Osteopathy

Introduction

According to the World Health Organization (WHO), traditional and complementary medicine encompasses knowledge, skills, and practices derived from indigenous cultural beliefs and experiences used to maintain health and treat physical and mental conditions. The rising incidence of chronic and malignant diseases, alongside limitations in conventional healthcare delivery and concerns about pharmaceutical side effects, has increased interest in alternative medical approaches. Despite their growing popularity, many such practices lack comprehensive scientific validation, prompting regulatory frameworks to ensure safety and appropriate use.

Among alternative therapies, acupuncture and dry needling have gained prominence for their therapeutic potential in pain management and functional restoration. This paper aims to present an integrative overview of these methods, focusing on their physiological basis, clinical indications, and treatment outcomes.

Historical Background and Mechanisms of Acupuncture

Acupuncture, a key component of Traditional Chinese Medicine (TCM), involves the insertion of fine needles into specific points on the body to stimulate healing and balance the flow of Qi (vital energy) through meridians. This technique has been practiced for over 2000 years, with foundational texts such as the Huang Di Nei Jing ("The Yellow Emperor's Inner Canon") dating back to approximately 500 BCE.

Qi is conceptualized as a dynamic interplay of Yin and Yang forces; disease arises from imbalances or disruptions in this energy flow. Acupuncture seeks to restore harmony by targeting biologically active points along meridians. Needles may be manipulated manually or electrically to enhance therapeutic effects.

A notable archaeological discovery supporting acupuncture's ancient origins is the "Ice Man" (Ötzi), whose 5300-year-old preserved body exhibited tattoo patterns corresponding to known acupuncture points.

Clinical Applications of Acupuncture

Acupuncture is widely used in China, Japan, South Korea, and increasingly in Western countries, for treating chronic conditions including:

- Neuritis
- Spinal osteochondrosis
- Arthrosis
- Neuroses
- Facial nerve paralysis (facial neuritis)

For facial neuritis, needles are inserted into specific points on the face, hands, feet, and auricle, providing analgesic, anti-inflammatory, sedative, and stimulatory benefits. Optimal results are achieved when treatment is initiated early, with typical courses comprising 10–12 sessions (maximum 15). In some cases, particularly diabetic patients or those with persistent muscular contractures, a second treatment course is applied after a 10-day interval. Combining acupuncture with massage and pharmacopuncture further enhances outcomes.

In Western medicine, acupuncture is employed for headache, migraine, back pain, and as an adjunct during anesthesia in surgical procedures. Physiological effects include the stimulation of endorphin release, contributing to analgesia and euphoria.

Dry Needling: A Modern Neuromuscular Technique

Dry needling is a minimally invasive treatment targeting painful trigger points—hyperirritable spots within taut muscle bands—without the injection of substances. Though technically similar to acupuncture, dry needling differs by focusing on myofascial pain syndromes rather than traditional acupoints.

Indications for dry needling include:

- Myofascial pain syndrome (trigger point disease)
- Fibromyalgia
- Cervical and lumbar spondylosis

- Disc herniations
- Tendonitis
- Chronic shoulder pain

Muscle stiffness in myofascial pain syndrome arises from overuse, postural strain, stress, or nerve compression leading to calcium-rich nodules within muscle fibers. Dry needling enhances localized blood flow, promotes tissue oxygenation, facilitates clearance of pathological tissue, and supports regeneration.

Treatment Protocols and Session Frequency

The number and frequency of treatment sessions depend on diagnosis and patient response:

Condition	Recommended Sessions
Trigger Point Syndrome	**5–10**
Fibromyalgia	**15–20**
Cervical/Lumbar Spondylosis	**10–15**
Acute Muscle Spasm	**1–3**

Sessions are typically administered daily or 2–3 times per week. Dry needling is often combined with physical therapy, therapeutic exercises, and electrotherapy to maximize outcomes, especially in cases of spinal degeneration.

Discussion

Both acupuncture and dry needling offer significant potential in managing musculoskeletal and neurological disorders. Acupuncture's holistic approach aims to restore energetic balance and systemic health, while dry needling provides a targeted neurophysiological intervention addressing localized muscle dysfunction. Integration of these techniques within multidisciplinary care can improve pain control, functional recovery, and quality of life.

Despite their benefits, it is essential to consider that acupuncture and dry needling should be performed by trained professionals to minimize risks and optimize therapeutic efficacy. Further rigorous clinical trials and mechanistic studies are warranted to deepen understanding and standardize treatment protocols.

Conclusion

Acupuncture and dry needling represent complementary therapeutic modalities with distinct yet synergistic mechanisms. Their evidence-based application in clinical practice provides effective options for patients

suffering from chronic pain and neuromuscular disorders. As interest in integrative medicine grows, these techniques will likely continue to expand their role in modern healthcare.

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Bioenergetics and Alternative Therapies: Bridging Science and Spirituality

Biyoenerjetik ve Alternatif Tedaviler: Bilim ile Spiritüellik Arasında Bir Köprü

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Abstract

Bioenergetics explores the flow, transformation, and utilization of energy within living systems, uniting biochemical, physiological, and quantum perspectives. This paper examines the historical evolution and scientific foundations of bioenergetics, from ancient notions of vital energy—*Qi*, *Prana*, and *Pneuma*—to modern discoveries in quantum biology and biophoton emission. It highlights how cellular metabolism, electromagnetic fields, and subatomic coherence collectively sustain life and health. The study reviews key energy-based therapies such as acupuncture, Reiki, qigong, and therapeutic touch, analyzing both their physiological mechanisms and empirical evidence. Although controversies persist regarding the measurability of subtle energies, recent advances in electrophysiology, magnetoencephalography, and photonic imaging support the view that biological systems function as coherent energy networks. Integrating bioenergetics into contemporary medicine offers a holistic framework that addresses not only physical but also emotional and spiritual dimensions of healing. By bridging traditional wisdom and modern science, bioenergetics provides a transformative paradigm for understanding life as a dynamic interplay of energy, information, and consciousness.

Keywords: Bioenergetics, Alternative Medicine, Energy Therapy, Quantum Biology.

1.1 Introduction

Bioenergetics, as a multidisciplinary field, investigates the flow, transformation, and utilization of energy within biological systems. It seeks to understand how energy governs cellular processes, organismal function, and even consciousness. While traditionally rooted in **biochemistry and cellular physiology**, the field has expanded into broader interpretations that include **subtle energy systems, electromagnetic fields,** and **quantum-level interactions**. The underlying premise is that life processes are driven not only by molecular reactions but also by complex energy dynamics that integrate physical, mental, and spiritual dimensions.

Interest in bioenergetics has grown rapidly over the past few decades due to the convergence of **quantum biology, neuroscience,** and **integrative medicine.** These disciplines have begun to question the reductionist model of biomedicine, which often neglects the energetic and informational aspects of life. The recognition that energy transfer and communication occur at every level of biological organization—from subatomic

particles to whole-body systems—has redefined the boundaries of health and disease. As a result, bioenergetics has become both a theoretical framework and a practical foundation for various **energy-based therapeutic approaches,** including **Reiki, acupuncture, qigong,** and **therapeutic touch.**

The origins of bioenergetic thought are deeply embedded in the **philosophical and medical traditions** of ancient civilizations. In traditional Chinese medicine, the concept of *Qi* refers to the vital life force that circulates through meridians, maintaining harmony between body and mind. Similarly, the Indian Ayurvedic tradition speaks of *Prana*, the universal energy sustaining all living beings. In ancient Greek philosophy, *Pneuma* represented the "breath of life," connecting the material body with the soul. Despite differences in terminology, all these traditions share a fundamental belief: **life is an expression of energy in motion.**

In Western science, the formal study of bioenergetics began in the **19th century,** coinciding with the development of **thermodynamics**. Hermann von Helmholtz, one of the pioneers of biophysics, formulated the principle of **energy conservation**, asserting that energy can neither be created nor destroyed—only transformed. Later, the German physiologist **Otto Warburg** advanced our understanding of cellular respiration and metabolism, discovering how energy is produced in cells through oxidation and phosphorylation. His research laid the biochemical foundation for modern bioenergetics.

In the **20th century**, new paradigms emerged as **quantum mechanics** and **systems biology** expanded scientific inquiry into the subatomic and informational domains. Scientists began to explore phenomena such as **biophoton emission, cellular coherence,** and **bioelectromagnetic communication**, suggesting that energy and information are inseparable aspects of living matter. Visionaries like **Albert Szent-Györgyi, Rupert Sheldrake,** and **Fritz-Albert Popp** proposed that biological systems exhibit quantum coherence, meaning that cells may operate as unified energetic fields rather than isolated chemical entities.

1.2 **Scientific Basis of Bioenergetics**

At the **molecular level,** bioenergetics focuses on how living organisms acquire, store, and utilize energy to sustain life. The **adenosine triphosphate (ATP)** molecule acts as the universal "energy currency" of the cell. Through **glycolysis, the Krebs cycle,** and **oxidative phosphorylation,** cells convert nutrients into usable energy. The **mitochondria**—often called the "powerhouses of the cell"—play a central role by generating ATP through electron transport and proton gradient formation.

However, this classical biochemical understanding only explains part of the picture. Emerging fields such as **quantum biology** suggest that **quantum coherence, tunneling, and entanglement** may underlie biological

energy processes. For instance, in photosynthesis, energy transfer between chlorophyll molecules occurs with almost perfect efficiency—an effect that cannot be explained by classical physics alone. This discovery has led scientists to reconsider how **energy information** is transmitted within cells and tissues.

Moreover, the **mitochondrial membrane potential** produces an **electromagnetic field** that influences cellular communication and metabolism. Recent studies in **bioelectromagnetics** have demonstrated that living cells emit weak electromagnetic radiation, often referred to as **biophotons**. These ultra-weak light emissions appear to play a role in cell signaling, DNA repair, and tissue regeneration. According to **Fritz-Albert Popp**, coherent biophoton emission reflects the degree of order and vitality within biological systems, providing a measurable indicator of health at the energetic level.

Additionally, **electrophysiological research** reveals that the nervous system operates as both a biochemical and an electrical network. Brain and heart coherence studies, such as those conducted by the HeartMath Institute, indicate that emotional states directly influence electromagnetic fields generated by the heart, which can, in turn, affect other organisms and the environment.

2.1 Major Bioenergetic Therapies

Several therapeutic modalities have evolved based on the principles of bioenergetics, integrating ancient wisdom with modern science.

1. **Acupuncture** – Originating in ancient China, acupuncture aims to restore balance within the body's meridian system by inserting fine needles into specific points. Modern research has shown that acupuncture stimulates the release of endorphins, modulates immune response, and influences brain activity. Functional MRI (fMRI) studies reveal that acupuncture can alter neural connectivity patterns associated with pain and stress regulation.
2. **Reiki** – Developed in Japan by Mikao Usui in the early 20th century, Reiki is a method of channeling universal life energy (*rei-ki*) through the practitioner's hands to the recipient's body. Studies suggest that Reiki sessions promote relaxation, lower blood pressure, and enhance psychological well-being by influencing the parasympathetic nervous system.
3. **Therapeutic Touch** – Pioneered by Dolores Krieger and Dora Kunz in the 1970s, therapeutic touch involves consciously directing healing intent and energy flow without physical contact. It has been widely used in nursing and palliative care to reduce anxiety and pain.

4. **Qigong and Tai Chi** – Both practices combine movement, breath control, and meditation to regulate internal energy flow. Clinical trials indicate that qigong improves immune function, balance, and cardiovascular health while reducing symptoms of anxiety and fatigue.
5. **Biofield Therapy** – A more contemporary approach, biofield therapy refers to interventions that modulate the human energy field surrounding the body. The National Center for Complementary and Integrative Health (NCCIH) recognizes biofield therapies as promising complementary interventions for pain, anxiety, and fatigue.

Collectively, these methods aim to **restore energetic balance, optimize physiological function,** and **promote holistic healing** by interacting with the body's electromagnetic and subtle energy fields.

2.2 Evidence and Controversies

Despite increasing interest, **bioenergetic medicine remains controversial** in the scientific community. Critics argue that many claims lack reproducible evidence within the conventional biomedical framework. Double-blind clinical trials for energy healing often face challenges such as placebo effects, subjective outcomes, and methodological variability.

However, an expanding body of research provides empirical support for physiological effects that cannot be explained solely by placebo. Studies show measurable outcomes such as:

- Reduced cortisol and stress hormone levels (Wardell & Weymouth, 2004);
- Increased immune cell activity (Baldwin et al., 2017);
- Improved heart rate variability and autonomic regulation (McCraty et al., 2010);
- Enhanced wound healing and reduced postoperative pain (Jain & Mills, 2010).

Advanced imaging and measurement technologies—such as **biophoton detection, magnetoencephalography (MEG),** and **electrodermal screening**—are now being used to observe subtle energy exchanges. The challenge lies not in whether these effects exist, but in **developing new epistemological and methodological tools** to measure them reliably. Traditional medical science, rooted in Newtonian materialism, may need to evolve toward a more **quantum-informed and systems-oriented model** of biology.

2.3 Integration into Modern Medicine

Modern healthcare increasingly recognizes the importance of **integrative medicine,** which combines evidence-based conventional treatments with complementary approaches addressing the whole person—body, mind, and spirit. Hospitals and universities around the world, including those affiliated with Harvard, Stanford, and the Cleveland Clinic, now offer Reiki, acupuncture, and energy therapy programs as adjuncts to standard care.

The **World Health Organization (WHO, 2019)** supports the integration of traditional and complementary medicine, acknowledging its potential to enhance global health outcomes and reduce the burden of chronic diseases. Furthermore, advances in **psychoneuroimmunology** and **neuroendocrinology** demonstrate that emotional and energetic states significantly influence immune function, inflammation, and neurochemical balance.

Integrating bioenergetics into clinical practice does not mean abandoning the biochemical model—it means expanding it. By including **energetic diagnostics, electromagnetic monitoring,** and **patient-centered energy interventions**, medicine can move toward a more **holistic and preventative paradigm**. This transformation requires interdisciplinary collaboration among physicians, physicists, biologists, and spiritual healers.

3. Philosophical and Ethical Dimensions

Beyond its scientific implications, bioenergetics raises profound **philosophical and ethical questions** about the nature of life and consciousness. If living organisms are energetic fields, then healing may involve restoring coherence between physical and informational dimensions. This view resonates with the **Gaia hypothesis**, which portrays Earth itself as a self-regulating energetic organism.

Moreover, recognizing the interconnectedness of all living systems encourages an ethic of compassion and ecological responsibility. Bioenergetic medicine, when practiced ethically, fosters not only personal well-being but also collective harmony with the environment. It invites humanity to view health as a dynamic balance within a larger cosmic field of energy and information.

Emerging technologies such as **quantum sensors, AI-based energy diagnostics, and biophotonic imaging** may soon provide the empirical tools necessary to validate subtle energy phenomena. As these developments unfold, bioenergetics could redefine our understanding of healing as an interplay between **energy, information, and consciousness.**

4. Conclusion

Bioenergetics offers a unifying framework that connects molecular biology with quantum physics, and modern medicine with ancient healing wisdom. By emphasizing the energetic foundations of life, it challenges the mechanistic worldview and opens new possibilities for preventive, personalized, and consciousness-based healthcare. Although debates persist, the growing body of interdisciplinary evidence suggests that energy is not a metaphor—it is the very fabric of life. As science continues to evolve, bioenergetics may hold the key to a more complete understanding of health, disease, and the human spirit.

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The current status and development trend of Alzheimer's disease in the Nakhchivan Autonomous Republic

Nahçıvan Özerk Cumhuriyeti'nde Alzheimer hastalığının mevcut durumu ve gelişme eğilimi

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Abstract

Alzheimer's disease, which has become a global problem worldwide, is a brain disorder that results in memory impairment. According to data from the Alzheimer's Association, approximately 55 million people worldwide were reported to have symptoms of Alzheimer's disease in 2019. Statistical analyses conducted over the years predict that this number will triple by 2050. This projection serves as a serious warning about the severity of the situation. Alzheimer's disease mainly arises as a result of impaired enzymatic processes, leading to the accumulation of β-amyloid polypeptides in brain cells. Enzymes such as acetylcholinesterase, butyrylcholinesterase, tyrosinase, and others are involved in this process. Although these enzymes play essential biochemical roles in the human body, disruption of their activity leads to neurodegeneration. One of the primary causes of this enzymatic disruption is the increase in free radicals and the resulting oxidative stress. The main objective of the present study was to conduct a statistical analysis of Alzheimer's patients in the Autonomous Republic and to examine the findings of scientific research on the use of plants in alleviating the symptoms of the disease. According to the statistical data from the Ministry of Health of the Nakhchivan Autonomous Republic, there is an observed upward trend in the prevalence of Alzheimer's disease among the population. While no hospitalized cases were recorded in the Neurology Department of the Autonomous Republic Hospital in 2022, 3 hospitalized patients (2 women and 1 man) were registered in 2023, and 6 patients (5 women and 1 man) in 2024. Additionally, many individuals consider memory loss in old age to be normal and therefore do not seek medical attention, which likely results in official statistics underestimating the true prevalence of the disease. Considering all these factors, analysis of the past three years indicates that Alzheimer's disease, which has become a serious global health issue, is also increasingly manifesting within the population of the Autonomous Republic.

In Alzheimer's disease, the inhibitory effects of plant-based extracts such as *Zingiber officinale* Rosc., *Berberis darwinii* Hook., *Malus domestica* Borkh., *Morus alba* L., *Morus nigra* L., *Elaeagnus angustifolia* L., *Arctium lappa* L., and others on enzymes that cause neurodegenerative disorders have been investigated through scientific studies. These natural substances, particularly through their action on enzymes like

acetylcholinesterase, butyrylcholinesterase, and tyrosinase, are considered promising for slowing the progression of the disease. For this reason, the development of natural dietary supplements and plant-based pharmaceutical products aimed at protecting human health and alleviating neurological disorders, either directly or indirectly, remains a highly relevant and timely field of scientific research.

The Nakhchivan Autonomous Republic is a region with a rich flora of beneficial plants, distinguished by its geographical location and ecologically clean environment. To implement strategies aimed at building a healthy society, there is a strong need to investigate the biochemical composition of these plants and to explore their new, scientifically substantiated therapeutic properties.

Keywords: enzyme, biochemistry, neurodegeneration, Alzheimer's disease, plant

Bioecological Features of Species of The Genus Sedum L. in the Nakhchivan Autonomous Republic

Nahçivan Özerk Cumhuriyeti'ndeki Sedum L. Cinsi Türlerinin Biyoekolojik Özellikleri

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Abstract

In the article, the bioecological study of 10 species of the Crassulaceae J.St.-Hil. - Sedum L. - Sedum genus of the family Crassulaceae, distributed in the Nakhchivan Autonomous Republic, was carried out. There are more than 1400 species of the Crassulaceae J.St.-Hil. family in the world, which are included in 35 genera. In the 2nd edition of the work "Taxonomic spectrum of the flora of the Nakhchivan Autonomous Republic" by T.H. Talibov, A.M. Ibrahimov and A.Sh. Ibrahimov, 21 species belonging to 6 genera mentioned in the Crassulaceae family are given. The discovered *Sempervivum montanum* L. - Mountain rockrose and *Sedum acre* L. - "Acı" sedum are new species for the flora of the autonomous republic. After the analysis, 20 taxa belonging to 4 genera were noted in the territory of the autonomous republic, of which 10 species belong to the genus Sedum L. The bioecological characteristics of some species belonging to the genus *Dovshankalami* are given.

Keywords: Flora biodiversity, Crassulaceae, Sedum, Dovshankalemi, Sempervivum, Nakhchivan MR

INTRODUCTION

Crassulaceae J.St.-Hil.,non. cons., 1805 - Plants belonging to the Crassulaceae family are herbs or shrubs. Their leaves are usually fleshy (succulent) and simple, arranged oppositely, and the stem is succulent. Their flowers are bisexual, often bisexual, five-membered, and in some cases they have 3-4-6 members. Their sepals are free, rarely connate from below. Their petals are free or more or less connate. Their stamens are 10, sometimes 6-8-12 or 20. The ovary is superior, in rare cases the ovary is half inferior. The fruit is a multi-seeded leafy fruit formed by the union of 5-10 fruit leaves. Entonomophilous and xerophytic plants.

On Earth, there are more than 1400 species of Crassulaceae J.St.-Hil., non. cons., 1805 - Crassulaceae family, which includes 35 genera [11, p.101-102]. According to the literature, the first information about the plants of Crassulaceae family, which are distributed in the area, is found in the fundamental works of A.A. Grossheim [3;4;5] and "Flora of Azerbaijan" [8]. Later, T.H. Talibov included 16 species of 3 genera [6, p.33-38], and in the 2nd edition of the work "Taxonomic spectrum of flora of Nakhchivan Autonomous Republic" compiled by T.H. Talibov, A.Sh. Ibrahimov and A.M. Ibrahimov (7, p.101-102), 21 species of 6 genera were preserved

in the Crassulaceae family. The results of the latest research are APG II, Talibov T.H. and S.K. Jamalbeyli [8; 9, pp. 33-38] were used as a basis. Taking advantage of the recent relative calm in the border areas, we organized expeditions to the higher peaks of the Demirlidag - Soyugdag sections of the Zangezur range on June 10-13, 2025. During the research, we collected a lot of materials belonging to the genus from Demirlidag, Kotamdag and Soyugdag. During the determination of the collected materials, Sempervivum montanum L. and Sedum acre L. were new species for the flora of the autonomous republic. Since the Sedum acre L. species had not yet bloomed, we collected it and planted it in the laboratory on a cutting, and after flowering we prepared its herbarium. After the last taxonomic study, some species were given synonymous status. As a result, it was determined that the following 20 taxa belonging to 4 genera are included in the territory of the autonomous republic, including the newly discovered species:Ordo: Saxifragales Bercht. & J. Presl

Familia: Crassulaceae J.St.-Hil.,non. cons., 1805 - Dovşankələmikimilər

Subfamilia: *Sempervivoideae* (Durande) Arn.

Tribus 1: *Semperviveae* Dumort.

1. Genus: *Sempervivum* L., 1754

1(1) *Sempervivum armenum* Boiss. & Huet (*S.glabrifolium* Boriss.) - Erməni qayaotu

2(2) *S. caucasicum* Rupr. ex Boiss. - Qafqaz q.

3(3) *S. montanum* L. - Dağlıq qayaotu

4(4) *S. transcaucasicum* Muirhead - Cənubi Qafqaz q

Tribus 2: Sedeae Fr.

Subtribus: *Sedinae*

2. Genus: *Sedum* L., 1754 - Dovşankələmi

Section 1: *Sempervivoides* Boiss., 1872

5(1) *Sedum maximum* subsp. *ruprechtii* (Jalas) Soo [*Sedum caucasicum*(Grossh.) Boriss.] -Big Dovshankelami

Section 2: *Telephlum* S.F. Gray

6(2) *S. aetnense* Tineo [*Sedum tetramerum* Trautv; *Macrocepalum tetramerum* (Trautv.) Palanov] - Four-petaled d.

Section 3: *Sedagenuina* Koch

Subsection 1: *Spathulata* Bor., 1939

7(3) *S. oppositifolium* Sims - Opposite leaf d.

Subsection 2: *Crassifoliae* Bor., 1939

8(4) *S. acre* L. - Bitter d.

9(5) *S. album* L. - White d.

10(6) *S. gracile* C.A. Mey. - Elegant d.

11(7) *S. subulatum* (C.A. Mey.) Boiss. - Biz d.

12(8) *S. tenellum* M.Bieb.

Section 4: *Epeteium* Boiss., 1872

13(9) *S. annuum* L.

14(10) *S. hispanicum* L. (*S. pentapetalum* Boriss.; *S. corymbosum* Grossh.)

3. Genus: *Rosularia* (DC.) Stapf

15(1) *Rosularia elymaitica* (Boiss. & Hausskn.) A.Berger

16(2) *R. persica* (Boiss.) A. Berger

17(3) *R. radiciflora* Steud. ex Boriss.

18(4) *R. sempervivum* (M.Bieb.) A.Berger

4. Genus: *Prometheum* (A.Berger) H.Ohba

19(1) *Prometheum pilosum* (Fischer ex M. Bieb.) H.Ohba (*Sedum pilosum* M.Bieb.)

20(2) *P. sempervivoides* (Fisch. ex M. Bieb.) H.Ohba (Sedum sempervivoides Fisch. ex Bieb.)

MATERIALS and METHOD

As can be seen from the taxonomic spectrum, the genus Sedum L. includes 10 species. We present the bioecological characteristics of some of these species. *Sedum* L. - Species belonging to the genus Sedum are annual or perennial plants with fleshy leaves. The flowers have 5, rarely 4-9 members, petals are free or united at the base, yellow, white, pink and red. Stamens are twice as many as the petals or the same number. The fruits are a collection of multi-seeded goblet. There are 18 species of the genus in Azerbaijan, 10 species in the Nakhchivan Autonomous Republic, and 8 species in the Zangezur National Park.

Sedum acre L. - "Acı dovşankələmi". Popularly known as "daşçiçəyi", "Acı sedum", or "Sarı daşçiçəyi", it is a perennial, succulent plant belonging to the Crassulaceae family. It is usually 5-15 cm tall, with a creeping and branching stem, covered with dense leaves. Its leaves are small, fleshy, cylindrical and pointed, and have the ability to collect water. Its flowers are yellow, star-shaped, very bright and have 5 petals. The flowering period occurs in May-July. It is very resistant to drought and sun. It grows easily even on rocky, dry and poor soils. It is also resistant to cold, therefore it spreads naturally in alpine and alpine zones. In nature, it grows in rocky, stony, dry and sunny places. It is very resistant to heat, can withstand up to +40°C. In winter, it can withstand frosts up to -20°C. It likes full sunny places (it is a heliophyte). It grows poorly in the shade. Very sensitive to moisture - excess water causes root rot. Newly discovered area [N 390 14' 12"; E 450 57' 24"; H= 2666 m]

Sedum annuum L. -“Birillik dovşankələmi”. It has a branching stem 5-15 cm high and the leaves are fleshy and oblong-linear. The flower cluster is branched and leafy. Its petals are yellowish. The fruit is ovoid, oblong, naked. It is found on rocks and slopes of the middle and high mountain belt. The flowering and fruiting period is in July-August. It is a xerophyte, geographical type: Europe.

Sedum corymbosum Grossh. -“Qalxanvari dovşankələmi”. The height of the plant's stem is 7-15 cm, the leaves are alternate and cylindrical. The flower group is shield-shaped, the flowers are 5, rarely 4 or 6-membered. The sepal is 3-angled. The petals are whitish-green or yellowish. It is found in the rocky areas of the middle mountainous belt. The flowering and fruiting period occurs in May - July. It is a xerophyte, geographical type: Northern Iran.

Sedum gracile C.A. Mey. -“Zərif dovşankələmi”. The stem is 5-10 cm high and is scattered with densely leafy branches. The leaves are lanceolate. The flower group is shield-shaped and many-flowered. The flowers are sessile. The petals are white. The subfoliate scales are wedge-shaped. The fruit is ovoid-oblong. It is found in rocky areas of the subalpine and alpine zones. The flowering and fruiting period is in July-August. It is a xerophyte, geographical type: Caucasus- Minor Asia

Sedum hispanicum L. - “İspan dovşankələmi”. The stem is 5-25 cm high, branched. The leaves are sessile, light yellow or reddish, linear or cylindrical. The flowers consist of 6 (9) members. The petals are white and have a red midrib. The fruit is 6-9 pieces, with stellate hairs. It is found in rocky areas of the middle and high mountain belt. The flowering and fruiting period occurs in June-July. It is a xerophyte, geographical type: Mediterranean.

Sedum oppozitifolium Sims. -“Qarşıyarpaq dovşankələmi”. It has a long, creeping rhizome, 6-15 cm high. The leaves are opposite, convex and toothed. The flower group is umbellate-shield-shaped, the flowers are almost sessile. The petals are white or light yellow. The fruit is oblong-ovate. It is found in rocky areas of the middle and high mountain belt. The flowering and fruiting period is in July-August. It is a xerophyte, geographical type: Caucasus- Minor Asia.

Sedum album L. - “Ağ dovşankələmi”. It is a plant that grows in the shape of a ball, 5-20 cm high. Its leaves vary from bluntly cylindrical to ovate. The flower group is sparsely shield-shaped or broom-shaped, many-flowered. The petals of the short-stemmed flowers are white. It is distributed in stony-rocky areas at an altitude of up to 2500 m above sea level. The flowering and fruiting period occurs in July-August. It is a xerophyte, geographical type: Europe.

Sedum tenellum Bieb. - “İncə dovşankələmi”. The stem is densely leafy and 4-8 (10) cm high. The flowerless shoots are small, the leaves are alternate, oblong-linear and blunt. The flower group is shield-shaped and dense. The petals are 3.5-5 mm long, red or whitish inside. The stamens are 10, reddish and have

a wide leg. The fruits are 3.5-4 mm long, oval. The flowering and fruiting period occurs in July-August. It is found in stony-gravelly areas of the Alpine belt. It is a xerophyte, geographical type: Caucasus.

CONCLUSION

Thus, after the conducted research, the species Sedun acre L. and Sempervivum montanum L. were newly included in the flora of the Nakhchivan Autonomous Republic. As a result, it was clarified that the Crassulaceae family is represented by 20 species belonging to 4 genera. The genus Sedum L. covers half of the plants of the family with 10 species. The bioecological characteristics of some species of the Sedum genus are presented.

Figure 1. *Sempervivum montanum* L. -“ Dağlıq qayaotu”

Figure 2. *Sedum acre* L. - “Acı dovşankələmi ”

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Taxonomic Composition and Usage Directions of the Genus Avena L. (Oats) Distributed in the Nakhchivan Autonomous Republic

Nakhchivan Özerk Bölgesi'nde Yayılan Avena L. (Yulaf) Cinsinin Taksonomik Yapısı ve Kullanım Alanları

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Abstract

The presented article provides information about the taxonomic spectrum and usage directions of the species belonging to the genus Avena L. within the Poaceae Barnhart family, nom. cons., in the flora of the Nakhchivan Autonomous Republic. Research has shown that five species of this genus are found in the flora of the Nakhchivan Autonomous Republic. Based on literature data and our studies, it has been determined that the species belonging to this genus are used in medicinal, food, fodder, and erosion control areas.

Keywords: Avena L., endemic, taxonomic composition, usage directions, rare

INTRODUCTION

The Nakhchivan Autonomous Republic stands out from other regions of Azerbaijan due to its geographical location, orographic features, relief, and unique flora. One of the region's main natural resources is its rich flora and vegetation. This richness has developed and evolved over a long evolutionary process through the combined influence of natural-historical, ecological, and anthropogenic factors, gradually taking shape over time.

One of the widely distributed plant groups in the flora of the Nakhchivan Autonomous Republic is the representatives of the genus *Avena*. The genus *Avena* is spread across many regions of the world and consists of annual or perennial grass species mainly cultivated in dry grassy and rocky slope areas. The family is represented by 95 genera and 309 species. In Azerbaijan, the genus includes 16 species, of which 5 species are found in the Nakhchivan Autonomous Republic. Species of the genus *Avena* L. are found on the slopes of the region. The species belonging to this genus are used in medicinal, food, fodder, and erosion control applications.

Considering all these factors, the study of the taxonomic composition and usage directions of the genus *Avena* L. has been recognized as a relevant and important topic.

MATERIALS AND METHODS OF THE STUDY

The research was conducted during 2024-2025 in various regions of the Nakhchivan Autonomous Republic. The study focused on the dry grassy and rocky slopes of the region, and the material consisted of

species belonging to the genus Avena L. The identification and verification of species names of the genus Avena L. were based on A. Əsərov's *"Flora of Azerbaijan"* [1], *Flora of Azerbaijan* [2], and other sources. The latest taxonomic updates were verified using *World Flora Online* [4].

DISCUSSION AND RESULTS OF THE STUDY

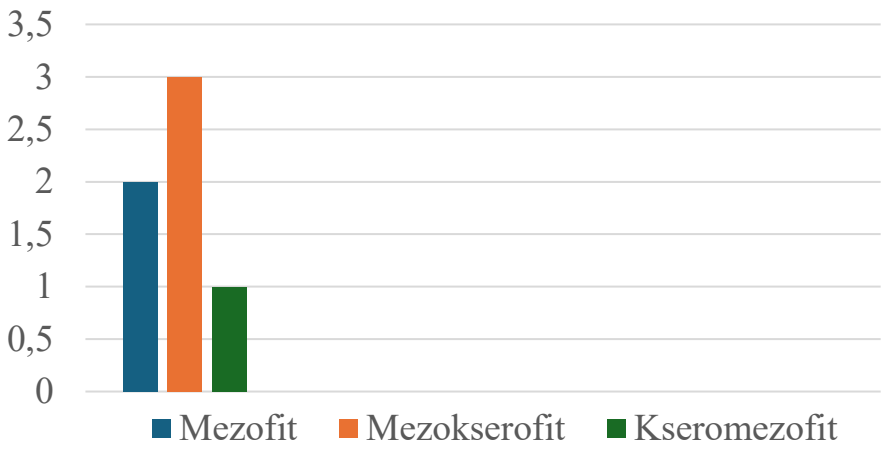
The genus Avena is one of the important plant groups included in the rich flora of the Nakhchivan Autonomous Republic. There are 26 species of this genus in Azerbaijan and 5 species found in the flora of Nakhchivan AR. The systematic composition, ecological groups, distribution class, altitude range, flowering, and fruiting phases of the species belonging to this genus are presented in the table below (Table 1).

Table 1. Taxonomic composition of species belonging to the genus Avena L.

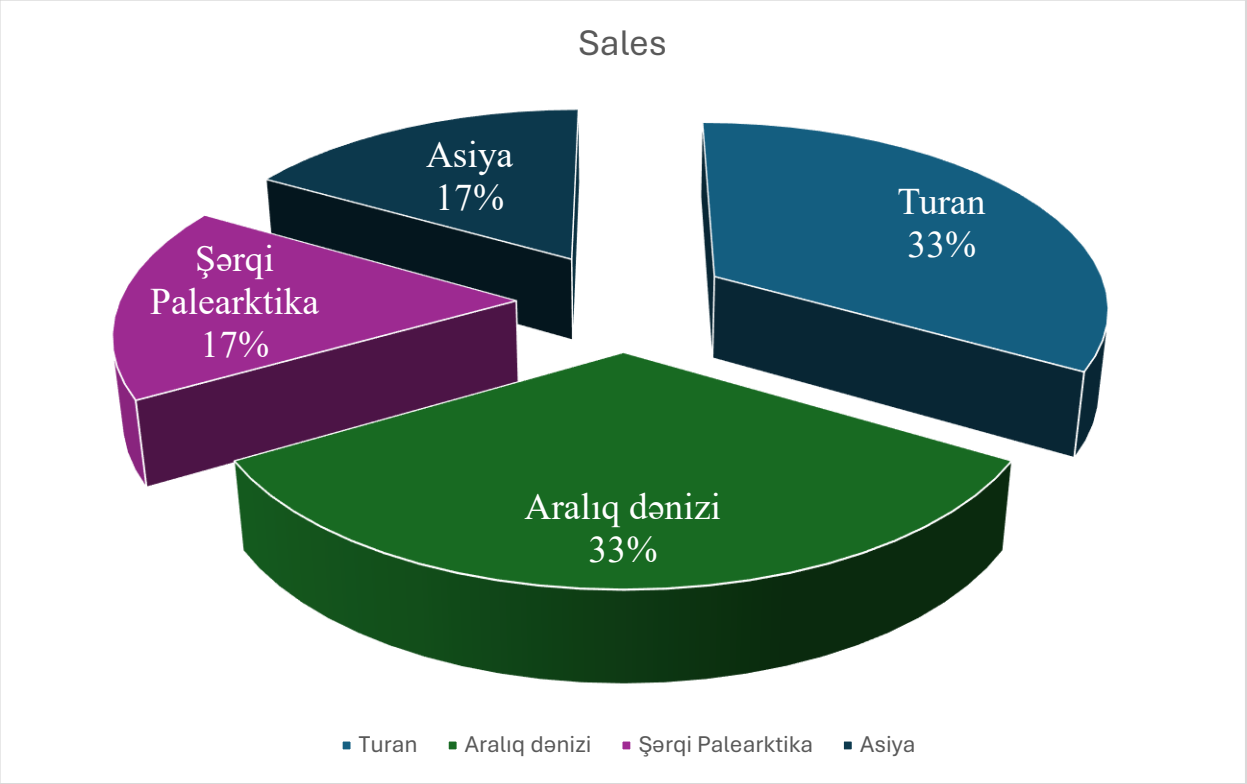
S\№	Növlərin adı	Ekoloji qrupları	Areal sinfi	Hündürlük qurşağı	Çiçəkləmə və meyvə vermə fazası
1.	A. persica Steud	Mezokserofit	Turan	Orta və yüksək qurşağı	IV-VII
2.	A. fatua L	Mezokserofit	Şərqi Palearktika	Orta və yüksək qurşağı	VI-VII
3.	A. sativa L	Mezofit	Asiya	Daşlı yamaclar	IV-VII
4.	A. barbata Pott ex Link	Kseromezofit	Aralıq dənizi	Aşağı dağ qurşağı	V-VI
5.	A. eriantha Durieu	Mezokserofit	Aralıq dənizi	Quru otlu və daşlı yamaclar	IV-VII
6.	A. trichophylla C.Koch	Mezofit	Turan	Aşağı dağ qurşağı	IV-VII

Analysis of the ecological groups of the species belonging to the genus revealed that the mesoxerophytic ecological group is widely distributed in the study area and represented by 3 species, accounting for 50% of the total flora. The mesophytic ecological group is represented by 2 species, making up 33.3%, while the xeromesophytic ecological group is represented by 1 species, accounting for 16.6%, thus being monotypic [2].

***Avena* L. cinsinin ekoloji qrupları**



Based on the obtained literature sources and our own field studies, it was determined that the species belonging to the genus belong to various area classes, which allows identifying the migration routes of the species in the region. According to zonal and regional principles, it was found that the species of the genus are grouped into four area classes. As seen from the table, the Turan and Mediterranean area classes are each represented by 2 species, while the Asia and Eastern Palearctic area classes are each represented by 1 species [1].



The flowering group of the genus Avena L. is characterized by a loose and unilateral panicle. Its spikelets contain 2-4 flowers, and the glumes are large with 7-9 veins. The upper glume of the lower flower has 2 sharp stigmas or fine awns, its back is bent, and the lower part has spirally twisted awns. In Azerbaijan, there are 16 species of the genus, with 5 species distributed in the Nakhchivan Autonomous Republic [3, pp. 158-159].

Avena persica Steud. (A. ludoviciana Durieu) is found in grassy areas of mid and high altitudes. The plant is used for medicinal purposes.

Avena fatua is widely distributed up to the mid-mountain zone along the edges of cultivated fields, plantations, roadsides, and around settlements. Because the species is rich in compounds such as flavonoids, saponins, and phenols, it is widely used in the pharmaceutical field.

Avena sativa grows on rocky slopes, in gardens, and household plots. It is cultivated as a food and fodder crop. Due to its fiber, protein, and beta-glucan content, it is used in diets and helps regulate blood sugar and cholesterol levels.

Avena barbata Pott ex Link. is found from plains to lower mountain zones on dry, rocky, and gravelly slopes and sandy areas. This species is used in animal husbandry both as fresh and dry fodder.

Avena eriantha Durieu is distributed in plains and foothill areas on dry grassy and rocky slopes, as well as along roadsides and riverbeds. The plant is used in agro-technical, medicinal, genetic, and breeding fields. Additionally, in some regions, it is also used as green manure.

Avena trichophylla C.Koch is found up to the mid-mountain zone in plantations, cultivated fields, roadsides, settlements, and shrublands. The plant is cultivated for soil cover in erosion-prone zones to protect biodiversity and adapt to the environment.

CONCLUSION

1. Based on the conducted research, it was concluded that 5 species of the genus Avena L. are found in the flora of the Nakhchivan Autonomous Republic. It was determined that all species belonging to the genus have characteristics useful for food, medicine, fodder, and erosion control.
2. Analysis of the ecological groups of the species showed that 1 species belongs to the xeromesophytic group, 2 species to the mesophytic group, and 3 species to the mesoxerophytic group. According to the analysis of geographical area classes, 2 species belong to the Turan area, 2 species to the Mediterranean, 1 species to the Eastern Palearctic, and 1 species to the Asian area, making it monotypic.

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Biomorphographical Characteistics Of Nectarians of the Dıanthus L. Genus Distributed in The Flora of the Nakhchivan Autonomous Republic

Nahçivan Özerk Cumhuriyeti Florasında Dağılım Gösteren Dıanthus L. Cinsine Ait Nektarlı Türlerin Biyomorfolojik Özellikleri

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Özet

Nektar bitkileri, doğa ve tarım açısından çok yönlü bir öneme sahiptir. Bu bitkiler, arıcılığın gelişmesinde, ekosistem sürdürülebilirliğinin artırılmasında ve gıda güvenliğinin iyileştirilmesinde kritik bir rol oynamaktadır. Nektar bitkileri; arılar, kelebekler, sinekler ve kuşlar gibi tozlayıcıları cezbederek tozlaşmayı mümkün kılmakta, bu süreç bitkilerin üremesine ve genetik çeşitliliğin korunmasına katkı sağlamaktadır. Ayrıca bal arıları, nektar bitkilerinden bal üretmekte olup nektarın bileşimi; balın tadını, rengini ve kalitesini doğrudan etkilemektedir. Nektar bitkileri, tozlayıcı böcek popülasyonlarını destekleyerek ekosistem dengesinin korunmasına da katkıda bulunmaktadır. Bunun yanı sıra, ormanlık ve dağlık alanlarda toprak erozyonunun azaltılması yoluyla biyolojik çeşitliliğin korunmasına hizmet etmektedir.

Nahçıvan Özerk Cumhuriyeti'nde yayılış gösteren nektar bitkileri arasında Dianthus L. cinsine ait türler önemli bir yer tutmakta olup, bu türler çoğunlukla süs ve tıbbi özellikleriyle öne çıkmaktadır.

Bu çalışma, Nahçıvan Özerk Cumhuriyeti florasında bulunan Dianthus L. cinsine ait nektar üreten türler hakkında bilgi sunmayı amaçlamaktadır. Türlerin biomorfolojik özellikleri ve yayılış alanları açıklanmıştır. Araştırma sonucunda, bölge florasında yayılış gösteren üç Dianthus L. türünün (Dianthus armeria L., Dianthus calocephalus Boiss. ve Dianthus barbatus L.) nektar üreten türler olduğu belirlenmiştir. Bu türlerin flavonoidler, antosiyaninler ve fenolik bileşikler içerdiği; bu bileşiklerin antioksidan, antibakteriyel ve antiinflamatuvar özelliklere sahip olduğu tespit edilmiştir. Bu özellikler göz önünde bulundurulduğunda, Dianthus armeria L., Dianthus calocephalus Boiss. ve Dianthus barbatus L. nektarlarından elde edilen balın apiterapide yaygın olarak kullanılabileceği değerlendirilmektedir.

Anahtar Kelimeler: Dianthus L., cins, tür, nektar, apiterapi, yayılış alanı

Abstract

Nectar plants have multifaceted importance in nature and agriculture. These plants play a crucial role in the development of beekeeping, increasing ecosystem sustainability, and improving food security. Nectar plants attract bees, butterflies, flies, and birds, enabling pollination, which in turn helps plants reproduce and maintain genetic diversity. Furthermore, honeybees produce honey from nectar plants, and the composition of the nectar affects its flavor, color, and quality. Nectar plants also maintain ecosystem balance by maintaining pollinating insect populations. These plants contribute to the preservation of biodiversity by reducing soil erosion in forested and mountainous areas.

Among the nectar-bearing plants commonly found in the Nakhchivan Autonomous Republic, species belonging to the genus *Dianthus* L. can be counted; these are mostly plants of decorative and medicinal importance.

This article provides information on nectar-producing species of the genus *Dianthus* L. found in the flora of the Nakhchivan Autonomous Republic. The biomorphological characteristics and distribution areas of the species are described. The study identified three species of the genus *Dianthus* L. (*Dianthus armeria* L., *Dianthus calocephalus* Boiss., and *Dianthus barbatus* L.) distributed in the region's flora as nectar-producing. These species contain flavonoids, anthocyanins, and phenolic compounds that have antioxidant, antibacterial, and anti-inflammatory properties. Considering these properties, honey obtained from the nectars of *Dianthus armeria* L., *Dianthus calocephalus* Boiss., and *Dianthus barbatus* L. is considered to be widely used in apitherapy.

Keys words: *Dianthus L, genus, species, nectar, apitherapy, distribution area.*

1.INTRODUCTION

In the flora of the Nakhchivan Autonomous Republic, the genus Carnation is represented by 18 species distributed in a variety of areas, from meadows to high mountain belts. Species in the genus are widely used in medicine and ornamental plants. Furthermore, among the species of the genus Dianthus L. distributed in the Nakhchivan Autonomous Republic, useful, nectar-bearing, rare, endemic, and relict species listed in the "Red Book" predominate.

Dianthus armeria L., *Dianthus calocephalus* Boiss. and *Dianthus barbatus* L. species within the genus are used as potential nectar sources in beekeeping due to their nectar producing properties.

Considering the above mentioned, the study of bioecological characteristics of nectar producing species of the genus *Dianthus* L. and the determination of their distribution areas is a current issue that responds to today's demands.

2. MATERIAL and METHODS.

The object of the study is the territory of the Nakhchivan Autonomous Republic, and nectar-producing species of the genus Dianthus L. collected by us during our field research in the region were used as material.

The works "Flora of Azerbaijan", "Flora of the Caucasus" by A.A. Grossheim were used to identify the species of the studied genera in the region's flora [Flora of Azerbaijan 1952, Grossheim A.A. 1957]. Recent taxonomic additions and changes were made based on authentic materials from the Nakhchivan State University Herbarium Fund and the third volume of the "Compendium of the Flora of the Caucasus," as well as on the works of T.H. Talibov, A.S. Ibrahimov, and A.M. Ibrahimov on the Taxonomic Spectrum of the Nakhchivan Autonomous Republic [Abstract of the flora of the Caucasus. 2012, Tariyel Talibov, Aliyar Ibrahimov, Anvar Ibrahimov. 2021].

To clarify the names of plants common in the region, E.M. Gurbanov's "Higher Plants Systematics" and A.M. Askerov's "Plant World" were used [Askerov A.M. 2016, Gurbanov E.M. 2009].

3. DISCUSSION

Dianthus L. - The carnation genus is one of the largest genera in the *Caryophyllaceae* family, with over 300 species found in Eurasia, tropical Africa, and South Africa, with a small number in North America. The species is most widely distributed in the Mediterranean countries. It is represented by 28 species in Azerbaijan and 18 in the flora of the Nakhchivan Autonomous Republic, accounting for 14.5% of the carnation species distributed in the region. Wild carnation species are found in forests and shrublands, meadows, and rocky areas, from steppes to highland areas.

In carnation species, the sepals are attached, and there are 2-8 stipules surrounding the sepals. The stem of the petal is long, the annular part is variegated, solid, or toothed. There are 10 stamens and two stamens. It is widely used in ornamental plants.

The flower structure and color of *Dianthus armeria* L., *Dianthus calocephalus* Boiss., and *Dianthus barbatus* L., found in the flora of the Nakhchivan Autonomous Republic, enhance pollinator activity and serve as nectar sources for them. The composition of honey obtained from the nectar of these species is rich in bioactive substances derived from *Dianthus*. Therefore, species of the genus contain flavonoids, anthocyanins, and phenolic compounds, which have antioxidant, antibacterial, and anti-inflammatory effects. When bees collect nectar from these plants, these substances are transferred into the honey. This honey is used for therapeutic purposes, such as strengthening the immune system, treating skin diseases, reducing inflammation, and other ailments [Novruzova, E. 2024].

Dianthus Calocephalus Boiss. It is a perennial plant, 40-60 cm high, branched around the base, and glabrous above. The leaves are 15-20 mm wide, sessile, linear, lanceolate, acute, dark-edged, serrated, and fused at the base with a 15-20 mm long sheath. The flowers are sessile, borne in a many-flowered anther at the end of the

stem, the heads covered in a leathery covering. The inflorescence is elliptical, blunt-tipped, covered with whitish, elliptical scales. The calyx is 17-20 mm long, cylindrical, with a pointed tip and toothed margins on the upper surface, bordered by red scales. The petals are 5-6 mm long, bright red, obovate, hairy above, and toothed margins. The capsule is cylindrical, up to 10 mm long. The seeds are 2 mm long, oval, and have short claws. The plant produces fruit and seeds in June and July, and sometimes in August. It is attractive to bees due to the bioactive substances found in the plant's nectar.

Picture: Dianthus Calocephalus Boiss. Around Arafsa village, Julfa region

Dianthus Calocephalus Boiss. It grows mostly in mountainous areas, on grassy and rocky slopes. It is a Minor Asia geographical type species.

In the Nakhchivan Autonomous Republic, it is most common in the plains, lowlands, and lower mountain areas of the mountainous and foothill regions, and in the meadow-shrub areas of the central mountain slopes. The ornamental carnation species is found in the villages of Kuku, Nursu, and Yukarı Qishlag in the Shahbuz district, the surrounding area of İlanlıdağ in the Julfa district, the surrounding area of Nahajir village in the Babek district, and the surrounding area of Garagus Mountain in the Kangarlı district.

Dianthus armeria L. The stem is 30-50 cm high, solitary or in groups of several, erect or relatively erect from the base, simple or finely branched, densely and shortly hairy on the upper surface, and dark green. The leaves are 1-3 mm wide, sessile, erect, fused with the sheath at the base, pointed, linear-lanceolate or linear, with a glossy underside and a hairy surface. The flowers are sessile or on small stalks, with 3-10 thick-headed flowers on dense branches arising from the root. The stalks are covered with lanceolate-bead-shaped scales, the same size as the calyx or relatively long. The petals are 4-5 mm long, oblong-obovate, dark red or red, darkly spotted on the upper surface, and toothed on the upper surface. The calyx is 17-20 mm long, cylindrical, relatively narrow on the upper surface, and the sepals are covered with longitudinally convex veins, long lanceolate-toothed, and covered with a dense crust. The capsule is cylindrical and relatively shorter than the calyx. The

seeds are 1.5 mm long, black, oval, flat, with dark convex spots on the surface, and a short clove-like top. The plant produces flowers and seeds in June and july, and sometimes in august.

Dianthus armeria L. This species grows in forests, open areas, roadsides, and thickets from the plains to the mid-mountain belt. It belongs to the Atlantic-European geographical area type.

In the flora of the Nakhchivan Autonomous Republic *Dianthus armeria* L. is found around the villages of Jamaldin and Arafsa in the Culfa region.

Dianthus barbatus L. It is a perennial plant with an upright, densely leafed trunk 30-50 cm high. It is cultivated as a biennial plant for its decorative and nectar-producing properties. Its leaves are 3-7 cm long and 4-12 cm wide, dark green, linear-lanceolate, serrated, and pointed. Its flowers are 2-3 cm in diameter, have five petals, and have a cluster of approximately 30 flowers at the top of the stem. The plant attracts bees and butterflies due to its strong clove-scented nectar. It produces flowers and seeds between may and august.

Dianthus barbatus L. grows in lowland areas, clayey and alkaline soils, in parks and gardens, and along roadsides. It is a species of European geographical type.

In the Nakhchivan Autonomous Republic, *Dianthus barbatus* L. is grown in the wild around the city of Nakhchivan and in almost all parks and gardens [Novruzova E.S. 2021].

3.CONCLUSION

As a result of examining the biomorphological characteristics of nectar-producing species of the genus *Dianthus* L. distributed in the flora of the Nakhchivan Autonomous Republic, the following conclusions were reached in the light of our research and literature data.

In the flora of the Nakhchivan Autonomous Republic, three species of the genus *Dianthus* L. (*Dianthus armeria* L., *Dianthus calocephalus* Boiss., and *Dianthus barbatus* L.) were identified as nectar producers. The biomorphological characteristics and distribution areas of these nectar-producing species, distributed from the plains to the central mountainous belt of the Autonomous Republic, were examined. Due to the high bioactive substance content of *Dianthus armeria* L., *Dianthus calocephalus* Boiss., and *Dianthus barbatus* L., they can be widely used in beekeeping.

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Methods of joint application of medicinal plants and bee products in folk medicine

Dərman bitkiləri və arı məhsullarının xalq təbabətində birgə tətbiqi üsulları

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Abstract

Etnobotanika və apiterapiya arasındakı qarşılıqlı əlaqə, insan-bitki-arı münasibətlərinin ən qədim və kompleks sahələrindən birini təşkil edir. Son onilliklərdə etnobotanika və apiterapiya elmlərinin inteqrasiyası təbiət resurslarının ənənəvi bilikləri əsasında öyrənilməsində yeni elmi yanaşma modeli formalaşdırmışdır. Bu tədqiqat arı məhsulları və dərman bitkilərinin ekoloji və etnomədəni qarşılıqlı əlaqələrinin elmi təhlilinə həsr olunmuşdur. Tədqiqatın məqsədi Azərbaycanda yaşayan müxtəlif etnik icmalarda (tat, molokan, ləzgi, avar, kürd, ingiloy, saxur, talış, yəhudi və udi) arıçılıq və arı məhsulları (bal, mum, propolis, güləm, arı çörəyi, arı südü, arı zəhəri) ilə yerli şəfalı bitkilərin birlikdə istifadəsi, ekosistemlə əlaqələrinin öyrənilməsi, toplanılmış biliklərin ötürülməsidir. Bu istiqamət həm bioloji müxtəlifliyin qorunması baxımından, həm də mədəni irsin davamlılığı baxımından aktual elmi və praktik əhəmiyyətə malikdir. Tədqiqat zamanı qar topu üsulu ilə seçilmiş müsahiblər arasında sorğular aparılmış, etnobotaniki tədqiqat metodlarından (çöl etnoqrafiyası, müşahidə, sorğu, anketləşdirmə) istifadə edilmişdir. Əldə olunan nəticələr göstərir ki, yerli icmalarda bitkilərin arı məhsulları ilə birlikdə müxtəlif istifadə sahələri vardır. Müxtəlif etnik icmalarda istifadə olunan bitkilərin seçimi isə illərlə formalaşmış ənənəvi ekoloji biliklər sisteminə əsaslanır.

Arıçılıq, arı məhsulları və dərman bitkiləri arasında formalaşmış əlaqələr həm ekotarazlığın, həm də ənənəvi bilik sistemlərinin qorunmasına xidmət edir. Bu sahədə aparılan elmi tədqiqatlar apiterapiya və etnobotanika elmlərinin sintezini dərinləşdirməklə bərabər, eyni zamanda insan-təbiət harmoniyasının əsasını təşkil edən ənənəvi biliklər sisteminin müasir elmi əsaslarda yenidən qiymətləndirilərək inkişaf etdirilməsinə şərait yaradır. Aparılmış etnobotaniki sorğular nəticəsində məlum olmuşdur ki, bal fərqli dərman bitkiləri ilə birgə tətbiq edildikdə müalicəvi xüsusiyyətlərini dəyişir. Ürək əzələsinin zəifliyində *Rosa canina* L. və bal ürəyin əzələ fəaliyyətini gücləndirir. Ağız yaraları, angina, faringit zamanı *Matricaria chamomilla* L. və bal qarışığı iltihabəleyhinə və yarasağaldıcı təsirə malikdir. Mədə-bağırsaq xəstəliklərində *Aloe vera* L. bal və kərəyağı qarışığı bərpaedici və yarasağaldıcı xüsusiyyətlərinə görə, qarında ağrılar zamanı *Valeriana officinalis* L. və bal, tərlədici vasitə kimi *Sambucus nigra* L. və bal, immunitet gücləndirici kimi *Citrus lemon* (L.)Osbeck və bal geniş tətbiq olunur.

Tədqiqatın nəticələri göstərir ki, arı məhsulları yalnız təbii müalicə vasitəsi kimi deyil, həm də mədəni və estetik dəyər də daşıyır. Yerli icmalar arasında bal mumundan hazırlanan şamlar, təbii kosmetik vasitələr və dekorativ əşyalar ekoloji təmiz məhsul nümunələridir. Bu məhsullar təbii resursların dəyər zəncirini uzadaraq

regionda kiçik miqyaslı bioiqtisadi fəaliyyətlərin inkişafına imkan yaradır. Beləliklə , etnobotanika və apiterapiya arasındakı əlaqə yalnız biomüxtəlifliyin qorunması baxımından deyil, həm də yerli biliklərin davamlı idarə edilməsi baxımından effektivdir.

Naxşıvan Muxtar Respublikasında Arsenli Mineral Suların Hidrokimyəvi Və Ekoloji Göstəriciləri

Hydrochemıcal And Ecologıcal Indıcators Of Arsenıc Mıneral Waters In The Nakhshıvan Autonomous Republıc

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Özet

Məqalədə muxtar respublika ərazisindəki arsenli mineral suların yayılma özəllikləri, hidrokimyəvi və ekoloji göstəriciləri və səmərəli istifadə perspektivlərindən bəhs edilir. Bu məqalə arsenli mineral və termal bulaqların öyrənilməsi üçün makro- və mikro- tərkib vasitəsilə onların hazırkı vəziyyətinin ekoloji xüsusiyyətlərini müəyyən edir.

Bu sularının əsas keyfiyyət göstəriciləri olan kimyəvi tərkiblərini müəyyən etmək üçün Culfa və Şahbuz rayonlarında olan mənbələrdən götürülmüş mineral və termal su nümunələri təhlil edilmiş, su mənbələrinin indiki vəziyyəti və resurs potensialının diaqnostikası öyrənilmişdir. Ərazidə mineral suların, xüsusən də arsenli termal suların hidrokimyəvi özəlliklərinin və bu suların həyati amillər baxımından əhalinin sağlamlığına təsirinin çağdaş vəziyyətləri yeni baxış bucağından öyrənilmiş, bu suların ərazinin su təchizatında və müalicəvi turizmdə istifadə imkanları müzakirə edilmişdir.

Açar sözlər: Mineral və termal sular, makro- və mikroelementlər, hidrokimyəvi və ekoloji göstəricilər, müalicəvi turizm

Abstract

The article discusses the distribution features, hydrochemical and ecological indicators, and prospects for efficient use of arsenic-containing mineral waters in the autonomous republic. This article determines the ecological characteristics of the current state of arsenic-containing mineral and thermal springs through their macro- and micro-composition for the study of their properties. In order to determine the chemical composition of these waters, which are the main quality indicators, mineral and thermal water samples taken from sources in Julfa and Shahbuz regions were analyzed, and the current state of water sources and diagnostics of resource potential were studied. The current state of the hydrochemical properties of mineral waters in the area, especially arsenic-containing thermal waters, and the impact of these waters

on the health of the population in terms of vital factors were studied from a new perspective, and the possibilities of using these waters in the area's water supply and therapeutic tourism were discussed.

Keywords: Mineral and thermal waters, macro- and microelements, hydrochemical and ecological indicators, therapeutic tourism

Giriş

Naxçıvan düzənliyinin demək olar ki, bütün ərazisində IV dövr çöküntülərində qrunt suları, Sədərək və Şərur düzənliklərində isə təzyiqli sulu təbəqə, artezian suları və bulaqlar mövcuddur. Araz çayı boyu ərazilərdə yeraltı sular bulaqlar və kiçik fəvvarələr şəklində səthə çıxırlar. Naxçıvanın ərazisi ətrafı hündür dağlarla əhatələnmiş dərəni xatırladır. Bu isə yerli relyefə təsir edən quru və sərt kontinental iqlimin hökm sürməsinin səbəblərindən biridir. Ərazidə yeraltı suların, o cümlədən mineral suların formalaşmasında relyefin, çay şəbəkəsinin, yarandıqları geoloji mühitin, iqlimin böyük əhəmiyyəti vardır. Mineral suların mənşəyi, hərəkət sürəti, suya qarışan süxurların özəllikləri, temperatur və təzyiqi onların tərkibinin formalaşmasında böyük rol oynayır. Belə hallarda adətən dəqiq vertikal hidrokimyəvi zonallıq müşahidə edilir və dərinlikdən asılı olaraq yeraltı suların ümumi minerallığı artır. İntensiv dəyişmə baş verən dərin horizontlardakı hidrogeoloji strukturlarda bu horizontlar yaxşı yuyulur və yuxarı laylara nisbətən az minerallığa malik sular saxlayırlar. Minerallaşma dərəcəsindən asılı olaraq ionların yerləşmə xüsusiyyətləri iki qrup kationlar (Na++K+, Ca2+ və Mg2+) və üç qrup anionların (Cl□, SO42□ və HCO3□) mövcudluğu ilə müşahidə olunur. 200 q/l və yüksək minerallaşma zamanı mineral sularda kalsium, maqneziumun miqdarı natrium, kaliumun miqdarına yaxınlaşır. Xanlıqlar, Tənənəm, Dəmirçi, Təzəkənd, Dərə, Gömür, Kükü, Yuxarı Qışlaq kəndləri ərazisindəki bulaq, çeşmə və mineral sularında bu qanunauyğunluq gözlənilir □1□. Müxtəlif minerallaşmaya malik sularda makrokomponentlərdə olduğu kimi mikrokomponentlər üçün də müxtəlif hidrogeoloji şəraitdə müəyyən qruplar xarakterikdir. Belə ki, şirin yeraltı sularda dəmir, mis, sink, qurğuşun, azot birləşmələri, flüor və digərləri, minerallaşmış sularda bor, brom, yod geniş yayılmışdır. Bu növ sularda adətən mikrokomponentlər içərisində anion əmələgətirənlər (As, Se, Mo, J), qələvi metallar (Li,Rb, Sr), xalkofil elementlər (Zn, Cu, Pb, Ag), səpələnmiş elementlər (Be) və radioaktiv elementlər (U, Ra) mövcud olur.

Əksər hissəsi dağlıq zona olan Culfa rayonu ərazisindəki çaylar (Əlincə, Qaradərə və s.) Araz çayı hövzəsinə aiddir. Ərazidə qışı və yayı quraq keçən quru çöl iqlim tipi hakimdir. İllik yağıntının miqdarı 200-600 mm, orta illik yağıntının miqdarı isə 215 mm-dir. Araz və Əlincə çayları vadiləri boyunca soyuq sulu mineral bulaqlar, termal sular, kəhriz və çeşmə suları mövcuddur [2]. Culfa şəhərinə yaxın ərazidə, Darıdağın isti sulu arsenli bulaqlar qaynayaraq yer səthinə şıxır.

Şahbuz rayonunun 1000 km^2 - ə malik olan ərazisi zəngin yeraltı su ehtiyatlarına malikdir. 50 mineral su yatağının qeydə alındığı ərazidə mineral və termal bulaqların ümumi günlük su sərfi 2750640 litrdir. Culfada olduğu kimi, Şahbuz rayonunda da termal mineral mənbələr hələ qədim zamanlardan yerli əhali tərəfindən müalicəvi məqsədlər üçün geniş istifdə edilirdi. Hər iki ərazinin termal suları müalicəvi xüsusiyyəylərinə görə karbon qazlı, hidrogen sulfidli və arsenli sular qrupuna aiddir. Arsenin ən yüksək miqdarı Darıdağ suyunda (22 mq/l) qeydə alınmışdır. Amma nəzərə almaq lazımdır ki, təbiətdə heç bir kimyəvi element təcrid olunmuş formada təsir göstərmir. Arsendən əlavə araşdırılan termal sularda çay sularında rast gəlməyən bismut, stibium, selen, bor, brom da mövcuddur [3]. Su ekosistemlərinin əsasını təşkil edən mineral termal su mənbələrinin qanunauyğun paylanması, geniş spektrli müalicəvi özəllikləri onların istifadə sərhədlərini genişləndirir, rekreasiya və müalicə-sağlamlıq əhəmiyyətli obyektlər kimi istifadə edilməsinə şərait yaradır.

Təcrübi hissə

Yeraltı su nümunələrinin seçilməsi 2021-2025-ci illərdə sahə marşrutları zamanı "Hidrogeologiya və mineral sular" laboratoriyasının təşkil etdiyi ekspedisiyaların tərkibində aparılmışdır. Su nümunələrinin fiziki-kimyəvi parametrləri: temperatur, xüsusi elektrik keçiriciliyi, tamı, şəffaflığı, pH-ın qiymətləri mənbələrdə və laboratoriya şəraitində ölçülmüşdür. Bütün nümunələr üçün minerallaşma dərəcəsi, codluq, maqnezium, kalsium, natrium və kaliumun ümumi miqdarı, hidrokarbonat, xlorid, sulfat və pH göstəriciləri müəyyən edilmişdir [4,5].

Göstərilən komponentlərin suda miqdarı mq-ekv/l və mq/l-lə ifadə edilmişdir. Suların ümumi codluğu turşulu xrom tünd göyündən indikator kimi istifadə etməklə ammonyak bufer məhlulu mühitində su nümunəsini standart trilon B məhlulu ilə titrləməklə təyin edilmişdir [6]. Ümumi codluq $C=N_{tr\cdot B} \cdot k \cdot 1000/V_{H2O}$ (mq-ekv/l) formulu ilə hesablanmışdır. Ümumi minerallaşma dərəcəsi 100 ml su nümunəsini ehtiyatla buxarlandırıb, alınan quru kütləni analitik tərəzidə çəkməklə müəyyən edilmişdir [7]. Suların tərkibindəki mikroelementlər (As, B, Cd, Co, Cr, Cu, Mn, Ni, Zn) Türkiyə Respublikasının Van Yüzüncü Yıl Universitetinin Bilim Uyğulama və Araştırma Mərkəsinin əməkdaşları tərəfindən (VAN YYÜ BUAM) öyrənilmişdir.

Nəticələrin müzakirəsi

Culfa və Şahbuz rayonları ərazisindəki mineral və termal sularının kimyəvi tərkibini və keyfiyyətini müəyyən etmək üçün Darıdağ, Gülüstan, Gömür, Biçənək ərazilərini əhatə edən obyektlərdən götürülmüş su nümunələri analiz edilmişdir. Arsenli mineral sular içərisində Şəfa bulağı və Şorsu bulağı Şahbuz rayonunun Ağbulaq və Gömür kəndləri sərhədində, Kolanı-Gömür yolunun üzərində dəniz səviyyəsindən1500-1800

metr yüksəklikdə yerləşir. Hər iki mineral suların tərkibindəki əsas makrokomponentlər hidrokarbonatlar (CHO_3^-), xlorid (Cl^-), sulfat (SO_4^{2-}), kalsium (Ca^{2+}), maqnezium (Mg^{2+}), həmçinin arsen (As^{3+}), karbon qazı (CO_2), hidrogen-sulfid (H_2S) və s.- dir. Suların temperaturu yerin alt qatlarından sabit şəkildə formalaşır (təxminən 8-12^{0}C). Qaynadıldıqda və ya saxlandıqda kimyəvi tərkibləri dəyişə bilir (xüsusilə hidrokarbonatlar parçalanır). Bu sular mədə turşuluğu pozğunluqlarında, qaraciyər və öd yolları xəstəliklərində, eyni zamanda dəri xəstəliklərində (qotur, revmatizma, ekzema və s.) faydalı ola bilirlər. Cədvəl 1-də Şor su bulağından götürülmüş suyun əsaslı kimyəvi analizi aparılmışdır.

Cədvəl 1. Şahbuz rayonu Şor su bulağı suyunun mikro- komponent tərkibi

	Element	**Limit mq/l**	**ÜST* limitləri**	**İçmək üçün**	**Orqanizmə təsiri**
Şor su	Arsen (As^{3+})	0,2997-0,2903	0,01	Çox yüksək zəhərlidir	Dəri xəstəlikləri üçün (psoriaz,ekzema) vannalarda istifadə olunur.
	Bor (B^{3+})	0	2,4	Normal	Təsiri yoxdur
	Kadmium (Cd^{2+})	0,00456-0,00497	0,003	Limitdən yüksəkdir	Terapevtik faydası yoxdur, toksikdir,dəriyə təmas edə bilər.
	Kobalt (Co^{2+})	0,00327-0,00484	ÜST limiti yoxdur	Terapevtik miqdarda ola bilər	Bəzi hallarda dəri hüceyrələrinin bərpasınam üsbət təsir göstərə bilər.
	Xrom (Cr^{3+})	0-0,01214	0,05	Limit daxilindədir	Xrom (III) formasında antiseptik təsir göstərə bilir.
	Mis (Cu^{2+})	0-0,00365	2,0	Təhlükəsiz səviyyə	Antioksidant və iltihab əleyhinə təsir, kollagen sintezini stimullaşdırır
	Kalium (K^+)	1, 794-2,713	Limit yoxdur, təbii sularda normaldır	Faydalıdır, terapevtik	Dərinin nəmlənməsi və hüceyrə balansı üçün faydalıdır
	Manqan (Mn^{2+})	1,059-1,331	0,4	Yüksək dozadadır	İltihabəleyhinə və oksidləşmə əleyhinə təsir

					göstərə bilər, dəri yolu ilə sorulması azdır
	Nikel (Ni^{2+})	0	0,07	Normal	Fayda yoxdur. Çox yayılmış kontakt dermatit səbəblidir (allergen)
	Sink (Zn^{2+})	0,00044-0,00290	3,0	Təhlükəsiz səviyyədədir	Dəri bərpası, yara sağalması, akne və dermatit müalicəsində yararlıdır
	Flor (F^-)	0	1,5	Normal. Risk və fayda yoxdur	Təhlükəsiz
	Nitrit (NO_2^-)	32,6371	0,2	Çox yüksək dozadadır	Toksikdir, ciddi zəhərlənmə riski yarada bilər. Faydalı təsiri yoxdur.
	Bromat (BrO_3^-)	0,4284	0,01	Yuxarı həddən 4,2 dəfə yüksəkdir	Kanserogen, dəridən az da olsa keçə bilər, xroniki təmasda təhlükəlidir.
	Nitrat (NO_3^-)	21,82	50	Normal səviyyə, təhlükəsiz.	Yüngül qan dövranını artırıcı təsiri var. Bu dozada riskli deyil.
	Fosfat (PO_4^{3-})	0,0059	<5	Aşağı səviyyə, zərərsiz	Təhlükəsiz və neytral

Cədvəldən göründüyü kimi, Şor su bulaöının suyunda zərərli mikro-komponentlər olduğundan bu su içmək üçün yararsızdır, yalnız müəyyən miqdarı həkim nəzarəti ilə vannalar şəklində istifadə edilə bilər.

Rayonlar üzrə qruplaşdırmaqla bəzi su mənbələrinin kimyəvi analizinin nəticələri cədvəl 2-də verilmişdir.

Cədvəl 2. Culfa və Şahbuz rayonları ərazisində bəzi mineral su mənbələrinin fiziki-kimyəvi göstəriciləri

Mənbənin adı	Kimyəvi tərkibi	T, ^{0}C	M,mq/l	pH	D m^3/gün
Ağsal	CO_2 1,5 $\frac{HCO_3\ 87\ SO_4\ 12}{Ca\ 47\ Mg\ 33\ (Na+K)\ 20}$	13	3,4	6,5	22
Başkənd	CO_2 1,5 $\frac{HCO_3 85\ SO_4\ 11}{Ca\ 49\ (Na+K) 26 Mg 25}$	16	2,0	7,3	16
Darıdağ	As 22mq/l CO_2 0,8 $\frac{HCO_3 29\ Cl\ 64}{(Na+K)93}$	50	22,0	6,6	4507
Dərəlik	CO_2 1,3 $\frac{HCO_3 72\ Cl 18}{Ca\ 37\ Mg\ 25 (Na+K) 38}$	20	3,6	6,4	150
Dərəşəm	CO_2 1,3 $\frac{HCO_3 62\ SO4 20\ Cl 19}{Ca\ 47\ Mg\ 29 (Na+K) 24}$	22	2,5	6,6	200
Karvansara	600 H2S SO_4 78 $HCO_3$21 0,31 As Ca 58 (Na+K) 21 Mg 21	25	1,4	8,0	50
Gömür	1,3CO_2 $HCO_3$74 Cl 13 SO_4 11,0 0,30As Ca 33 (Na+K) 32 Mg 30	20	3,9	6,6	230
Şor su	1,5 CO_2 HCO_3 82,3 SO_4 5,77 Cl 1,0 0,31 As Ca159 Mg 106 (Na+K) 53	26	3,75	6,57	15
Şəfa bulağı	1,7 CO_2 HCO_3 85,2 SO_4 7,33 Cl 2,13 0,27 As Mg 16,95 (Na+K) 15,8 Ca 14	11	3,6	6,54	18

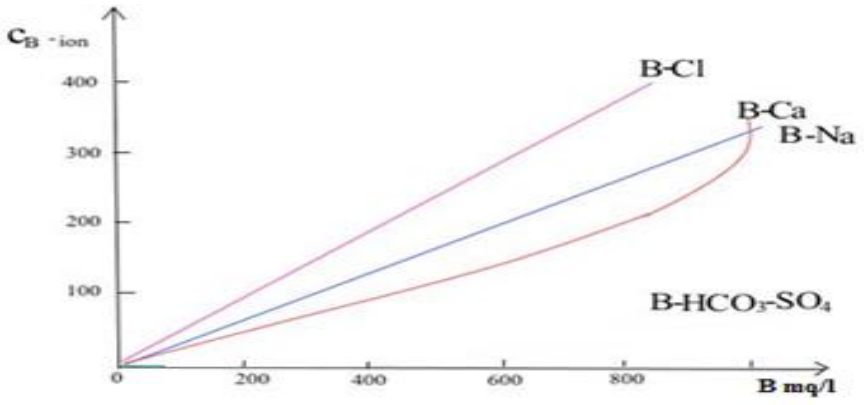
Cədvəldən göründüyü kimi, Culfa rayonu üzrə 5-dən artıq mineral və termal bulaqlardan götürülmüş su nümunələri analiz edilmişdir. Minerallaşma dərəcəsinə görə bu ərazinin sularını 3 qrupa bölmək olar. Şurut, Gal, Nəhəcir, Göynük və Xanəgahdan götürülən sular 0,4-0,5 q/l, Gülüstan, Camaldın, Xaçaparaq (Nahaq), Qızılca, Kırna, Əbrəqunus və Bənəniyarın bulaq suları 0,8-0,9 q/l, minerallaşma dərəcələri ilə xarakterizə olunurlar. Ərazidə mineral və termal mənbələr aşağıdakı qaydada yerləşmişlər: Darıdağ-37, Nəhəcir-10, Ləkətağ-5, Qazançı-2, Başkənd-2, Ağsal-2, Həvi-2, Dərəşəm-2, Teyvaz-2, Xoşkeşin-1, Gülüstan-1. Darıdağ mineral su mənbələri karbon qazlı, arsenli, sürməli olub yüksək temperaturludur. Bu sularda arsen və stibiumla birlikdə assosasiya edən arsen yarımqrupunun digər elementi bismutun da cüzi miqdarı var.

Darıdağ suyu karbon qazlı, arsenli, yüksək minerallaşmış xlorlu-hidrokarbonatlı-natriumludur. Polşada Kudova, Almaniyada Dürkheym, Rusiyada Sineqorsk sularının oxşarıdır. Lakin suyun tərkibindəki mineral duzların miqdarı ilə Darıdağ suyu onlardan daha üstündür.

Cədvəl 3. Darıdağ tipli termal sularda arsen yarımqrupu elementlərinin müqayisəli xarakteristikası

Kationlar, mq/l	**Darıdağ termal suyu**	**Lya-Burbul qələvili termal suyu**	**Dürkheym termal suyu**	**Kudova termal suyu**
Arsen	22	4,5	8,4 – 14,4	2,8
Sürmə	0,008	0,001	0,0035	0,0052
Bismut	0,009	0,005	-	0,0065

Bismut və stibiuma Darıdağ suyuna yaxın ərazidə yerləşən Kərimqulu-Dizə mənbəyində də rast gəlinir. Hər iki yüksək temperaturlu mənbənin sularında arsen yarımqrupu elementləri ilə yanaşı, qiymətli mikroelement bor da vardır. Bu elementlər birlikdə Darıdağ suyunun müalicəvi xüsusiyyətlərini müəyyən edirlər. Bu sularda B_2O_3-ə görə hesablamada borun miqdarı 850-900 mq/l arasında dəyişir. Bor müxtəlif hidrogeokimyəvi mühitlərdə qeyd edilən paylanma qanunauyğunluqları ilə müşayiət olunur. 100 mq/l - dən yüksək maksimal qatılıqları xloridli maqneziumlu şorabalarda, minimal (2,50 mq/l) miqdarı isə duzlu sulfatlı və xloridli natriumlu sularda rast gəlir. Onun aralıq qatılığı (80 mq/l-dən yüksək) xloridli natriumlu-kalsiumlu, xloridli natriumlu- kalsiumlu maqneziumlu və zəif minerallaşmış hidrokarbonatlı sularda rast gəlir. Borun sularda minerallaşma dərəcəsinə və xlora nisbəti müxtəlif tərkibli sularda düzxətlidir [8,9]. Borun minerallaşma dərəcəsi ilə və xlorla münasibəti müsbət korrelyasiya xarakterlidir. Əksər hallarda natriumla belə münasibət tərs xarakter daşıyır. Arsenli mineral sularda makrokomponentlərdən asılı olaraq borun yayılması şəkil 1-də verilmişdir.

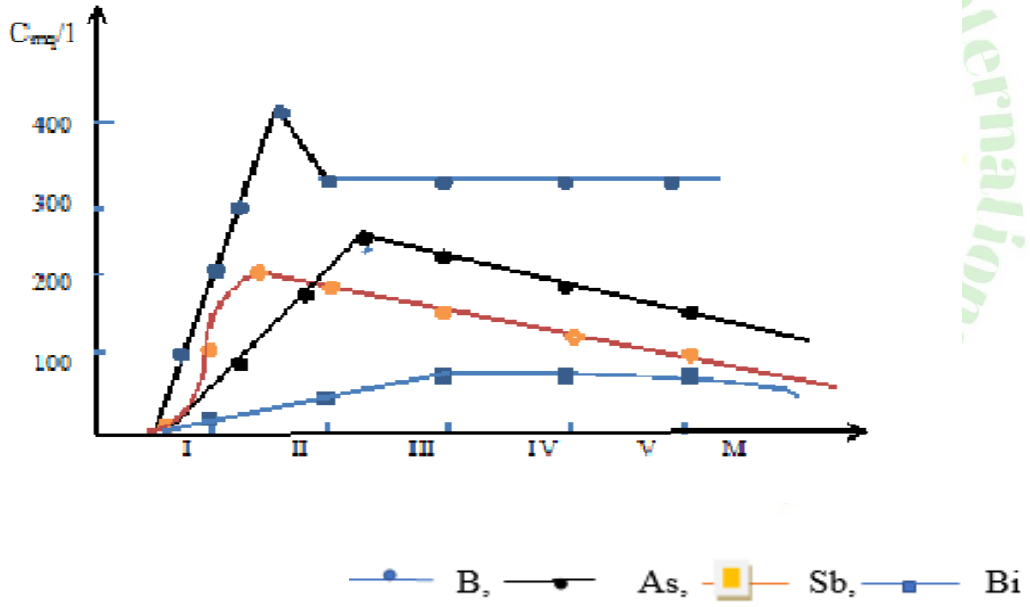


Şəkil 1. Yeraltı sularda makrokomponentlərdən asılı olaraq borun paylanması

Şəkil 1-dən göründüyü kimi borun xlorla korrelyasiya nisbəti düzxətli, natriumla isə qanunauyğunluq əksinədir. Sulfat və karbonat ionları ilə bu qanunauyğunluq minerallaşma dərəcəsinin artması ilə kiçilir.

Darıdağ mineral suyunun tərkibindəki arsen bioloji aktivdir. Darıdağ termal suyunda arsenin məhlulda vəziyyəti mühitin oksidləşmə-reaksiya şəraitindən və mühitdə hidrogen ionlarının qatılığından asılıdır [10,11]. Təcrübi yolla müəyyən edilmişdir ki, Darıdağ termal suyu yerin səthinə çıxdığı anda arsen üçvalentli anion–arsenit ionları şəklində olur. Müəyyən müddətdən sonra üçvalentli arsen tədricən beşvalentli arsenə oksidləşir. Bu proses 7 gün ərzində başa çatır. Bu mühitin reduksiyaedicidən oksidləsdiriciyə keçməsi ilə müşayiət olunur. Sonda həm havanın oksigeni, həm də üçvalentli dəmirin hesabına $As^{3+} \rightarrow As^{5+}$ oksidləşməsi baş verir [12].

Termal suların qrunt suları ilə qarışması prosesində kvars və onun modifikasiyalarının çökməsi baş verir və həll olunan silikat turşusunun son miqdarı hidrotermlərlə müqayisədə az olur.



Şəkil 2. Darıdağ termal mənbələrində mikroelementlərin qatılığının minerallıqdan asılılığı:

Şəkildən göründüyü kimi, II və III mənbələrin sularında mikroelementlərin minerallıqdan asılılığı xətti xarakter daşıyır və az dəyişkəndir. Suya güclü balneoloji özəlliklər verən arsenə nisbətən arsen yarımqrupunun digər elementlərinin qatılığı xeyli aşağıdır. Arsenlə zəngin olan termal suların digər mənbələrində bu növ qanunauyğunluq gözlənilmir. Arsen yarımqrupu elementlərinin, xüsusilə də arsenin sulara verdiyi müalicəvi xüsusiyyətlər orqanizmdə qan dövranını tənzimləyir, dəri xəstəliklərində, bel və oynaq ağrılarında effektiv təsir göstərir.

Suların tərkibinin formalaşmasında aparıcı geokimyəvi amil öyrənilən ərazidə karbon qazı və (mərmər, əhəng daşı və s.) termometamorfizmi hesabına geniş yayılmış dərinlikdə əmələ gələn karbonatın olmasıdır. Suya əhəmiyyətli miqdarda daxil olan karbon qazı, $OH^- + CO_2 = HCO_3^-$ reaksiyasından HCO_3^- ionlarının əmələ gəlməsi ilə suyun minerallığını artırır. Bu reaksiya hesabına məhlulun qələviliyi neytrallaşır və pH-ın qiyməti 5,8–6,3 səviyyəsində qalır. Bu, suların dağ süxurları ilə qarşılıqlı təsir proseslərinin aktivləşdirilməsinə, çoxlu sayda makro və mikrokomponentlərin (kalsium, silisium, dəmir) suya keçməsinə kömək edir. Bu zaman müəyyən ərazilərdə 39^0C temperaturlu karbon qazlı termal sularının əmələ gəlməsi üçün əlverişli şərait yaranır. Su böyük sürətlə aşağı qatlara nüfuz edir, təxminən 3 kilometr dərinliyə çatır və 100^0C temperatura qədər qızır, daha sonra isə su aşağı təzyiq sahəsində geniş yarıqlarla hərəkət edərkən bir qədər soyuyur və 1560 metr hündürlükdən Yer səthinə çıxmış olur. Su-süxur sisteminin qarşılıqlı təsiri müəyyən vaxt keçdikdən sonra daha intensiv inkişaf edir və hidrokarbonatlı-natriumlu-kalsiumlu sular formalaşır [13,14].

Hündürlükdən asılı olaraq düzənlik zonadan dağətəyi və dağlıq ərazilərə keçdikdə minerallıq və codluq azalır, bu qanunauyğunluq Ərəzin-Bəyəhməd kəndləri istiqamətində özünü daha qabarıq göstərir.

Şahbuz rayonunun 8 su mənbəyinin nümunələrindən Şada kəndinin Pir bulağının suyu qeyri-adi yumşaqlığı ilə fərqlənir (2,2 mq-ekv/l). Badamlı mineral suyu haqda da eyni fikri söyləmək olar: 4,0 mq-ekv/l. Lakin Gömür mineral bulaqların suları As 0,26 – 0,30 mq/l və minerallaşma dərəcələri ilə fərqlənirlər. İllik müşahidə və araşdırmaların sonucları Gömür su mənbələrinin hidrogeoloji və hidrogeokimyəvi parametrlərində əsaslı dəyişikliklərin olmadığını təsdiq edir. Arsenin bismut, stibium, litium, brom, maqnezium, radioaktiv elementlər, digər maddələrlə müştərək təsiri maddələr mübadiləsinin bərpasına, periferik sinir sisteminin fəallaşmasına müsbət təsir göstərir [15]. Ərazidəki bütün mineral və termal bulaqlarda, o cümlədən Gömür kəndindəki Şəfa mineral suyundakı Mg^{2+} insan orqanizmində qlükozanın metabolizmində, zülalın və nuklein turşularının sintezində, bədənin temperaturunun tənzimlənməsində iştirak edir. Maqneziumun orqanizmdə iştirakı sayəsində energetik karbohidrat və yağ mübadiləsi prosesləri baş verir. Maqneziumun orqanizmdə gündəlik tələbatı 300 mq-dır. Yaşlı insanların və uşaqların orqanizmi üçün mikroelementlərin gündəlik tələbat normasının universal cədvəlini tərtib etmək olmz. Bu fərdin yaşından, cinsindən, çəkisindən, orqanizminin xüsusiyyətlərindən və həyat tərzindən asılıdır. Eyni zamanda Şəfa mineral suyu aşağı debitli (18-20 m^3/gün) olsa da, digər bulaqlar kimi onun yer səthinə çıxışı təbii yolla baş verir. Bu amil ərazinin mineral su bulaqlarının ehtiyatlarının tükənmədiyini, Şəfa mineral suyunun təbii balansının qorunub saxlandığını sübut edir.

Hal-hazırda mineral və termal mənbələrdən istifadənin səmərəliliyini artırmaq üçün onların potensial imkanlarını nəzərə almaqla, bu bulaqların və onların ətrafındakı təbiət abidələrin qorunması, bərpası işi

gücləndirilir və bulaq, çeşmə, kəhriz sularından regionun su təchizatında istifadəsinə və müalicəvi turizmin inkişafına yönələn tədbirlər həyata keçirilir.

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The Chemical Composition and Antibacterial Effect of Propolis

Propolisin Kimyasal Bileşimi ve Antibakteriyel Etkisi

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Abstract

This article investigates the chemical composition and antibacterial effects of propolis. Propolis is a natural resinous substance collected by bees from plant secretions and used to protect the hive. Its complex composition includes waxes, polyphenols, terpenoids, flavonoids, vitamins, and trace elements. The main active components—flavonoids and phenolic acids—are responsible for its antibacterial properties. Propolis is particularly effective against Gram-positive bacteria and demonstrates activity against pathogens such as *Staphylococcus aureus*, *Escherichia coli*, and *Listeria monocytogenes*. Flavonoids damage bacterial membranes and reduce biofilm formation. Additionally, propolis exhibits antioxidant, anti-inflammatory, and antitumor properties, which may support the immune system and contribute to the prevention of various diseases, making it a valuable substance in apitherapy.

Keywords: Propolis, Chemical Composition, Antibacterial Effect, Flavonoids, Apitherapy

1. INTRODUCTION

Composition of Propolis: Propolis is a natural resinous substance collected by bees from various parts of plants, buds, and secretions. Bees use it to seal their hives, and it is also important to prevent the decay of deceased insects inside the hive when the hive is under attack. Propolis is chiefly a lipophilic substance; it is hard and brittle when cold, yet soft, elastic, and highly adhesive when warm. For this reason, it is called “bee glue.” It has a pleasant aroma, and its color varies depending on its source and the time of collection. Propolis contains diverse chemical constituents such as waxes, resins, balsams, aromatic and essential oils, pollen, and other organic compounds. The proportions of these substances change according to the collection place and time. The compounds identified in propolis resins originate from three sources:

1. Plant secretions collected by bees;
2. Substances formed via bee metabolism;
3. Other materials mixed during propolis formation.

Propolis Composition and Botanical Origins: Because the chemical composition of propolis is highly complex, isolating its individual components is not easy. Typically, the ethanol-soluble fraction of propolis is extracted and referred to as "propolis balm," while the insoluble wax fraction is left aside. The most commonly used extract is the ethanol extract, although other solvents are also used to identify certain compounds. Propolis contains vitamins B1, B2, B6, C and E, as well as minerals such as silver, cesium, mercury, lanthanum, antimony, copper, manganese, iron, calcium, aluminum, vanadium, and silicon. The botanical origin of propolis has also been studied. Research shows that propolis is mainly collected from secretions of tree buds. Samples of propolis gathered from various tree species include *Populus fremontii*, *P.* × *euramericana*, *Dalechampia*, *Clusia*, *P. nigra*, *P. italica*, *P. tremula*, *P. suaveolens*, *Betula*, *Pinus*, *Prunus*, *Acacia*, *Aesculus hypocastanea*, *Clusia minor*, *Plumeria acuminata*, and *P. acutifolia*.

Chemical Compounds of Propolis: The chemical composition of propolis is closely linked with the resins and balsams from plants used in its formation. With advances in research, more than 300 chemical compounds have been identified in propolis. Besides waxes, the major chemical groups found in propolis include waxes, polyphenols (phenolic acids, flavonoids), and terpenoids. Polyphenols and terpenoids are considered the most active components of propolis. The flavonoid group includes compounds such as chrysin, pinocembrin, apigenin, galangin, kaempferol, quercetin, tectochrysin, pinostrobin, and others. Another important class comprises aromatic acids, notably ferulic, cinnamic, caffeic, benzoyl, salicylic, and p-coumaric acids. For example, in Polish propolis, the flavonoid content ranges from 6.2 % to 18.8 %. Among the flavonoids, pinocembrin (~4.7 %), pinobenchin (3.1 %), galangin (2.2 %), and chrysin (2.1 %) are present in the highest amounts. Furthermore, propolis contains other phenolic compounds (e.g. artepillin C) and terpenes (terpineol, camphor, geraniol, nerol, farnesol), which contribute to its characteristic aroma. Propolis also includes micro- and macroelements (Mn, Fe, Si, Mg, Zn, Se, Ca, K, Na, Cu) and vitamins B1, B2, B6, C, and E. This diverse chemical composition gives propolis additional advantages as a potent antibacterial agent, as the combination of multiple active substances in varying proportions helps prevent bacterial resistance.

Antibacterial Effects of Propolis: The antibacterial effect of propolis and the activity of some of its constituents against bacteria, viruses, fungi, and protozoa have been documented in many studies. In various investigations, propolis has been tested against over 600 different bacterial strains. Studies show that propolis is more effective against Gram-positive bacteria than against Gram-negative ones. The geographic region from which propolis is collected also influences its antibacterial activity; for instance, Middle Eastern propolis has shown high efficiency against both Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria, whereas propolis from Germany, Ireland, and Korea exhibited weaker activity. The antibacterial action of propolis may occur via two mechanisms: by enhancing the host's immune system

or by direct effects on microorganisms, particularly Gram-positive bacteria. The phenolic mixtures in propolis act on the outer cell membranes of bacteria. Polish propolis showed antibacterial activity against MRSA and inhibited bacterial growth and biofilm formation. Iranian and Brazilian propolis samples are also effective against Gram-positive microorganisms. The flavonoids within propolis can target various components of bacterial cells. For example, kaempferol is used in treating skin infections caused by *S. aureus* and also shows high activity against *Enterococcus faecalis*, *Listeria monocytogenes*, and *Staphylococcus saprophyticus*. *Quercetin* binds to the subunit of *E. coli* DNA gyrase, weakening bacterial proliferation. Propolis can have synergistic effects with other antibacterial agents. For example, Bulgarian propolis and Brazilian honey acted synergistically against *Salmonella typhi*. Brazilian red propolis and fluconazole were effective against *Candida* species. Flavonoids like pinocembrin and apigenin in Chilean propolis showed antibacterial activity against *Streptococcus mutans*; apigenin also had a synergistic effect on B-lactam MRSA. Propolis is also rich in cinnamic acid, which is effective against *Bacillus spp.*, *Streptococcus pyogenes*, *Aeromonas spp.*, *Micrococcus flavus*, *Pseudomonas aeruginosa*, *Yersinia ruckeri*, *Vibrio spp.*, *E. coli*, *Mycobacterium tuberculosis*, *Listeria monocytogenes*, *Enterobacter cloacae*, and *Salmonella enterica* serotypes. Cinnamic acid disrupts the bacterial cell membrane, weakens ATPase activity, and inhibits bacterial division and biofilm formation.

Apitherapy and Health Applications: Propolis is not only valuable for its antibacterial properties but also as a bioactive product beneficial to human health. Studies of propolis from different countries reveal that its flavonoids, phenolic acids, terpenes, aromatic aldehydes, and other components exhibit antioxidant, anti-inflammatory, and antitumor effects. These bioactive compounds influence cell cycle regulation, support the immune system, and may exert synergistic effects with certain clinical treatments. In vitro and in vivo experiments, as well as some clinical studies, have demonstrated beneficial effects of propolis on diseases such as diabetes, obesity, and cancer. For instance, certain flavonoids and phenolic acids enhance insulin sensitivity, helping to regulate blood glucose; their antioxidant properties reduce cell damage and suppress inflammatory processes. Moreover, some components of propolis slow down the proliferation of cancer cells, providing additional benefit in apitherapy. These characteristics make propolis not only an antibacterial agent but also a natural product with broad health applications.

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Evaluation of Antimicrobial and Cytotoxic Activities of Methanolic and Aqueous Extracts of Alchemilla mollis (Buser) Rothm.

Alchemilla mollis (Buser) Rothm'un Metanol ve Sulu Ekstraktlarının Antimikrobiyal ve Sitotoksik Aktivitelerinin Değerlendirilmesi

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Abstract

Alchemilla mollis (Buser) Rothm., also known as lady's mantle, is a perennial plant in the Rosaceae family, traditionally used for treating wounds and women's health-related conditions. Members of the genus *Alchemilla* are known to contain high levels of tannins and flavonoids and to exhibit both anticancer and antimicrobial properties. Lung cancer remains one of the leading causes of cancer-related mortality worldwide, with limited therapeutic success due to adverse effects and multidrug resistance. Consequently, plant-derived compounds have gained increasing attention as alternative therapeutic agents, offering lower toxicity and improved safety profiles. This study investigated both the antimicrobial and cytotoxic effects of methanolic and aqueous extracts of *A. mollis* on human lung adenocarcinoma cells (A549) and selected bacterial and fungal strains.

The extracts were prepared by maceration from the dried aerial parts of the plant. Antimicrobial activity was evaluated using the microdilution method against *Bacillus cereus*, *Bacillus subtilis*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Yersinia pseudotuberculosis*, and the fungal strain *Candida albicans*. Cytotoxicity was assessed on A549 cells using the MTT assay at concentrations of 0, 10, 25, 50, 100, 125, 250, and 500 µg/mL for 24, 48, and 72 hours.

The results revealed that the aqueous extract exhibited the lowest MIC values against *Enterococcus faecalis* and *Yersinia pseudotuberculosis*, whereas the methanolic extract showed the lowest MIC value against *Enterococcus faecalis*. In the cytotoxicity assay, the aqueous extract significantly reduced A549 cell viability in a dose- and time-dependent manner. In contrast, the methanolic extract produced no statistically significant reduction in viability across the tested concentrations and incubation times.

Overall, these findings indicate that *A. mollis* represents a promising source of bioactive compounds with dual antimicrobial and cytotoxic potential. The results underscore its pharmacological relevance and possible application in the development of natural therapeutic agents with minimal side effects.

Keywords: *Alchemilla mollis*, Antimicrobial Activity, Cytotoxicity, Lung Cancer, Plant Extract, Bioactive Compounds

Issues Related to Soil Chemistry and The Importance of Oxidation-Reduction Processes in Soil

Toprağın Kimyası ve Toprakta Gerçekleşen Oksidasyon-Redüksiyon Süreçlerinin Önemi Üzerine Konular

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Özet

Toprak, çok sayıda farklı kimyasal elementi bünyesinde barındırmaktadır. Bu elementler, bitki beslenmesinde temel bir rol oynamakta olup makro elementler, mikro elementler ile toprakta bulunan alkali ve toprak alkali metallerin temel bileşikleri bu gruba örnek olarak verilebilir. Toprak kimyası, tarımda toprak verimliliğinin ve üretkenliğinin artırılmasında kilit bir öneme sahiptir.

Toprakta gerçekleşen oksidasyon–indirgenme (redoks) süreçlerinin incelenmesi büyük önem taşımaktadır. Oksidasyon–indirgenme süreçleri, bitki köklerinin iyi bir şekilde solunum yapmasını sağlamakta, toprak verimliliğini artırmakta ve bitkilerin sağlıklı gelişimine katkıda bulunmaktadır. Bu süreçler sırasında, bitki beslenmesi açısından önemli olan elementlerin dolaşımı gerçekleşmektedir. Toprak verimliliğinin artmasıyla birlikte azot, fosfor, karbon ve diğer besin elementlerinin döngüsü düzenlenmekte; bu elementler bitkiler tarafından kolaylıkla alınabilir formlara dönüştürülmektedir.

Anahtar Kelimeler: Toprak kimyası, oksidasyon süreci, indirgenme süreci, toprak bileşimi

Abstract

There are a large number of different chemical elements in the soil. These elements play a key role in plant nutrition. Examples of these include macroelements, microelements, basic compounds of alkaline and alkaline-earth metals in the soil, etc. Soil chemistry plays a key role in increasing soil productivity and fertility in agriculture.

The study of oxidation-reduction processes in the soil is of great importance. Oxidation-reduction processes lead to good respiration of plant roots, increased soil fertility, and healthy growth of plants. During the oxidation-reduction process, the process of circulation of elements important for plant nutrition occurs. As soil fertility increases, the circulation of nitrogen, phosphorus, carbon, etc. other nutrients is regulated and these elements are converted into a form that is easily absorbed by plants.

Keywords: Soil Chemistry, Oxidation Process, Reduction Process, Soil Composition

Soil Chemistry and Its Role in Agriculture

Soil chemistry is an integral part of agriculture and also studies the issues related to the purification of soil from harmful substances. In agriculture, soil chemistry plays a key role in increasing soil fertility and productivity. Soil is a living system composed of a mixture of minerals, organic matter, water, and air.

Soil consists of four main components. Research has shown that the mineral part of the soil includes elements such as silicon, aluminum, magnesium, iron, potassium, and calcium. This mineral portion constitutes about 45–46% of the soil.

Organic matter makes up 4–5% of the soil content. Organic matter forms as a result of the decomposition of plant and animal remains.

About 25% of the soil is water, which plants absorb through their roots. In areas of the soil where water is absent, air makes up about 25%. Air is essential for the respiration of plant roots.

There are numerous chemical elements in the soil. These elements play a crucial role in plant nutrition. Examples of macroelements include oxygen, sulfur, nitrogen, hydrogen, carbon, phosphorus, magnesium, potassium, and calcium.

Research has also shown that the soil contains microelements such as copper, zinc, boron, manganese, molybdenum, and iron. The main compounds of alkali and alkaline earth metals in the soil are in the form of oxides, hydroxides, carbonates, and other salts. These metals are not found in their pure form in nature but exist as compounds, which are essential for soil health. Alkali metals are mainly found in the soil in the form of sodium and potassium salts, especially sodium chloride and potassium chloride. Lithium compounds are less commonly found in soil.

Among the alkaline earth metals, calcium is the most widespread in soil. It is mainly found as calcium carbonate, such as in limestone, and in other calcium salts. The least common alkaline earth metals in soil are strontium and barium. These compounds are present in the form of minerals, including silicates, carbonates, and phosphates.

The presence of sufficient air in the soil is as important as water and nutrients. The primary sources of the soil's gas phase are atmospheric air and gases formed within the soil itself. Oxygen from the atmosphere enters the soil and is vital for the respiration of plant roots. During respiration, oxygen is absorbed, and carbon dioxide is released. Continuous oxygen supply to the root system and the removal of carbon dioxide from the soil enable many plants to grow properly. The optimal condition for plant growth is when the oxygen level in the soil air is about 20%. When the soil is well-aerated, conditions become favorable for plant growth and productivity.

A lack of free oxygen in the soil results in plant death. When soil has poor oxygen supply, its physical properties deteriorate, fertility decreases, and plant productivity drops. Oxygen deficiency in soil air halts plant growth, weakens root development, and reduces the absorption of water and nutrients. The absence of oxygen leads to the destruction of both the plant and its roots. Oxygen deficiency in soil not only negatively affects plant growth but also increases reduction processes, which ultimately reduce crop yields.

Oxidation-reduction (redox) processes continuously occur in the soil and lead to changes in its physical and chemical properties. During these processes, plants absorb nutrients more effectively, increasing their productivity. These redox processes involve chemical reactions that result in changes in the soil's chemical composition due to shifts in oxidation states. Elements like phosphorus, sulfur, nitrogen, iron, and others undergo cyclic changes during these processes.

When the soil is well-oxygenated, oxidation processes dominate; in oxygen-deficient conditions, reduction processes occur.

Oxidation primarily occurs in dry soils. Reduction takes place in anaerobic conditions, that is, in water-saturated soils. Redox processes help regulate the soil's chemical balance. During this time, the concentration of essential nutrients for plants increases. The color and composition of the soil also change.

As we know, oxidation is accompanied by the loss of electrons from atoms. In soil, oxidation occurs with the involvement of atmospheric oxygen. For example:

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

When the Fe^{2+} ion is converted into the Fe^{3+} ion, it becomes unusable for plants. This is because plants cannot directly absorb the Fe^{3+} ion. This ion precipitates in the form of $Fe(OH)_3$ and becomes unavailable to plants.

$$4\,Fe^{2+} + O_2 + 6H_2O \rightarrow 4\,Fe(OH)_3$$

When the Fe^{3+} ion is converted into the Fe^{2+} ion, it becomes beneficial for plants. This is because plants can easily absorb Fe^{2+} ions through their roots. During the process of photosynthesis, Fe^{3+} and Fe^{2+} ions act as electron carriers. During this process, the soil takes on a yellowish or reddish color. When the concentration of iron ions in the soil is low, plant leaves turn yellow, and plant development is poor. On the other hand, when iron levels are too high, the plant's root system is damaged, and brown spots appear on the leaves.

The oxidation process of nitrogen compounds occurs as follows:

$$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$$

Ammonium ions in the soil are oxidized and converted into nitrates. Nitrate ions are easily absorbed by plants through their roots, and they are used to synthesize essential compounds such as proteins, amino acids, and chlorophyll. In soils where nitrate ion concentration is high, plants grow better. Their leaves become larger and greener, and crop yields are abundant.

In manganese compounds found in soil, the oxidation process proceeds as follows:

$$Mn^{2+} \rightarrow MnO_2$$

In addition to the oxidation process, reduction processes also occur in the soil. Reduction is the process of gaining electrons. For example, the reduction process of iron proceeds as follows:

$$Fe(OH)_3 + e^- \rightarrow Fe^{2+} + 3OH^-$$

During the reduction of nitrogen compounds, nitrogen loss occurs in the soil.

$$NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2 \uparrow$$

The amount of nitrogen, an essential nutrient, is higher in soils where the photosynthesis process in plants accelerates. This is because, as we know, nitrogen is a component of chlorophyll. In such conditions, plants develop better and their leaves become greener. Since the stems and leaves of plants increase, productivity also rises.

During the reduction of manganese compounds, the following processes occur:

$$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2\,H_2O$$

As a result, soil moisture increases. Manganese helps activate enzymes in plants and improves seed germination. Manganese is required by plants in small amounts as a micronutrient. However, excessive manganese causes black spots to appear on leaves, and plant growth slows down.

Thus, it can be said that studying oxidation-reduction processes in soil is of great importance for agriculture. During oxidation-reduction processes, the cycling of essential nutrients for plant nutrition takes place. As soil fertility increases, the cycling of nutrients such as nitrogen, phosphorus, carbon, and others is regulated, and these elements become more easily absorbable by plants. This leads to increased crop yields and the preservation of ecological stability. Oxidation-reduction processes promote proper respiration of plant roots, enhance soil fertility, and contribute to the healthy growth of plants.

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Morphological Identification of Tropilaelaps spp. Mites

Tropilaelaps spp. Gənələrinin Morfoloji İdentifikasiyası

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Abstract

Tropilaelapsosis is an invasive disease of honey bee colonies caused by mites belonging to the genus *Tropilaelaps spp.* Morphological and molecular methods are used to identify each mite species. For accurate apiary diagnosis, the morphological identification of tropilaelapsosis should be conducted.

The first sign of *Tropilaelaps* infestation is the presence of reddish-brown elongated mites on bees or combs. Adult mites can be seen with the naked eye. The body length of the mite is greater than its width, which allows it to move more actively among the comb and the hairs on the bee's body. The dorsal shield of the mite is reddish-brown and covered with numerous short stiff setae, while the posterior lateral setae are long and softer. A distinguishing feature of mites belonging to the genus *Tropilaelaps* is the presence of a shield on both the dorsal and ventral surfaces. On the ventral side of the abdomen, there are four pairs of setae around the segments. Mites hold their first pair of legs in a vertical position. On the dorsal side, they have a dorsal shield, and on the ventral side, there is an ellipsoid anal plate forming a circular shape around the anal opening. The abdominal length varies by species and between males and females.

According to the "OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals," *Tropilaelaps* can be detected either on bees or in hive debris. Occasionally, the presence of brood, dead or deformed immature individuals, adult bees with abnormal wings crawling toward the hive, or small, reddish-brown, protruding, fast-moving mites on the comb indicates the presence of *T. clareae*. Diagnosis can be initially confirmed by opening capped brood cells and observing immature and adult mites.

Tropilaelaps mites more frequently parasitize drone bees. Morphological identification plays a crucial role in species determination, treatment of bee diseases, production and processing of apiculture products, and apitherapy. Morphological identification also involves visually comparing adult male *Tropilaelaps* mites with the morphological characteristics of mites from other genera.

Keywords: Tropilaelapsosis, Apiculture, Morphological, Identification, Diagnosis

Investigation of the Effects of Modern Technologies on the Physiological Indicators of Young People

Modern Teknolojilerin Gençlerin Fizyolojik Göstergeleri Üzerindeki Etkisinin İncelenmesi

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Abstract

Objective: The study aimed to investigate the perspectives of students studying at the Faculty of Medicine, Nakhchivan State University, regarding the use of modern technologies, as well as the positive and negative effects created by them. The research was conducted with 44 students aged 18-22. Among the participants, 36.36% were male and 63.64% were female.

Materials and Methods: To determine the indicators, questionnaires were given to the students and surveys were conducted. The obtained results were statistically analyzed using "Microsoft Excel 2010" and "IBM SPSS Statistics 22" software. The results were analyzed both by gender and overall.

Results and Innovations: Students prefer traditional methods (75%) while studying lessons to better memorize and forget later. However, 70.5% of the students believe that when teachers use modern methods to teach, it is more beneficial for them. When students use traditional methods, the number of lesson repetitions also increases. Students who use modern technologies while studying tend to repeat lessons less. 54.55% of the students think that modern technologies have a moderate impact on science and education activities. Among students who use modern technologies for a long time, 68.18% have problems with "attention distraction," and 56.82% of these students have difficulty "refocusing their attention." 63.6% of students experience "digital amnesia" (the tendency to record information on phones or tablets without the need to memorize it, and then forget it). 61.4% of the students believe that excessive use of social media affects short-term memory. 86.36% of the students think that excessive studying can lead to illness or disruption of routine. 65.9% of students believe that social media use creates "addiction." Among 15 students who use modern technologies mainly for social media (6 males, 9 females), "social addiction" was observed. Among 8 students who use modern technologies mainly for research and education (3 males, 5 females), "social addiction" was also present.

Keywords: Technology, Lesson, Method, Study, Modern

Assessment of the Productivity of Main Forage Plants in the Pastures of the Daridag Area

Darıdağ Ərazisi Otlaqlarında Əsas Yem Bitkilərinin Məhsuldarlığının Qiymətləndirilməsi

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Abstract

The article discusses the productivity characteristics, vegetation composition and biomass potential of winter and spring pastures in the Darıdag area. In the research work, the productivity of pasture ecosystems formed in semi-desert and mountainous xerophytic landscape conditions was analysed in terms of seasonal variability. Furthermore, the climatic conditions of the area, soil characteristics and the distribution characteristics of dominant plant species were also taken into account.

The territory is of particular importance in terms of the study and rational use of natural fodder resources. The predominant economic activity in this region is cattle breeding, and the sustainable development of livestock breeding is contingent on the productivity of pasture resources. The productivity of pastures is subject to seasonal variation, with vegetation undergoing intensive development in the spring months and a significant decline in pasture resources during the winter. Consequently, the evaluation of the productivity of winter and spring pastures, along with their efficient utilisation and conservation, is pertinent from both scientific and practical standpoints.

The winter pastures are located in the lower and more gentle relief parts of the Darıdag area and are formed mainly on saline, poorly fertile soils. It is evident that spring pastures are distributed in the elevated and more humid regions of the Darıdag area. The fertility of the soils is conducive to plant growth, which in turn stimulates the development of vegetation during the growing season.

The findings of the research indicate that the development of pasture plants is more pronounced during the spring season. In optimal years, productivity can reach 1000-1900 kg/ha. In winter pastures, productivity is comparatively low, averaging 350-400 kg/ha, due to the impact of drought. The findings obtained provide a significant scientific foundation for the

ecologically sustainable management of pasture resources and the efficient organisation of the feed base in the Darıdag area.

Keywords: Darıdag, pasture, productivity, winter pastures, spring pastures, biomass

INTRODUCTION

Pastures are of strategic importance to Azerbaijan's agricultural system. About half of the country's total area is covered by natural pastures, which form the main feed base for livestock farms.

The Darida region of the Nakhchivan Autonomous Republic has an arid climate and belongs to the semi-desert and mountainous xerophytic landscape type. It is distinguished by its unique flora. The area is home to perennial xerophytic grasses, ephemeral and ephemeroid plants, and various shrubs. This area is particularly important for studying and using natural fodder resources sustainably [2]. The main economic activity in this region is cattle breeding, and the sustainable development of this industry depends on the productivity of pasture resources. Pasture productivity varies by season: vegetation develops intensively in spring and pasture resources decrease significantly in winter. Therefore, assessing the productivity of winter and spring pastures and ensuring their efficient use and protection is relevant from both scientific and practical points of view.

MATERIAL and METHODS

A number of botanists, such as A.A. Grossheim [6], Y.M. Isayev [7], V.J. Hatamov [8], A.Sh. Ibrahimov and F.G. Movsumova [1], have studied the productivity, forage quality, and capacity of pastures in different regions of Azerbaijan at certain times [4, 5]. Despite these studies, the aforementioned research and literature lacks accurate information about individual pastures or phytocenological complexes. Additionally, there is no information in the literature about noteworthy phytocenological areas in the Nakhchivan Autonomous Republic, such as Darydagh, Goynuk and Deresham.

DISCUSSION and CONCLUSIONS of the STUDY

The winter pastures in the Darıdag area are located in the lower, more moderate relief parts and are formed mainly on saline, infertile soils. Drought-resistant xerophytic grasses and shrubs dominate these areas. During the winter, the vegetation process in the pasture areas weakens. Most plants enter a dormant stage, while only certain xerophytic species retain green mass. For this reason, winter pasture productivity is low, averaging 350-400 kg/ha dry matter (Figure 1).

Figure 1: Winter Pastures in the Darıdag Area

During the winter, these pasture resources are insufficient for the animals' primary nutrition, so additional feeding is necessary. Pasture resources in winter are mainly provided by stored plant residues and a few winter-hardy grasses and shrubs. Thus, additional stored feed, such as hay or mixed feed, is necessary for feeding animals on winter pastures. Intensive grazing in winter can lead to degradation of soil cover and weakening of plants' regeneration potential. Thus, grazing on these pastures should be kept to a minimum, with a "use ratio" of no more than 20-25%.

Spring pastures are widespread in the higher, wetter areas of Darıdag. Soil fertility is relatively good here, and rainfall during the growing season stimulates vegetation growth (Figure 2).

Spring is the season of the most intensive vegetation development in the Darıdag area. During this time, the soil is more moist, and perennial grasses and ephemeral and ephemeroid plants grow rapidly. Spring pastures are significantly more productive than winter pastures, and according to experimental data, their productivity ranges from 300 to 900 kg/ha of dry matter. In the most favorable years, productivity can increase to 1,000–1,900 kg/ha.

Figure 2: Spring Pastures in the Darıdag Area

Since pasture biomass production peaks in the summer, proper management of grasses is particularly important during this period. Spring pastures are the main source of feed for livestock. If spring pastures are overgrazed, the plants' generative development is disrupted, seed formation is weakened, and, in the long term, the pasture cover thins, which leads to a decrease in species composition and an increased risk of soil erosion.

Figure 3: Summer Pastures in the Darıdag Area

To make effective use of pastures, grazing should be carried out in short, rotational periods, and the areas should be given sufficient rest periods for grass to regenerate (Figures 3 and 4).

Figure 4. Autumn Pastures in the Darıdag Area

To accurately assess pasture productivity, we established sample plots with four replicates, each measuring 25 m². These plots were composed of special frames measuring 5 m x 5 m, or 25 m². The crop was harvested according to the size of the frames. The fresh mass was determined by weighing and the average productivity per 100 m² was calculated (Table 1, Diagram 1).

The main fodder plants are found in the Darıdag area *Agropyron cristatum* Gaertn, *Avena sativa* L., *Eremopyrum bonaepartis* (Spreng.) Nevski, *Poa bulbosa* L., *Thinopyrum intermedium* subsp. *Intermedium, Koeleria eriostachya* Pancic., *Trisetum flavescens (*L.) P.Beauv., *Dactylis glomerata* L., *Hordeum murinum* subsp. *leporinum* (Link) Arcang., *Bromus japonicus* subsp. *Japonicus., Bromus scoparius* L., *Bothriochloa ischaemum* (L.) Keng., *Lolium perenne* L., *Festuca valesiaca* Schleich. ex Gaudin., *Astragalus fabaceus* M.Bieb., *Astragalus oleifolius* DC., *Astragalus microcephalus* subsp. *Microcephalus., Astragalus tribuloides* Delile., *Astragalus* aduncus Willd., *Astragalus* argyroides Beck., *Medicago varia* Martyn., *Trigonella coerulescens* (M.Bieb.) Halacsy., *Malva sylvestris* L, *Tragopogon reticulatus* Boiss. & A.Huet., *Capsella bursa – pastoris* (L.) Medik et al.

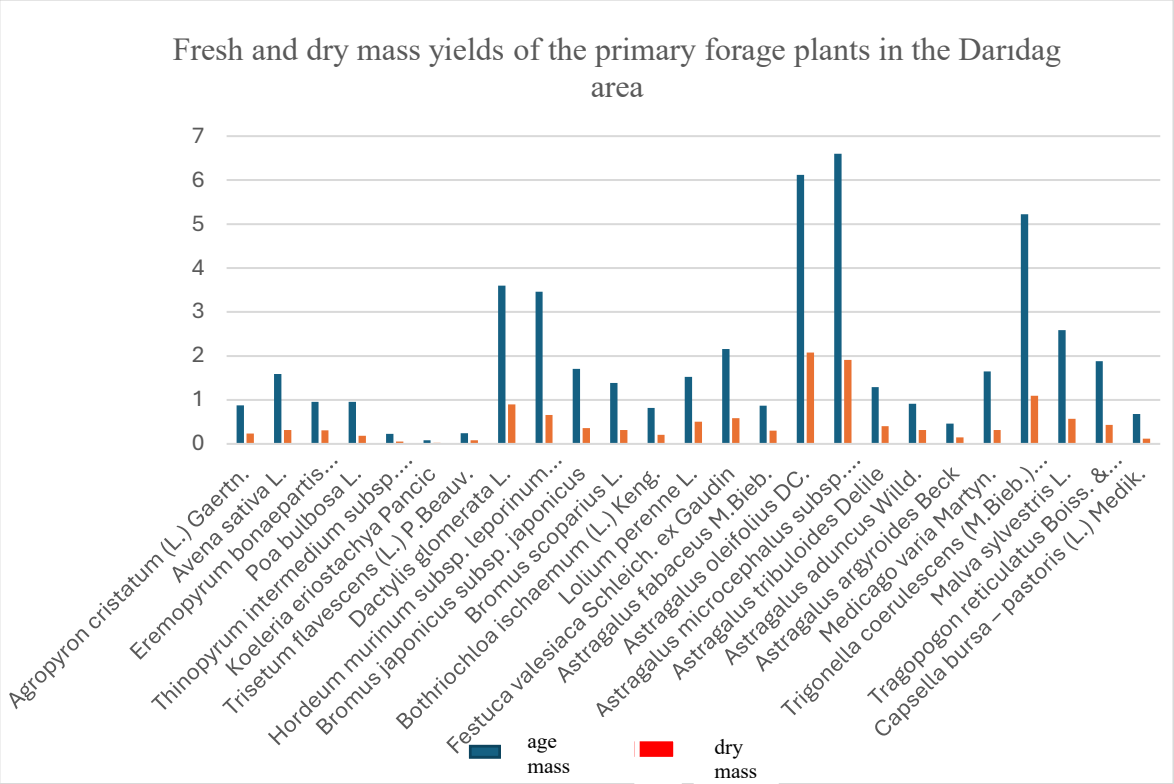

Diagram 1: Fresh and Dry Mass Yield of Fodder Plants in the Darıdag Area

To determine the pasture area's capacity, the load per hectare was calculated using the following formula. This formula took into account the productivity of plant groups, the amount of feed per unit, how long cattle or sheep grazed in the phytocenosis, and the daily feed rate (Equation 1).

$$T = \frac{MxY}{HxD} \quad \text{(Equation 1).}$$

T: Number of cattle per hectare of pasture (in heads)

M: Productivity of dry grass eaten by cattle per hectare of pasture (kilograms per hectare)

Y: Feed unit in the above-ground mass of pasture per 100 hectares (kilograms per hectare)

H: Feed unit required per head of cattle per day (1.3 kilograms for small-horned cattle and 3.9 kilograms for cattle)

D: Number of days cattle graze on pastures per year (245 days)

The table reflects quantitative indicators and the fresh and dry mass yields of the main fodder plants in the Darıdag area. The plant density, as well as the fresh and dry mass yields and dry matter percentages, were determined for each plant species per 1 m² and 1 hectare.

As the data show, the main forage crops in the area are cereals and legumes.

The results show that the fresh mass yield varies between 0.081 and 6.60 tons per hectare (t/ha), and the dry mass yield varies between 0.024 and 2.081 t/ha. The dry matter content ranges from 18% to 34%, depending on the morphological structure of the plant species and growth conditions.

The highest productivity was recorded in *Astragalus oleifolius* DC. (6.12 tons per hectare (t/ha) fresh, 2.081 t/ha dry mass) and *Astragalus microcephalus* subsp. *microcephalus* (6.6 t/ha fresh, 1.914 t/ha dry mass). These species' high productivity indicates their deep root systems, drought-resistant morphological characteristics, and good adaptation to semi-desert conditions.

In contrast, relatively low-yielding species such as *Koeleria eriostachya* Pancic (0.081 t/ha fresh; 0.024 t/ha dry mass) and *Thinopyrum intermedium* subsp. *Intermedium* (0.225 t/ha fresh; 0.056 t/ha dry mass) were selected. These figures suggest that these species have poor biomass potential and limited forage value under pasture conditions.

The cereal species *Hordeum murinum* subsp. *leporinum* (Link) Arcang (3.46 tons per hectare of fresh mass and 0.657 tons per hectare of dry mass) and *Bromus japonicus* subsp. *japonicus* (1.71 tons per hectare of fresh mass and 0.359 tons per hectare of dry mass) were selected for their moderate productivity. However, they play an important role as pasture plants due to their high adaptability.

The results of the studies revealed that the productivity and quality of these phytocenoses depend on the bioecological characteristics of the distributed fodder plants, as well as the effects of anthropogenic and edaphic factors. In this regard, the productivity of pasture phytocenoses formed in the Darıdag area based on botanical groups was determined for the winter and spring seasons.

Table 1. Yield per Hectare of Main Fodder Crops Distributed in the Darıdag Area (Wet and Dry Mass in kg/ha)

Serial number	Plant name	Replications (5m x 5m), 25 m^2/ number of plants, in numbers				Number of plants per 100 m^2, pcs.	Number of plants per 1 m^2, pcs.	Number of plants per 1 ha, pcs.	Fresh mass of a plant, grams	Yield per hectare, fresh weight kg/ha	Productivity per hectare, fresh weight t/ha	Dry mass %	Productivity per hectare, dry mass t/ha
		I	II	III	IV								

1.	*Agropyroncristatum* (L.) Gaertn.	30	25	40	30	125	1,25	12500	70	875	0,875	27	0,236
2.	*Avenasativa* L.	45	47	50	70	212	2,12	21200	75	1590	1,59	20	0,318
3.	*Eremopyrum bonaepartis* (Spreng.)Nevski.	57	60	75	20	212	2,12	21200	45	954	0,954	32	0,305
4.	*Poabulbosa* L.	40	37	65	50	192	1,92	19200	50	960	0,96	19	0,182
5.	*Thinopyrum intermedium* subsp. *Intermedium*	5	10	8	7	30	0,3	3000	75	225	0,225	25	0,056
6.	*Koeleria eriostachya* Pancic	3	10	5	9	27	0,27	2700	30	81	0,081	30	0,024
7.	*Trisetum flavescens (*L.) P.Beauv.	7	4	8	10	29	0,29	2900	85	246,5	0,2465	33	0,081
8.	*Dactylis glomerata*L.	50	80	100	47	277	2,77	27700	130	3601	3,601	25	0,900
9.	*Hordeum murinum* subsp. *leporinum* (Link) Arcang	70	85	90	101	346	3,46	34600	100	3460	3,46	19	0,657
10.	*Bromus japonicus* subsp. *japonicus*	40	35	70	45	190	1,9	19000	90	1710	1,71	21	0,359
11.	*Bromus scoparius* L.	41	47	35	40	163	1,63	16300	85	1385,5	1,3855	23	0,319
12.	*Bothriochloa ischaemum* (L.) Keng.	17	25	21	19	82	0,82	8200	100	820	0,82	25	0,205
13.	*Lolium perenne* L.	45	47	51	60	203	2,03	20300	75	1522,5	1,5225	33	0,502
14.	*Festucavalesiaca* Schleich. exGaudin	60	75	48	57	240	2,4	24000	90	2160	2,16	27	0,583
15.	*Astragalus fabaceus* M.Bieb.	15	10	11	15	51	0,51	5100	170	867	0,867	35	0,303
16.	*Astragalus oleifolius* DC.	17	13	11	10	51	0,51	5100	1200	6120	6,12	34	2,081
17.	*Astragalus microcephalus* subsp. *microcephalus*	7	10	8	5	30	0,3	3000	2200	6600	6,6	29	1,914
18.	*Astragalus tribuloides* Delile	10	15	21	40	86	0,86	8600	150	1290	1,29	31	0,400
19.	*Astragalus* aduncus Willd.	8	10	9	8	35	0,35	3500	260	910	0,91	35	0,319
20.	*Astragalus* argyroides Beck	11	10	9	7	37	0,37	3700	125	462,5	0,4625	32	0,148
21.	*Medicago varia* Martyn.	27	35	40	30	132	1,32	13200	125	1650	1,65	19	0,314
22.	*Trigonella coerulescens* (M.Bieb.) Halacsy	55	57	37	60	209	2,09	20900	250	5225	5,225	21	1,097
23.	*Malva sylvestris* L.	45	47	55	60	207	2,07	20700	125	2587,5	2,5875	22	0,569
24.	*Tragopogon reticulatus* Boiss. & A.Huet	52	37	49	50	188	1,88	18800	100	1880	1,88	23	0,432
25.	*Capsella bursa – pastoris* (L.) Medik.	47	58	49	72	226	2,26	22600	30	678	0,678	18	0,122

CONCLUSIONS

1. The dry mass yield of the main forage crops in the Darıdag area ranged from 0.024 to 2.081 tons per hectare, corresponding to a low-to-medium productivity level in semi-desert conditions.
2. The highest productivity was recorded among species belonging to the *Astragalus* L. genus, which were evaluated as a promising source of feed resources.
3. The lowest productivity was observed in the *Koeleria eriostachya* Pancic and *Thinopyrum intermedium* subsp. *intermedium* species.

4. To increase the area's fodder resources, it is advisable to protect and reproduce species belonging to the genera *Astragalus* L., *Medicago* L., *Hordeum* L. and *Bromus* L. from ecological and economic points of view.

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Synthesis, structural characterization and antimicrobial activity of (E)-1-(4-chlorophenyl)-2-(2,2-dichloro-1-(2,3-dimethoxyphenyl)vinyl)diazene

(E)-1-(4-klorofenil)-2-(2,2-diklor-1-(2,3-dimetoksifenil)vinil)diazenin sentezi, yapısal karakterizasyonu ve antimikrobiyal aktivitesi

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Abstract

In this study, a novel aryl-hydrazone derivative, (E)-1-(4-chlorophenyl)-2-(2,2-dichloro-1-(2,3-dimethoxyphenyl)vinyl)diazene, was synthesized and its structural and antimicrobial characteristics were comprehensively investigated. The compound was prepared through a condensation reaction between the corresponding α-ketoester and 4-chlorophenylhydrazine in ethanol under reflux with a small amount of acetic acid. The resulting product was purified by recrystallization and characterized using UV–Vis, FTIR, ^{1}H NMR, ^{13}C NMR, and elemental analysis techniques.The molecular geometry and electronic properties of the synthesized compound were optimized by Density Functional Theory (DFT) calculations at the Gaussian 09 program. FTIR spectra showed characteristic absorption bands for C=N (1610 cm^{-1}) and N=N (1510–1550 cm^{-1}) functional groups, confirming the diazene structure. The ^{1}H NMR spectrum displayed aromatic proton signals in the 6.8–7.6 ppm range and methoxy group signals around 3.75–3.85 ppm. Antimicrobial screening was carried out against Escherichia coli, Staphylococcus aureus, and Candida albicans using the disk diffusion method at a concentration of 100 µg/mL. The compound exhibited strong inhibitory activity against S. aureus (16 mm inhibition zone), moderate activity against E. coli (11 mm), and weak activity against C. albicans (12 mm). The presence of chloro and methoxy substituents is believed to enhance the lipophilicity and membrane permeability of the compound, thus improving its antibacterial potential. In conclusion, the synthesized diazene derivative demonstrates high structural stability and promising antimicrobial activity, especially against Staphylococcus aureus. These results suggest that aryl-hydrazone derivatives could serve as valuable scaffolds for the design of new bioactive molecules and antimicrobial agents.

Keywords: α-Ketoester, Aryl-hydrazone, Diazene derivative, Antimicrobial activity

Bioecological Analysis of The Genus Suaeda (Suaeda forssk. Ex Scop.) Distributed in The Flora of Azerbaijan

Azerbaycan Florasinda Yayilan Suaeda Cinsinin (Suaeda forssk. Ex Scop.) Biyoekolojik Analizi

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Abstract

Today, biodiversity conservation remains one of the most pressing global challenges, and its study constitutes a key objective for biologists. In Azerbaijan, floristic research plays an integral role in understanding the laws governing florogenetic processes, as well as in developing effective strategies for biodiversity assessment and conservation. Within this context, the genus *Suaeda* (*Suaeda* Forssk. ex Scop.), belonging to the family *Chenopodiaceae* Vent., occupies a specific ecological niche in the regional flora, acting as both an edificator and a dominant element in vegetation cover formation.

Herbarium specimens of the genus *Suaeda* found in Azerbaijan were identified based on the sources *"Flora of Azerbaijan"* and *"Flora of the Caucasus"*. During analysis, the life forms of species were classified according to C. Raunkiaer and I.G. Serebryakov; geographic and areal types according to A.A. Grossheim and N.N. Portenier; ecological groups according to A.P. Shennikov. The nomenclature of genera and species was aligned with the taxonomy of S.K. Cherepanov.

This article presents a bioecological analysis of the genus *Suaeda* (*Chenopodiaceae* Vent.) distributed in the flora of Azerbaijan. Taxonomic analysis revealed the presence of 7 species of *Suaeda* within the territory of the Republic. According to life forms, therophytes (annuals) account for 5 species (71.4%) and chamaephytes (subshrubs) for 2 species (28.6%). Regarding areal types: Desert – 4 species (57.1%) and Ancient Mediterranean – 3 species (42.9%). By areal classes: Turan – 4 species (57.1%), Western Asia – 2 species (28.6%), and Mediterranean – 1 species (14.3%). Based on moisture requirements: xerophytes – 3 species (42.9%), mesoxerophytes – 3 species (42.9%), and mesophytes – 1 species (14.2%). All 7 species (100%) are halophytes. Based on substrate texture: nephephytic (rocky terrain) – 5 species (71.4%), facultative petrophytes – 2 species (28.6%); facultative psammophytes (sandy terrain) – 7 species (100%). According to response to anthropogenic impact: anthropophobes – 3 species (42.9%), facultative anthropophobes – 2 species (28.6%), and facultative anthropophiles – 2 species (28.6%).

The study of desert vegetation in Azerbaijan has been significantly advanced by the works of R.A. Aliyev, F.G. Movsumova, R.K. Melikov, E.M. Gurbanov, etc. The *Suaeda* formation group is characteristic of desert vegetation in Azerbaijan, typically occurring on saline and salty soils. These species form independent plant communities and are components of halophytic desert and semi-desert ecosystems.

The genus *Suaeda* includes approximately 100 species worldwide (8 species in the Caucasus, 7 in Azerbaijan), distributed across all continents except Antarctica. In Azerbaijan, *Suaeda*-dominated formations are particularly characteristic of saline soils and play an essential role in structuring halophytic desert vegetation. These formations are represented by several community types: *Suaedeta confusae* (mixed *Suaeda* communities), *Suaedeta altissimae* (tall *Suaeda*), *Suaedeta salsae* (saline *Suaeda*), *Suaedeta prostratae* (prostrate *Suaeda*), *Suaedeta dendroideae* (shrubby *Suaeda*), and *Suaedeta microphyllae* (small-leaved *Suaeda*). The article provides information on species composition, abundance, stratification, and phenological phases for each of these formations.

A comprehensive analysis of the genus *Suaeda* (*Suaeda* Forssk. ex Scop.) in Azerbaijan's flora is of both theoretical and practical significance for the study of biodiversity.

Keywords: *Chenopodiaceae*, *Suaeda*, halophytes, facultative psammophytes, anthropophobes.

Distribution and dominance degree of Tamarix ramosissima Ledeb. in the vegetation around the Mingachevir Reservoir

Mingəçevir Baraj Gölü çevresindeki bitki örtüsünde Tamarix ramosissima Ledeb. türünün yayılışı ve baskınlık derecesi

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Abstract

The aim of the study is to describe the spatial distribution characteristics of the species in the shoreline and nearby terrestrial-aquatic ecotones, its position within the phytocoenotic structure, and its relationships with ecological factors (moisture regime, salinity, anthropogenic impacts). The methodological approach includes geobotanical field observations, recording the visual cover and relative abundance of plant associations involving the species, route surveys, as well as a comparative analysis of cartographic materials and regional floristic literature. To assess the degree of dominance, field observation records on the species' relative abundance, frequency, and projected cover in phytocoenoses are systematized and compared with classifications and descriptions from the literature.

Without conducting laboratory experiments, the article, based on field data and references, highlights the species' preference tendencies in habitats such as shorelines, terraces near water, and drainage structures, as well as its influence on the composition of plant communities. Consequently, the habitat types where the species occurs, observed dominance patterns, and its relationships with ecological factors have been identified, and the species' significance has been evaluated in the context of biodiversity, shoreline management, and ecosystem sustainability. This approach provides a scientific basis for clarifying the actual distribution patterns of the species and its role in phytocoenoses in the region.

Keywords: *Tamarix ramosissima*, Mingachevir Reservoir, Phytocoenotic Structure, Degree of Dominance.

Characterization and Pathogenicity of Beauveria bassiana Strains Isolated from Galleria mellonella L. (Lepidoptera: Pyralidae) in Turkey

Türkiye'de Galleria mellonella L. (Lepidoptera: Pyralidae) Türünden İzole Edilen Beauveria bassiana Suşlarının Karakterizasyonu ve Patojenisitesi

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Abstract

Galleria mellonella (greater wax moth) is one of the most destructive pests of honeycombs, causing serious economic losses to beekeeping by feeding on beeswax during its larval stage. In this study, two native entomopathogenic fungi (EPF) isolates, designated as *Beauveria bassiana* G-A and G-B, were isolated from naturally infected *G. mellonella* larvae collected from beehives in Turkey and characterized morphologically and molecularly. The identification of both isolates was confirmed through sequencing of the ITS1-5.8S-ITS2 rDNA region and phylogenetic analysis, which placed them within the *B. bassiana* clade. Bioassays were conducted to evaluate their pathogenicity against third-instar *G. mellonella* larvae using conidial suspensions ranging from 1×10^5 to 1×10^9 conidia/mL under controlled laboratory conditions. The highest concentration resulted in 96.54% and 89.66% mortality for the G-A and G-B isolates, respectively, within ten days post-inoculation. The calculated LC_{50} values were 0.2×10^6 and 0.6×10^6 conidia/mL, while the LT_{50} values were 2.68 and 2.43 days, respectively. Both isolates caused visible mycosis and typical white fungal growth on cadavers. These findings demonstrate that native *B. bassiana* isolates possess strong entomopathogenic potential against *G. mellonella* and can be considered promising biological control agents as eco-friendly alternatives to chemical insecticides in apiculture. Further investigations are needed under field conditions to evaluate their persistence, formulation stability, and safety for non-target organisms.

Keywords: *Galleria mellonella*, *Beauveria bassiana*, Entomopathogenic Fungi, Biological Control

Investigation of the Chemical Properties of Azerbaijan and Turkish Teas

Azerbaycan ve Türk Çaylarının Kimyasal Özelliklerinin İncelenmesi

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Abstract

Dünyada en çok tüketilen içeceklerden biri olan çay, yalnızca kültürel bir unsur değil, aynı zamanda insan sağlığına katkılarıyla da dikkat çeken bir bitki ürünüdür. Farklı bölgelerde yetişen çay türleri, içerik bakımından çeşitlilik gösterebilmekte ve bu durum, çayın biyolojik değerinin anlaşılması açısından bilimsel araştırmaları gerekli kılmaktadır. Bu çalışmada, Azerbaycan çayı ile Türkiye'de özellikle Rize bölgesinde elde edilen Mayıs hasadı Türk çayının, aynı demleme yöntemi kullanılarak kimyasal ve biyolojik özelliklerinin karşılaştırılması amaçlanmıştır. Her iki çay türü, geleneksel Türk demleme yöntemi ile demlenmiş ve sonrasında toplam fenolik madde miktarı, toplam flavonoid içeriği ve antioksidan kapasite (DPPH yöntemi) analizlerine tabi tutulmuştur. Çalışmanın amacı, farklı coğrafyalarda yetiştirilen ancak benzer tüketim şekillerine sahip bu iki çay türünün sağlık açısından potansiyel katkılarını bilimsel olarak ortaya koymaktır. Her iki çay örneği üçer tekrar ile analiz edilmiştir. Örnekler, geleneksel yöntemle demlendikten sonra elde edilen çay sıvıları üzerinden spektrofotometrik analizler yapılarak fenolik ve flavonoid içerikleri belirlenmiştir. Antioksidan kapasite değerlendirmesi için DPPH serbest radikal süpürme yöntemi tercih edilmiştir. Elde edilen veriler istatistiksel olarak analiz edilmiş; çay türleri arasındaki anlamlı farklılıklar, bitkilerin yetiştiği iklim koşulları, toprak özellikleri ve uygulanan işleme yöntemleri çerçevesinde değerlendirilmiştir.

Keywords: Tea, Phenolic compounds, Antioxidant capacity, Infusion

Chemical Composition of Royal Jelly from Honey Bees Fed with Different Sugars

Farklı Şekerlerle Beslenen Bal Arılarından Elde Edilen Arı Sütünün Kimyasal Bileşimi

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Abstract

Royal jelly is used in human nutrition due to its biochemical properties. Colonies are fed to increase royal jelly yield per hive. The research was conducted in two different locations (Doğanşehir and Uluköy) and four different feeding groups (crystallized granulated sugar, pasteurized bee feed syrup, and glucose syrup) were formed for each location. For phenolic component extraction in royal jelly samples, pure water was added to royal jelly at 100 mg/ml and kept in an ultrasonic bath until fully mixed. Then it was centrifuged at 15000 g for 10 minutes at 4℃ and the supernatant was placed in vials. Glucose feeding generally increased invertase and catalase concentrations, while sucrose feeding decreased these concentrations. It was observed that location and feeding mode had significant independent effects on the biochemical parameters of bees. These factors are critical in shaping the phenolic compound profiles in royal jelly. The most abundant phenolic compounds in royal jelly were found to be 2,3,4-trihydroxybenzoic acid, 4-hydroxybenzoic acid, p-coumaric acid, and gallic acid. Glucose feeding specifically increased the amounts of 4-hydroxybenzoic acid and p-coumaric acid, while bee meal feeding increased the concentration of ellagic acid.

Keywords: Royal Jelly, Phenolic Compounds, Enzymatic Activity

Expression in vitro of Capsid Proteins of Chronic Paralysis Virus (CBPV)

Kronik Arı Felci Virüsü (CBPV) Kapsid Proteinlerinin in vitro İfadesi

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Abstract

Beekeeping is a widespread industry in Türkiye. One of the biggest problems in this sector is diseases affecting honeybees. Some diseases can lead to colony collapse and the spread of the disease to other hives. One of these diseases is caused by chronic bee paralysis virus (CBPV), which causes symptoms such as wing drooping, trembling, feather loss, clustering in front of the hive, and the death of infected bees.

CBPV is an RNA virus and has gene sequences (ORF2 and ORF3) in its genome for two capsid proteins (hSP and pSP). This study aimed to enable the expression of these CBPV proteins in an insect expression system. This study will allow us to investigate the combined effects of the resulting viral protein and the virus on bee life.

In the study, cDNA sequences of the genes were generated, and these DNAs were cloned into the bac-to-bac system intermediate vectors. Bacmid vectors were then generated, and the expression vectors enabled the production of hSP and pSP proteins in insect cell culture. The resulting capsid proteins were prepared for later use in feeding bees.

This study is the first to focus on developing a vaccine for bees. In the final phase of the study, CBPV and the produced viral capsid proteins will be tested on bees. It is expected that bees fed with the produced capsid proteins will be more resistant to CBPV infection than bees fed with a normal diet.

Keywords: Bac-to-bac protein expression system, Beekeeping, Chronic Paralysis Virus (CBPV), Capsid Proteins

Entomopathogenic Fungi Effective Against Galleria mellonella L. (The Greater wax moth) (Lepidoptera: Pyralidae)

Galleria mellonella L. (Büyük bal mumu güvesi) (Lepidoptera: Pyralidae)'ya Karşı Etkili Entomopatojenik Funguslar

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Abstract

In this study, thirteen entomopathogenic fungi strains belonging to the genera *Metarhizium* and *Beauveria* and isolated from various sources in Türkiye were tested against third instar *Galleria mellonella* larvae at a concentration of 1 x 10^7 conidia/ml under laboratory conditions. According to the screening test results, 4-Güm-A (*M. anisopliae*) and Hp-5 (*B. bassiana*) strains produced 66.6% and 70% mortality on the pest on the 10^{th} day of infection, respectively. Mycosis of whole cadavers showed that these strains had the highest insecticidal activity and entomopathogenicity on the pest. 4-Güm-A and Hp-5 strains were subjected to dose-response experiment on *G. mellonella* larvae at concentrations of $1x10^{5-9}$ conidia/ml. The mortality rates of 4-Güm-A and Hp-5 strains on the 10^{th} day of application at a concentration of 10^9 conidia/ml were 83.3% and 96.6%, respectively. As a result of this test, it was determined that 80% of the deaths caused by 4-Güm-A and all of the deaths caused by Hp-5 were mycosis. All these findings showed that both strains have a high potential for use in biological control of *Galleria mellonella*. Further studies are planned to be aimed at developing a mycoinsecticide against the pest from these strains.

Keywords: *Galleria mellonella*, *Beauveria bassiana*, *Metarhizium anisopliae*, Entomopatogenic fungi, Biological control

1. INTRODUCTION

The large wax moth (*Galleria mellonella*) is a pest belonging to the order Lepidoptera. While adult individuals and other developmental stages of this species do not directly harm the honeycomb, the larvae cause serious damage to the honeycombs, especially in hot, humid, poorly ventilated and dark environments, causing significant economic losses in beekeeping (Akyol & Korkmaz, 2008). These pests, whose populations increase rapidly during the warm seasons, can destroy honeycombs and wooden frames in as little as a week (Cynthia, 2012). The population, which increases in March, peaks in August. Although the economic damages

caused by *Galleria mellonella* have not yet been evaluated in detail on a global scale, it is estimated to have caused millions of dollars in losses in the USA, China, and various European countries (Hosni et al., 2022). This pest was first detected in Asian honeybee (*Apis cerana*) colonies, and over time it has spread over a wide geographical area such as North Africa, the British Isles, parts of Europe, North America, and New Zealand (Kwadha et al., 2017).

Today, it is common in many regions where beekeeping is practiced (Hosni et al., 2022). Physical, chemical, cultural and biological control methods are applied against the pest (Komala & Seram, 2020). Bacillus thuringiensis (Bt), one of the most commonly used agents in biological control methods, has been evaluated in this field for many years (Kwadha et al., 2017). However, in a study conducted by Burges (1977), it was found that BT was effective only in the first season; in the second and third seasons, larval mortality rates were significantly reduced. Similarly, Gulati and Kaushik (2004) reported that BT maintained its effectiveness for 13 months. Burges (1977) suggested that there may be two reasons for this decline in activity: (i) mature honeybees dilute Bt spores through the accumulation of wax and propolis, and (ii) bacterial degradation. Entomopathogenic fungi (EPF) have long been considered effective agents in the biological control of insect pests. Species belonging to the genera *Metarhizium*, *Beauveria*, *Nomuraea*, *Lecanicillium* and *Isaria* in this group stand out. EPFs are naturally present in the soil environment and can be isolated from both soil samples and infected insect samples (Sree & Varma, 2015).

The purpose of this study is to evaluate the insecticidal activity and entomopathogenicity potential of entomopathogenic fungi strains belonging to the genera *Metarhizium* and *Beauveria*, isolated from various source in Türkiye, against *G. mellonella* larvae under laboratory conditions. The findings obtained will lay the groundwork for developing an effective, locally sourced biological control agent against this pest.

2. MATERIALS and METHODS

2.1.Insect and fungal culture

The primary culture of *G. mellonella* larvae was obtained through samples collected from wax honeycombs stored in Trabzon/Türkiye. A culture of the wax moth, *G. mellonella*, was maintained in temperature and humidity-controlled chambers (30°C, 70% relative humidity (RH)) in constant darkness on an artificial diet (Sehnal, 1966). In the bioassay experiment, individuals in the 3rd larval stage obtained from this laboratory culture were used. The entomopathogenic fungi used in this study were obtained from the culture collection of entomopathogenic fungi at the Karadeniz Technical University Department of Biology Microbiology Laboratory. These isolates were collected from various agricultural and forestry pests commonly found in the region, along with several soil samples taken from the Eastern Black Sea Region (Table 1).

2.2. Preparation of conidiospore suspensions

Fungal isolates used in screening and dose experiments were diluted to 100 µL from stock suspensions at 1 × 10^5 spores/mL and spread onto PDAY medium using the spreading method. The Petri dishes were incubated at 25 °C for 2-3 days. After the incubation period, individual cultures from the developing colonies were selected and transferred to fresh PDAY medium. These new cultures were incubated at 25 °C for four weeks, after which 10 ml of sterile 0.1% Tween 80 solution was added to each Petri dish, and the spores on the surface were scraped using a glass rod. The obtained spore suspensions were filtered through a double layer of sterile cheesecloth and collected into sterile 50 ml Falcon tubes to remove mycelium and agar residues. The suspensions were then vortexed for 5 minutes to create a homogeneous solution. Spore concentrations were adjusted using a Neubauer hemocytometer, and only suspensions showing ≥95% germination determined on PDAY after 24 h incubation by counting spores with germ tubes longer than the spore diameter were used in pathogenicity assays (Sevim et al., 2010a, b).

Table 1. Entomopathogenic fungus strains used in the study

No	Isolates	Origin	Species	Reference
1	4-Güm-A (KTU-51)	Toprak	*Metarhizium anisopliae*	Sevim et al., 2010a
2	287 (KTU-7)	Toprak	*Beauveria bassiana*	Sevim et al., 2010a
3	269 (KTU-60)	Toprak	*Metarhizium brunneum*	Sevim et al., 2010a
4	As-2	*Amphimallon solstitialis*	*Metarhizium flavoviride*	Biryol et al., 2020
5	As-18	*Amphimallon solstitialis*	*Metarhizium flavoviride*	Biryol et al., 2020
6	Hp-4	*Hypera postica*	*Beauveria bassiana*	Yücel et al., 2018
7	Hp-5	*Hypera postica*	*Beauveria bassiana*	Yücel et al., 2018
8	K4	*Hypera postica*	*Beauveria bassiana*	Yücel et al., 2018
9	K5	*Hypera postica*	*Beauveria bassiana*	Yücel et al., 2018
10	Oj-3	*Orasanga japonica*	*Beauveria bassiana*	Bayramoğlu et al., 2025
11	Oj-7	*Orasanga japonica*	*Beauveria bassiana*	Bayramoğlu et al., 2025
12	Pa-5	*Pristiphora abietina*	*Beauveria bassiana*	Biryol et al., 2021
13	Rh (KTU-57)	*Rhynchites bacchus*	*Beauveria bassiana*	Sevim et al., 2010b

2.3. Screening test

The bioassay was established as 1 × 10^7 spores/mL and was administered by spraying using a hand-held spray atomizer. A sterilized 0.01% Tween 80 solution was supplied to the control groups. The ten larvae were placed in plastic boxes measuring 20 × 20 cm. All larval test groups were kept in plastic boxes and reared in a climate-controlled incubator at 25 ± 1°C and 65 ± 5% relative humidity (RH), under a light:dark photoperiod (L12:D12). Insect mortality in each treatment was observed daily for 7 days. Each treatment was replicated

three times on separate days (Sevim et al., 2010a). The deceased individuals were placed in petri dishes with sterile, damp filter paper, where fungal growth was noted. Four isolates were selected to be evaluated during the dose response experiment, showing the highest mortality rate in screening tests: 4-Gum-A (*M. anisopliae*), As-2 (*M. flavoviride*), Hp-5 and Pa-5 (*B. bassiana*). These selected entomopathogenic fungal strains were tested on *G. mellonella* larvae at five different concentrations: 1×10^5, 1×10^6, 1×10^7, 1×10^8 and 1×10^9 spores/mL. The methodology used in the screening tests was used. Bioassay data were observed daily for seven days, and the deceased larvae were recorded. Using the mortality data obtained, the potency level of each isolate was calculated with the Abbot formula (Abbott, 1925).

3. RESULTS and DISCUSSION

Beekeeping and honey production are of great importance for ecosystems, agricultural productivity and human health. Türkiye's rich vegetation and suitable ecological conditions offer significant potential in the beekeeping sector. However, despite the current conditions, the yield per colony is well behind the world average (Akyol, 2013). The main reasons for this low yield include genetic structure, environmental factors, colony management, and diseases and parasites. In particular, the lack of effective control over diseases and parasites reduces productivity and harms human health by requiring the use of multiple chemicals in beekeeping products. The large wax moth (*Galleria mellonella* L.) is also one of the pests that cause productivity losses in honeybees and is a significant problem for beekeepers in honeycomb protection (Akyol, 2013). The initial screening assays clearly demonstrated the significant virulence of two specific strains against *G. mellonella* larvae. Specifically, on the 10th day post-infection, the Hp-5 (B. bassiana) strain induced the highest mortality at 70%, followed by the 4-Güm-A (*M. anisopliae*) strain at 66.6% (Figure 1). The high insecticidal activity and entomopathogenicity of these two strains were further confirmed by the widespread mycosis observed on the entirety of the larval cadavers. Subsequently, these superior strains were advanced to a dose-response study, tested across a concentration gradient ranging from 1×10^5 to 1×10^9 conidia/ml. At the maximum applied concentration of 1×10^9 conidia/ml, the mortality rates were substantially elevated. The Hp-5 strain again outperformed, achieving 96.6% mortality by the 10th day post-application, whereas the 4-Güm-A strain resulted in 83.3% mortality.

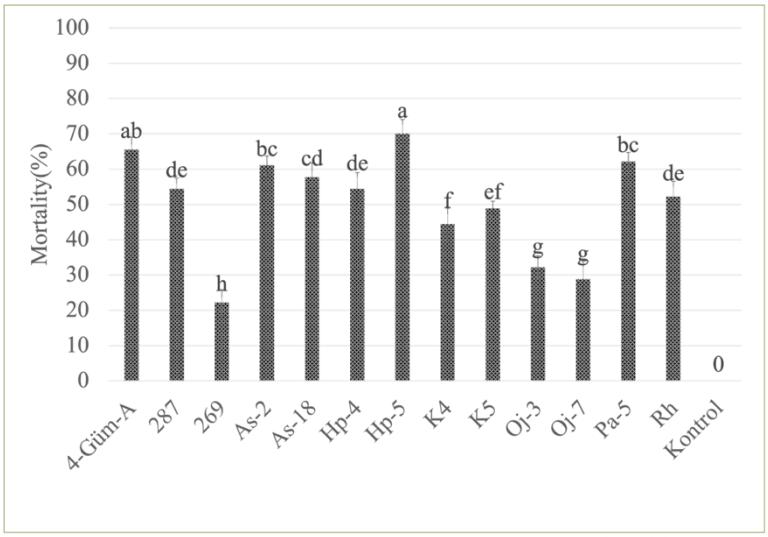

Figure 1. Screening test experiments of entomopathogenic fungus strains on *G. mellonella* larvae. Control: 0.01% Tween80. Mortality indicates the mean of three repetitions.

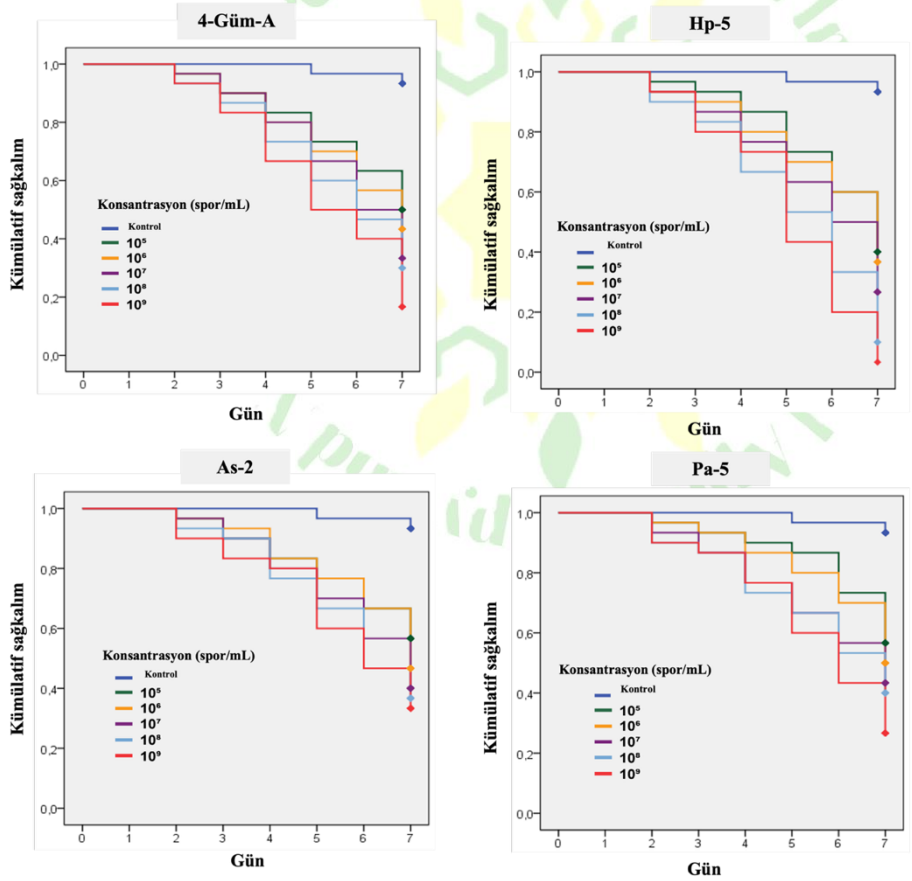

Figure 2. Dose experiments of entomopathogenic fungus strains on *G. mellonella* larva. Control: 0.01% Tween80. Mortality indicates the mean of three repetitions.

Subsequently, these superior strains were advanced to a dose-response study, tested across a concentration gradient ranging from 1×10^5 to 1×10^9 conidia/ml. At the maximum applied concentration of 1×10^9 conidia/ml, the mortality rates were substantially elevated. The Hp-5 strain again outperformed, achieving 96.6% mortality by the 10th day post-application, whereas the 4-Güm-A strain resulted in 83.3% mortality. Crucially, the diagnostic analysis of dead larvae revealed that mycosis accounted for 80% of deaths attributed to 4-Güm-A and 100% of deaths caused by Hp-5, underscoring the highly infectious nature of the *B. bassiana* strain. The use of entomopathogenic fungi is a promising alternative for biological control of Galleria mellonella (Reithinger et al., 1997). In the research, an efficacy test was conducted against *Galleria mellonella* using 13 entomopathogenic fungus isolates from our country, and it was determined that the Hp-5 (*Beauveria bassiana*) isolate was the most effective against this pest.

4. CONCLUSION

This laboratory study successfully identified two local entomopathogenic fungal strains (*M. anisopliae* strain 4-Güm-A and *B. bassiana* strain Hp-5) with high biological control potential against *Galleria mellonella*. Screening and dose-response experiments clearly demonstrated that the strains' insecticidal activity is concentration-dependent. Specifically, the Hp-5 strain exhibited a remarkable mortality rate of 96.6% at the highest concentration (1×10^9 conidia/mL), and all observed deaths were attributable to mycosis (fungal infection). This high level of entomopathogenicity establishes the Hp-5 strain as a superior biocontrol agent candidate among those tested. The findings align with the broader literature supporting the efficacy of B. bassiana and M. anisopliae in controlling *G. mellonella*. In conclusion, both the 4-Güm-A and, particularly, the highly virulent Hp-5 strains hold significant potential for the development of a commercial mycoinsecticide to control the Greater Wax Moth in apiculture, offering an environmentally friendly alternative to chemical pesticides.

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Taxonomic Diversity of the Lamiaceae Lindl. Family in the Flora of the Talysh Region (Azerbaijan)

Talış Bölgesi (Azerbaycan) Florasında Lamiaceae Lindl. Familyasının Taksonomik Çeşitliliği

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Özet

Bu çalışma, yüksek biyolojik çeşitlilik ve endemizm ile bilinen Azerbaycan'ın Talış bölgesi florasında yer alan Lamiaceae familyasının taksonomik çeşitliliğine ilişkin kapsamlı bir değerlendirme sunmaktadır. Türlerin kimliklerinin doğrulanması ve taksonomik kayıtların güncellenmesi amacıyla sistematik arazi çalışmaları, herbaryum örneklerinin analizi ve ilgili literatürün ayrıntılı incelenmesi gerçekleştirilmiştir. Çalışma sonucunda, 4 alt familyaya ait toplam 27 cins, 98 tür ve 9 alttür tespit edilmiştir. Nepetoideae ve Lamioideae alt familyaları en yüksek tür zenginliğini gösterirken, Scutellarioideae alt familyası en az temsil edilen grup olmuştur.

Sınırlı yayılışa sahip bazı taksonların belirlenmesi, bölgenin floristik özgünlüğünü ve koruma açısından taşıdığı önemi ortaya koymaktadır. Taksonomik adlandırmalar, POWO, IPNI ve WFO gibi uluslararası kabul görmüş veri tabanlarına göre güncellenmiştir. Elde edilen bulgular, Talış florasındaki Lamiaceae türlerinin ekolojik, farmakolojik ve koruma açısından önemini vurgulamakta ve gelecekte yapılacak biyolojik çeşitlilik ve ekolojik araştırmalar için sağlam bir temel oluşturmaktadır.

Anahtar Kelimeler: Lamiaceae, taksonomik çeşitlilik, tür zenginliği, alt familya, endemik taksonlar, Talış bölgesi

Abstract

The present study provides a comprehensive assessment of the taxonomic diversity of the family Lamiaceae within the flora of the Talysh region of Azerbaijan known for high biodiversity and endemism. Systematic field surveys, herbarium specimen analysis, and a thorough review of relevant literature were employed to verify species identity and update taxonomic records. A total of 27 genera, 98 species, and 9 subspecies distributed among 4 subfamilies were documented. Subfamilies Nepetoideae and Lamioideae demonstrated the greatest species richness, whereas Scutellarioideae was the least represented. Several taxa with restricted distributions were identified, underscoring the floristic uniqueness and conservation significance of the region.

Taxonomic nomenclature was updated according to internationally recognized databases, including POWO, IPNI, and WFO. These findings highlight the ecological, pharmacological, and conservation relevance of Lamiaceae species in the Talysh flora and provide a robust baseline for future biodiversity and ecological research.

Keywords: Lamiaceae, taxonomic diversity, species richness, subfamily, endemic taxa, Talysh region

1.INTRODUCTION

The Lamiaceae family (mint family) is one of the largest and most evolutionarily developed families of dicotyledonous plants, comprising over 7,000 species distributed across various regions of the world. Representatives of this family play a key role in maintaining ecosystem biodiversity and hold great importance in applied fields such as medicine, nutrition, and agriculture. In Azerbaijan, the Lamiaceae family is represented by numerous taxa, including several endemic, rare, and relict species that constitute a significant component of the country's natural flora. The investigation and sustainable use of these species are highly relevant today, as they help meet the increasing demand for aromatic, medicinal, and spice plants while also supporting human adaptation to stress and disease through their bioactive compounds.

In addition to their pharmacological and ecological significance, Lamiaceae species are of exceptional value to apiculture. Owing to their nectar-rich and aromatic flowers, many genera of this family such as Thymus, Salvia, Melissa, Mentha, and Origanum—are among the most productive melliferous (honey-yielding) plants. Their extended flowering periods and high nectar secretion capacity are vital for sustaining bee populations, particularly during dry or transitional seasons when other nectar sources are scarce. Therefore, the conservation and cultivation of Lamiaceae species contribute not only to the protection of biodiversity but also to the improvement of honey quality and productivity. Moreover, by maintaining the mutual relationships between flowering plants and pollinators, these species enhance the ecological stability and sustainability of both natural and agricultural ecosystems.

The present study aims to investigate the taxonomic diversity, systematic characteristics, and ecological importance of the Lamiaceae family within the Talysh flora. The relevance of this research stems from the unique climatic and floristic conditions of the Talysh region, which hosts numerous endemic and relict species. Studying the taxonomy and bioecology of Lamiaceae taxa in this area provides not only a deeper understanding of Azerbaijan’s flora but also a scientific basis for the conservation of genetic and population diversity within these valuable species.

The Lankaran-Astara region, located in southeastern Azerbaijan, encompasses the northern and northeastern slopes of the Talysh Mountains and the Caspian Sea coast. The study area includes the administrative districts of Lankaran, Astara, Masalli, Lerik, Jalilabad, and Yardimli. This region integrates humid subtropical lowlands with warm mountainous zones, forming a unique ecological mosaic with high vegetation diversity. Such environmental heterogeneity renders the study of the taxonomic, bioecological, and population characteristics of Lamiaceae particularly relevant and timely. Preliminary botanical investigations in the Talysh region date back to the early 19th century, initiated by F. Hohenacker and E. Eichwald. Subsequent comprehensive studies were conducted by prominent botanists, including A.A. Grossheim [4], L.I. Prilipko [5], and V.J. Hajiyev [6], significantly advancing the understanding of the region's flora. Despite these efforts, however, the overall taxonomic diversity of Lamiaceae within the Lankaran flora remains incompletely documented. Previous research has primarily focused on individual genera or species, leaving the family's compositional structure and spatial distribution insufficiently explored.

Therefore, the objective of this study is to provide a comprehensive assessment of the taxonomic diversity of the Lamiaceae family in the Lankaran region, document the distribution of its species, identify new localities for selected taxa, and analyze their ecological and geographical characteristics. This research is expected to contribute valuable insights into the floristic composition and ecological understanding of the Talysh vegetation zone of Azerbaijan, with implications for biodiversity conservation and sustainable utilization.

2. MATERIALS AND METHODS

2.1.Study Area

The present study was conducted in the Talysh region, encompassing the administrative districts of Lankaran, Astara, Lerik, Jalilabad, Masalli, and Yardimli. The region is characterized by heterogeneous topography, humid subtropical climate, and diverse vegetation types, which provide a unique environment for examining the distribution and diversity of the Lamiaceae family.

2.2.Field Sampling

Data on Lamiaceae taxa were collected through systematic field surveys and herbarium investigations. Specimens were collected during the summer of 2024 and the spring of 2025 from multiple localities across Lankaran and Lerik districts. For each collection site, GPS coordinates were recorded, and photographic documentation of habitats and individual specimens was performed to ensure reproducibility.

2.3.Specimen Identification

Taxonomic identification was carried out following standard botanical references for the flora of Azerbaijan, including Flora of Azerbaijan (Vols. I–VIII) [7], A.A. Grossheim [4], N.P. Mekhtiyeva [6], and A.S. Zernov [11-13]. Additionally, updated taxonomic and nomenclatural information from international databases such as GBIF [3], POWO [8], IPNI [9], and WFO Plant List 2025-06 [10] was applied. Synonyms and outdated names were critically reviewed and excluded.

2.4.Herbarium Analysis

Collected specimens, along with existing herbarium materials, were examined in the laboratory. All pressed specimens were systematically and floristically classified according to morphological characteristics. Detailed records were maintained to allow independent verification of identifications.

2.5.Data Analysis and Visualization

Data were processed and visualized using tables and figures to accurately reflect taxonomic composition and distribution patterns. The taxonomic status of subfamilies, genera, and subspecies was revised and presented in tabular form. Statistical analyses, where applicable, were performed to evaluate distribution trends and population characteristics.

3.RESULTS AND DISCUSSION

The Lankaran region exhibits remarkable landscape diversity, shaped by the interaction of multiple phytogeographical units and the historical development of its vegetation, positioning it as one of the biologically richest areas in terms of species diversity. In this study, all herbarium specimens of the family Lamiaceae Lindl. were meticulously examined in the laboratory. Specimens collected from various localities across the Talysh region—including Lankaran, Astara, Lerik, Jalilabad, Masalli, and Yardimli—were systematically organized and classified following established floristic and taxonomic criteria.

Members of the family Lamiaceae are readily recognized by their bilabiate corolla, a feature that, while occasionally present in other families, is particularly diagnostic for this group. Additional key taxonomic characteristics include the morphological structure of the fruit, 1leaf arrangement, and stem anatomy. Stems are typically quadrangular in cross-section. Leaves are simple, entire, or variably divided; most are oppositely arranged, though in some species they occur in whorls, and stipules are absent. The surfaces of stems and leaves are covered with glandular trichomes containing essential oils or with short-stalked scales. Flowers are organized in trimerous dichasia or bilaterally coiled inflorescences. The inflorescence axis is short, and as the

flowers develop in the axils of opposite leaves, they form globose clusters. In some instances, the flowers are arranged in spikes, panicles, or head-like complex inflorescences. [1]

As a result, a comprehensive taxonomic list based on systematic classification was compiled. The analysis revealed that the family Lamiaceae in the Talysh region comprises four subfamilies, 27 genera, and 107 taxons. Detailed tables presenting the identified species, genera, and subfamilies, along with their distribution data, provide a clear overview of the floristic and ecological composition of the family.

Table 1. Taxonomic composition and localization data of the Lamiaceae family in the Talysh region

№	Subfamily	Tribe	Subtribe	Genus	Species	Accepted names in Azerbaijani	Location records in Lankaran
1.	• Ajugoideae Kostel (1834)	Ajugeae	Ajuginae	*Ajuga L. (Dirçək)*	*A.chamaepitys subsp. chia (Schreb.) Arcang. (= Ajuga glabra C.Presl, A. pseudochia Shost.)*	- Çılpaq d.	Lerik
2.					*A.genevensis L.*	- Cenevrə d.	Lerik
3.					*A.orientalis L.*	-Şərq d.	Astara Yardımlı
4.					*A.reptans L.*	- Sürünən d.	Lerik
5.		Teucrieae	Teucrinae	*Teucrium L. (Məryəmnoxudu)*	*Teucrium canum Fisch. & C.A.*	- Çal m.	Lerik
6.					*T.chamaedrys L.*	- Adi m.	Astara
7.					*T.hircanicum L.*	- Hirkan m.	Lerik Astara
8.					*T. orientale L.*	- Şərq m.	Lerik Astara Yardımlı
9.					*T. parviflorum Schreb.*	- Xırdaçiçəkli m.	Lerik
10.					*T. polium L.*	- Ağ m.	Lerik
11.	• Scutellarioideae Prantl (1880)	Scutellarieae	Scutellariinae	*Scutellaria L. (Başlıqotu)*	*S.galericulata L.*	- Adi b.	Lerik
12.					*S.grossheimiana Juz.*	- Qrossheym b.	Lerik
13.					*S. orientalis L.*	– Şərq b.	Lerik Yardımlı

14.					*Scutellaria prilipkoana Grossh.*[1]	- Prilipko b.	Yardımlı
15.					*S. tournefortii Benth.*	- Turnefor b	Lerik Yardımlı
16.	Lamioideae Harley (2003 •	Sideriteae	Sideritinae	*Sideritis L. (Dəmrək)*	*Sideritis montana L*	-Kəkilli d	Lerik Astara
17.		Stachydeae	Stachyinae	*Stachys L (poruq)*	*Stachys annua (L.) L.*	-Birillik p.	Lerik
18.					*S. atherocalyx C. Koch*	- Qılçıqkasalı p.	Lerik Yardımlı
19.					*S. byzantina K. Koch*	- Bizans p.	Lerik
20.					*S. cretica L.*	- Krit p.	Lənkəran Astara
21.					*S. germanica L.*	-Alman p	Lerik
22.					*Stachys inflata Benth. (= S. fruticulosa M. Bieb.)*	- Şişkin p	Lerik
23.					*S. lavandulifolia Vahl*	-Ləvəndyarpaq p.	Lerik
24.					*S. palustris L.*	- Bataqlıq p	Lənkəran Astara
25.					*S. persica S.G. Gmel. ex C.A. Mey.*	- İran p	Lerik
26.					*S. pubescens Ten.*	- Tüklü p	Lerik
27.					*S. setifera C. A. Mey.*	- Qıllı p.	Lerik
28.					*S. spectabilis Choisy ex DC.*	- Əla p.	Lerik Yardımlı
29.					*S.talyschensis Kapeller*	– Talış p.	Lerik
30.		Phlomideae	Phlominae	*Phlomis L. (odotu)*	*Ph. herba-venti subsp. lenkoranica (Knorring) Rech.f.*	- Lənkəran o.	Lerik
31.					*Ph. orientalis Mill. (=Ph. caucasica Reching. Fil.)*	– Şərq o	Lerik Yardımlı
32.					*Ph.herba-venti subsp. pungens (Willd.) Maire ex DeFilipps*	- Tikanlı o.	Lerik Yardımlı

33.				*Phlomoides*	*Phlomoides laciniata (L.) R. Kamelin & Makhmedov (=syn. Phlomis laciniata L.)*	– Cırımlı o.	Lerik Yardımlı
34.		Leonureae	Leonurinae	*Leonurus* (şirquyruğu)	*Leonurus glaucescens Bunge*	-Bunge ş.	Lerik Yardımlı
35.					*Leonurus cardiaca L.*	-Adi ş.	Yardımlı
36.		Marrubieae	Marrubiinae	*Ballota L.* (ağpopur)	*Ballota grisea Pojark.*	- Boz a.	Lerik Yardımlı
37.					*B. nigra L.*	– Qara a.	Yardımlı
38.				*Marrubium L.* (itotu)	*Marrubium astracanicum Jasq.*	– Həştərxan i.	Yardımlı
39.					*M. catariifolium Desr.*	– Pişiknanəyarpaq i.	Lerik
40.					*M. leonuroides Desr.*	- Kalafa i.	Lerik Yardımlı
41.					*M. parviflorum Fisch. et C.A. Mey.*	– Azçiçəkli i.	Lerik Yardımlı
42.					*M. persicum C.A. Mey.*	- İran i.	Lerik Yardımlı
43.					*M. propinguum Fisch. et C.A. Mey.*	– Şar i.	Yardıml
44.					*M. purpureum Bunge.*	- Çəhrayımtıl i.	Lerik
45.					*M. vulgare L.*	- Adi i.	Lerik Yardımlı
46.				*Moluccella L.*	*Moluccella laevis L.*	- Hamar m.	Lənkəran Astara
47.		Lamieae	Laminae	*Lamium L.*	*Lamium album L.*	– Ağ d.	Lerik Yardımlı Astara

48.					*L. amplexicaule L.*	- Gövdəni qucaqlamışyarpaqd.	Lənkəran Lerik Astara Yardımlı
49.					*Lamium album L., subsp. crinitum (Montbret & Aucher ex Benth.)*	- Benth d.	Yardımlı
50.					*Lamium galeobdolon (L.) L. (= Galeobdolon luteum Huds.)*	-Sarı d.	Astara Lerik
51.					*Lamium album L., subsp. hyrcanicum (A.P. Khokhr.) Menitsky (=syn. Lamium hyrcanicum A.P. Khokhr.)*	– Hirkan d.	Lerik Astara Yardımlı
52.					*L. maculatum (L.) L. –*	- Ləkəli d.	Lerik
53.					*L. purpureum L.*	– Purpur d.	Lerik
54.	• Nepetoideae Kostel., Allg. Med.- Pharm. Fl. 3: 752	Mentheae	Salviinae (Dumort.) Endl	*Salvia L (adaçayı)*	*Salvia aethiopis L.*	- Həbəşstan s	Lerik Yardımlı
55.					*S. ceratophylla L.*	- Kütyarpaq s	Lerik Yardımlı
56.					*S. limbata C.A. Mey.*	- Köbəli s	Lerik Yardımlı
57.					*S. officinalis L.*	– Aptek s	Lerik Yardımlı
58.					*Salvia rosmarinus Spenn. (≡ Rosmarinus officinalis L.)*	- Dərman rozmarini	Lənkəran
59.					*S. sclarea L.*	- Ənbər s	Lerik Yardımlı
60.					*Salvia virgata Jacq.*	- Sibtorp s	Lerik Yardımlı
61.					*S. syriaca L.*	- Suriya s	Astara Lerik
62.					*S. vergeduzica Rzazade*	– Vergədüz s	Yardımlı

63.					*S. verticillata L.*	- Qırçınlı s	Lerik Yardımlı
64.					*S. viridis L.*	– Yaşıl s	Astara Lerik
65.					*S. xanthocheila Boiss. ex Benth*	– Sarıdodaq s	Lerik
66.			Menthinae (Dumort.) Endl.	*Melissa L. (Bədrənc)*	*Melissa oficiniallis L.*	-Dərman bədrənci	Lənkəran
67.				*Thymus L. (Kəklikotu)*	*Thymus coriifolius Ronn. (=Th. sosnovskyi Grossh.)*	- Dəriyarpaq k.	Astara
68.					*Th. kotschyanus Boiss. et Hohen.*	– Koçi k.	Astara Lerik
69.					*Th. trautvetteri Klok. et Des. – Shost.*	– Trautfetter k	Lerik Yardımlı
70.				*Clinopodium L.(İyəvər)*	*C. umbrosum (M. Bieb.) Kuntze.*	– Kölgə i.	Lerik Astara Lənkəran
71.					*C. vulgare L.*	- Adi i.	Yardımlı
72.					*C. acinos (L.) Kuntze.*	-Kəkotu qəlbotu	Lerik
73.					*C. graveolens subsp. rotundifolium (Pers.) Govaerts.*	-İyli q.	Lerik Yardımlı
74.					*Clinopodium grandiflorum (L.) Kuntze*	- Iriçiçək ətirnaz	Lerik Yardımlı
75.					*Clinopodium menthifolium (Host) Stace*	- Dərman ətirnaz	Lənkəran Astara
76.				*Lycopus L.(ləçəkotu*	*L. europaeus L.*	- Avropa ləçəkotu	Lerik Astara
77.				*Mentha L. (yarpız)*	*M. aquatica L.*	-Su yarpızı	Lənkəran Lerik Astara Cəlilabad Masallı Yardımlı
78.					*M. longifolia (L.) L.*	- Uzunyarpaq y.	Lənkəran Lerik

							Yardımlı Astara
79.					*M. x piperita L.*	– İstiot y.	Lənkəran Lerik Astar
80.					*M. pulegium L.*	– Pulqar y.	Lənkəran Lerik Astara Yardımlı
81.					*M. suaveolens Ehrh.*	– Dəyirmiyarpaq y.	Lənkəran Astara
82.				*Origanum L. (Qaraqınıq)*	*O. vulgare L.*	- Adi qaraqınıq	Lənkəran Lerik Astara Yardımlı
83.				*Satureja L. (Çöl nanəsi)*	*S. borissovae Zeynalova*	– Borissova çöl nanəsi	Lerik
84.					*S. densiflora Zeinalova*	-Sıxçiçək ç.n.	Lerik
85.					*S. hortensis L.*	- Dağınıqçiçək ç.n.	Lerik
86.					*Satureja intermedia (C.A.Mey.) Kuntze*	- Orta ç.n.	Lerik
87.					*S. macrantha C.A. Mey.*	- İriçiçək ç.n.	Lerik Yardımlı
88.					*S. mutica Fisch. et C.A. Mey.*	- Kütyarpaq ç. n.	Lerik Yardımlı Astara
89.					*S. spicigera (C. Koch.) Boiss.*	- Sünbüllü ç.n.	Lerik Yardımlı Astara
90.				*Prunella L.(boğazotu)*	*P. laciniata (L.) L.*	– Dilimli b.	Lerik Yardımlı Astara
91.					*P. vulgaris L.*	-Adi b.	Lənkəran Lerik Yardımlı Astara
92.				*Ziziphora*	*Ziziphora biebersteiniana (Grossh.) Grossh.*	– Biberşteyn d.n.	Lerik Astara

93.					*Z. persica Bunge*	– İran d.n.	Lerik Astara Yardımlı
94.			Nepetinae (Dumort.) Coss. & Germ.	*Nepeta L., (Pişiknanəsi)*	*Nepeta betonicifolia C. A. M.subsp.betonicifolia*	- Betonikavari p.	Lerik
95.					*N. buhsei Pojark.*	– Buze p.	Lerik Yardımlı
96.					*N. meyeri Benth.*	– Meyer p.	Lerik
97.					*N. mussinii Spreng.*	– Mussin pişiknanəsi	Lerik Yardımlı
98.					*Nepeta ucrainica subsp.schischkinii (Pojark.)Rech.f.*	– Şişkin p	Lerik Yardımlı
99.					*Nepeta nuda subsp. nuda (=N.pannonica)*	-Macar p.	Lerik
100					*Nepeta nuda subsp. Nuda (=Nepeta sulphurea K. Koch)*	- Kükürdü – sarı p.	Lerik Yardımlı
101					*N. teucrifolia Willd.*	– Dilimli p.	Yardımlı
102				*Lallemantia Fisch. & C.A.Mey*	*Lallemantia canescens (L.) Fisch. et C.A. Mey.*	– Bozaq lallemansiyası	Yardımlı
103					*L. iberica (Bieb.) Fisch. et C.A.*	- Gürcü l.	Lerik
104					*L. peltata (L.) Fisch. et C.A. Mey*	– Daraqlı l.	Lerik
105		Ocimeae Dumort.	Lavandulinae Endl.	*Lavandula L.*	*Lavandula angustifolia Mill.*	- Ensizyarpaq lavanda	Lənkəran
106			Ociminae (Dumort.) Schmidt	*Ocimum L. (Reyhan)*	*Ocimum basilicum L.*	– Adi reyhan	Lənkəran
107		Elsholtziea e (Burnett)	no subtribal division	*Perilla L. (Perilla)*	*Perilla frutescens (L.) Britton*	- Perilla	Lənkəran

Note:[1] S. prilipkoana Grossh. — see : IPNI 77176936-1 — accepted (POWO, IPNI); WFO 2025: unplaced / sometimes treated within S. orientalis complex (“Scutellaria orientalis subsp. prilipkoana Fed.”)

Within the Lankaran flora, some species exhibiting distinct morphological and ecological differentiation at the subspecies level were identified:

Ajuga chamaepitys subsp. chia (Schreb.) Arcang.,

Clinopodium graveolens subsp. rotundifolium (Pers.) Govaerts,,

Phlomis herba-venti subsp. lenkoranica (Knorring) Rech.f.,

Phlomis herba-venti subsp. pungens (Willd.) Maire ex DeFilipps.,

Lamium album L., subsp. crinitum (Montbret & Aucher ex Benth.).,

Lamium album L., subsp. hyrcanicum (A.P. Khokhr.) Menitsky.,

Nepeta ucrainica subsp.schischkinii (Pojark.)Rech.f.,

Nepeta nuda subsp. Nuda (=Nepeta sulphurea K. Koch.,

Nepeta nuda subsp. Nuda (=N.pannonica).

Recent taxonomic revisions have resulted in several nomenclatural changes in the Lamiaceae of the Lankaran region. For example:

Acinos arvensis (Lam.) Dandy → Clinopodium acinos (L.) Kuntze;

Acinos rotundifolius Pers. → Clinopodium graveolens subsp. rotundifolium (Pers.) Govaerts;

Calamintha grandiflora (L.) Moench → Clinopodium grandiflorum (L.) Kuntze;

Calamintha menthaefolia Host → Clinopodium menthifolium (Host) Stace;

Galeobdolon luteum Huds. → Lamium galeobdolon (L.) L;

Lamium crinitum Montbret & Aucher ex Benth. → Lamium album subsp. crinitum (Montbret & Aucher ex Benth.);

Lamium hyrcanicum A.P. Khokhr. → Lamium album subsp. hyrcanicum (A.P. Khokhr.) Menitsky;

Rosmarinus officinalis L. → Salvia rosmarinus Spenn;

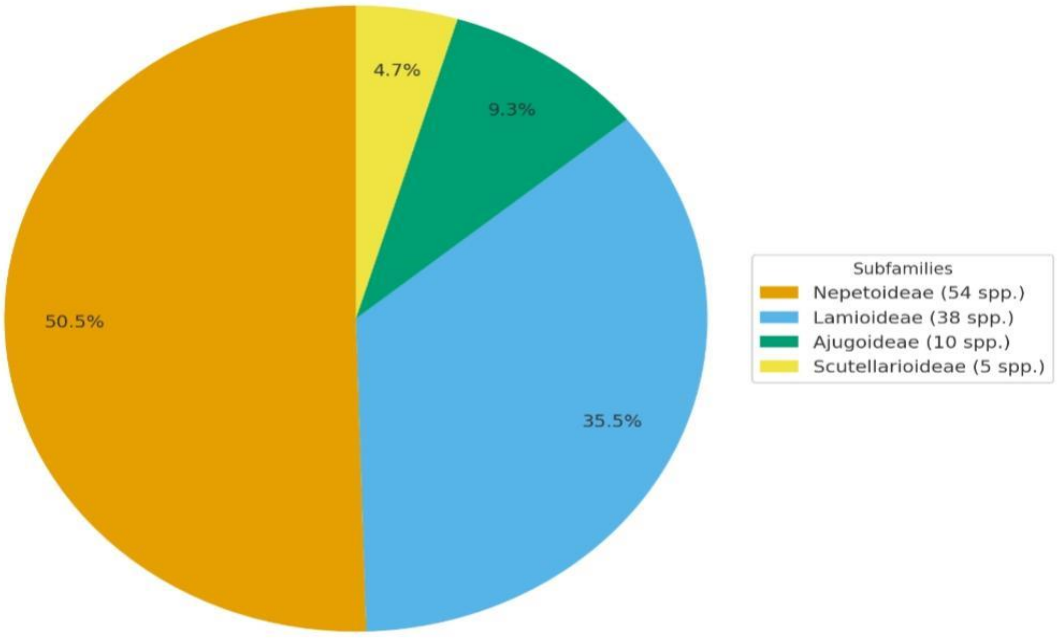
Salvia sibthorpii Smith. → Salvia virgata Jacq.

These revisions reflect the current consensus in international taxonomic databases and ensure alignment with modern systematic classifications.

As a result of these taxonomic revisions, four previously recognized genera were consolidated into the currently accepted genera, and outdated synonyms were eliminated. Consequently, the floristic composition of Lamiaceae in the Lankaran region has been updated to reflect both contemporary nomenclatural standards and the morphological and ecological distinctions observed at the subspecies level.

In terms of species richness, the subfamilies are represented as follows: *Nepetoideae (54 species), Lamioideae (38 species), Ajugoideae (10 species),* and *Scutellarioideae (5 species).*

Figure 1. Percentage distribution of *Lamiaceae* subfamilies in the Talysh flora



The subfamily *Nepetoideae* is represented in the Talysh flora by 15 genera and 54 species. Within this subfamily, three tribes—*Mentheae, Ocimeae, and Elsholtzieae*—and six subtribes have been identified. The most species-rich tribe is Mentheae, subdivided into three subtribes *(Salviinae, Menthinae, Nepetinae)* encompassing 12 genera and 51 species. The genera *Salvia (12 species), Nepeta (8 species)* and *Satureja (7 species)* exhibit the highest species diversity. Among the subtribes, *Menthinae* predominates, comprising 9 genera and 28 species. The tribe *Ocimeae* is represented by 2 genera *(Lavandula, Ocimum)* and 2 species, whereas *Elsholtzieae* includes a single genus and species *(Perilla frutescens)*.

Most taxa within *Nepetoideae*—including *Satureja L. (field mint), Clinopodium L. (savory), Origanum L. (oregano), Majorana Hill. (marjoram), Thymus L. (thyme), Mentha L. (mint), Ocimum L. (basil), Perilla L. (perilla), Lavandula L. (lavender), and Lycopus L. (bugleweed)*—are highly aromatic. Many of these species are widely utilized in traditional medicine, pharmacology, cosmetology, and the food industry, either as spices or in herbal teas.

One of the most widespread subfamilies in the Talysh flora is *Lamioideae* (referred to as *Stachyoideae* in some literature), represented by 9 genera and 38 species. This subfamily primarily comprises genera distributed outside tropical regions. The genera of *Lamioideae* and their local names are as follows: *Marrubium L. – Itotu; Sideritis L. – Dəmrək; Nepeta L. – Pişiknanəsi; Lallemantia Fisch. & C.A. Mey. – Lallemansiya; Prunella L. – Boğazotu; Phlomoides Moench – Odotuca; Phlomis L. – Odotu; Lamium L. – Dalamaz; Leonurus L. – Şirquyruğu; Moluccella L. – Molusella; Ballota L. – Kalafagülü; Stachys L. – Poruq; Salvia L. and Ziziphora*

L. – Dağ nanəsi. This subfamily occupies both montane-xerophytic and meadow habitats. Notably, the genera *Stachys , Marrubium* and *Lamium* are widely distributed in terms of species number and are distinguished by their ecological adaptations.

Although the subfamily *Ajugoideae* exhibits lower species richness in the Talysh flora compared to *Lamioideae* and *Nepetoideae*, it is of considerable taxonomic and ecological significance. Ajugoideae comprises two tribes: *Ajugeae* (represented by the genus *Ajuga, 4 species)* and *Teucrieae* (represented by the genus *Teucrium, 6 species).* The floral and seed morphology of both genera indicates that the subfamily represents a relatively advanced group: the flowers are oppositely arranged, the seeds are endospermless, and most species are xerophytic.

The subfamily *Scutellarioideae* is represented in the Talysh flora as a monogeneric group, comprising only five taxa of the genus Scutellaria. This subfamily exhibits taxonomically advanced characteristics: the flowers are oppositely arranged, and in some species, they form glomerulate clusters. For example, *Scutellaria prilipkoana* remains a taxon under discussion in international databases (POWO, IPNI, WFO 2024) and is sometimes included within the *S. orientalis* complex. The subfamily Scutellarioideae contributes significantly to the taxonomic and floristic diversity of the Talysh flora. Moreover, through its endemic and narrow-range species, it highlights the bioecological importance and conservation value of the region. This subfamily also provides an essential dataset for studying the morphological and ecological structure of the regional flora.

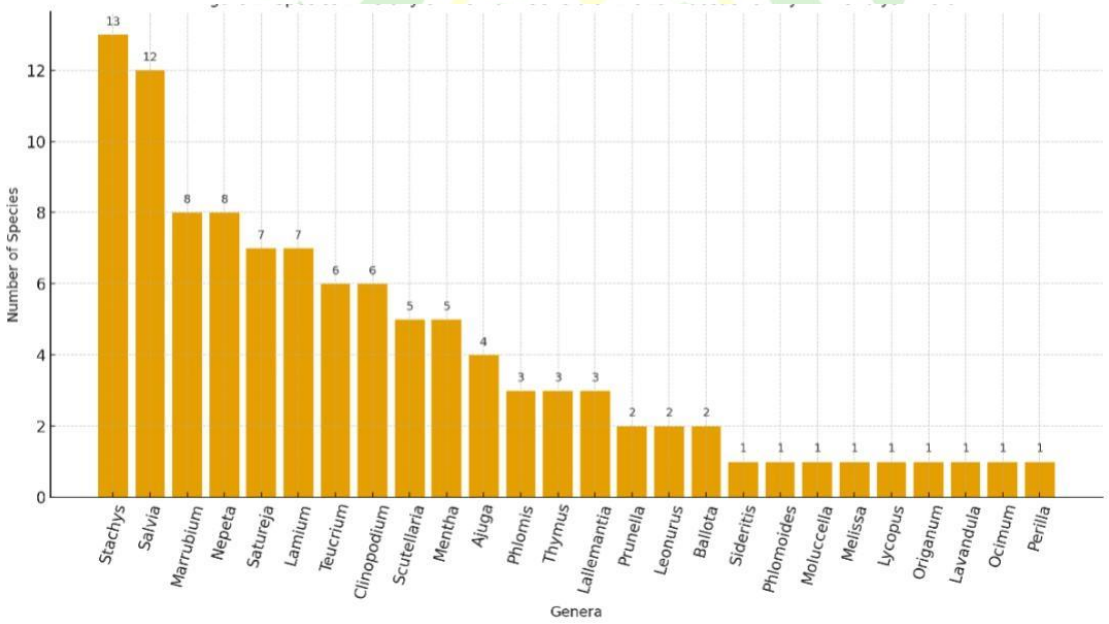


Figure 2. Species diversity of the main genera of the Lamiaceae family in the Talysh flora

Figure 2 illustrates the species richness of the principal genera of the family Lamiaceae in the Talysh flora. The genera with the highest number of species are Stachys (13 species) and Salvia (12 species), followed by Marrubium (8 species) and Nepeta (8 species). The next most diverse groups include Satureja (7 species) and Lamium (7 species), followed by Teucrium (6 species) and Clinopodium (6 species). Scutellaria and Mentha are each represented by 5 species. Genera with moderate species richness include Ajuga (4 species), Phlomis (3 species), Thymus (3 species), and Lallemantia (3 species). Genera represented by two species each are Prunella, Leonurus, Ziziphora, and Ballota. The least represented genera—each with a single species—are Sideritis, Phlomoides, Moluccella, Melissa, Lycopus, Origanum, Lavandula, Ocimum, and Perilla.

Members of the family Lamiaceae are predominantly distributed in mountainous regions, particularly within xerophytic plant communities. However, they are also present in mesophytic forest and meadow communities in the Lankaran region. Comparative analysis across different areas (Table 1) indicates that the Diabar region and the mountainous parts of Lankaran exhibit the highest species and genus diversity, whereas the Lankaran lowlands and Lankaran-Mugan phytogeographical regions display the lowest species richness.

Based on field studies, herbarium materials, and data from existing literature, this study represents the first comprehensive taxonomic analysis of the family Lamiaceae Lindl. (Labiatae) in the Talysh region. In addition, the biomorphological and bioecological characteristics, as well as the endemicity of these species, were analyzed, and the results have been published in relevant scientific articles.

4.CONCLUSION

The present study provides a comprehensive assessment of the Lamiaceae family in the Lankaran-Astara region, integrating field observations and herbarium analyses. The research clarified the taxonomic composition of local Lamiaceae taxa, updated distribution ranges, and documented new localities for several species. Notably, species previously unrecorded in the region were identified, reflecting the influence of long-term climatic changes and other ecological factors on vegetation patterns. Observed adaptations include modifications in growth forms, flowering periods, and habitat preferences. Systematic examination of herbarium specimens further confirmed that taxa once considered rare or uncertain in occurrence are now observable. These results emphasize the importance of continuous floristic monitoring and research, as well as the crucial role of the Lamiaceae family in supporting biodiversity conservation in the Talysh region.

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Bactericidal and Fungicidal Properties of Polysaccharide Fractions from Pleurotus Species

Pleurotus Türlerine Ait Polisakkarit Fraksiyonlarının Bakterisid ve Fungisid Özellikleri

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Özet

Pleurotus cinsine ait mantarlar, besinsel, tıbbi ve biyoteknolojik önemleriyle geniş ölçüde tanınmaktadır. Bu mantarların biyoaktif bileşenleri arasında, özellikle bakterisidal ve fungisidal etkileri nedeniyle polisakkarit fraksiyonları önemli bir ilgi odağı hâline gelmiştir. Başlıca β-(1→3)-glukanlar, β-(1→6)-glukanlar, mannanlar, galaktanlar, ksilanlar, kitin türevleri ve heteropolisakkaritlerden oluşan bu polisakkaritler, mantar hücre duvarının yapısal bileşenleri olmanın yanı sıra güçlü doğal biyoaktif makromoleküller olarak da işlev görmektedir. Polisakkaritler, suda çözünen ve suda çözünmeyen fraksiyonlar olarak sınıflandırılmakta olup, suda çözünen formlar mikrobiyal hücre reseptörleriyle daha etkili etkileşim kurabilmeleri ve daha yüksek moleküler esneklikleri nedeniyle daha güçlü biyolojik aktivite sergilemektedir [Silveira, M.L.; ve ark., 2014]. *Pleurotus* polisakkaritlerinin bakterisidal aktivitesi, Gram-pozitif (örneğin *Staphylococcus aureus*, *Bacillus subtilis*) ve Gram-negatif bakterilere (örneğin *Escherichia coli*, *Pseudomonas aeruginosa*) karşı kapsamlı bir şekilde araştırılmıştır. Antimikrobiyal etki mekanizmaları; hücre duvarı bütünlüğünün bozulması, membran geçirgenliğinin değiştirilmesi, iyon ve protein sızıntısı, bakteriyel protein sentezinin inhibisyonu, metal iyonlarıyla kompleks oluşturma ve oksidatif stresin indüklenmesi gibi çoklu yolları içermektedir. Benzer şekilde, bu polisakkaritlerin fungisidal özellikleri *Candida albicans*, *Aspergillus niger*, *Fusarium oxysporum* ve *Alternaria alternata* gibi patojenik mantarlara karşı da doğrulanmıştır. Antifungal etki mekanizmaları; mantar hücre duvarında kitin ve β-glukan sentezinin inhibisyonu, mitokondriyal fonksiyonların bozulması, enerji üretiminin azalması ve hücresel bileşenlerde oksidatif hasara yol açan reaktif oksijen türlerinin oluşumunu kapsamaktadır.

Biyoteknolojik açıdan, polisakkaritler sıcak su veya çözücü ekstraksiyonu, alkolle çöktürme, diyaliz ve liyofilizasyon yöntemleri kullanılarak etkin bir şekilde ekstrakte edilip saflaştırılabilmektedir. Saman, odun talaşı ve tarımsal atıklar gibi düşük maliyetli lignoselülozik substratlar üzerinde *Pleurotus* türlerinin optimize edilmiş yetiştirilmesi, bu biyoaktif bileşiklerin sürdürülebilir üretimini mümkün kılmaktadır. Düşük toksisiteleri, biyobozunur yapıları ve çevresel güvenlikleri sayesinde *Pleurotus* kaynaklı polisakkaritler;

farmasötik ürünler, gıda muhafazası, tarım ve biyomedikal araştırmalar gibi birçok alanda önemli bir uygulama potansiyeline sahiptir.

Sonuç olarak, *Pleurotus* türlerinden elde edilen polisakkarit fraksiyonlarının bakterisidal ve fungisidal aktiviteleri, bu bileşikleri sentetik antimikrobiyal ajanlara doğal ve umut verici alternatifler hâline getirmekte; çağdaş biyoteknoloji, farmakoloji ve ekolojik uygulamalar açısından önemlerini ortaya koymaktadır.

Anahtar Kelimeler: Mantar, Bakterisidal, Fungisidal, Biyoteknolojik, Polisakkarit

Abstract

Fungi of the genus Pleurotus are widely recognized for their nutritional, medicinal, and biotechnological significance. Among their bioactive constituents, polysaccharide fractions have attracted considerable attention due to their multifaceted biological activities, particularly bactericidal and fungicidal effects. These polysaccharides, primarily composed of β-(1→3)-glucans, β-(1→6)-glucans, mannans, galactans, xylans, chitin derivatives, and heteropolysaccharides, are structural components of the fungal cell wall and simultaneously act as potent natural bioactive macromolecules. The polysaccharides can be classified into water-soluble and water-insoluble fractions, with water-soluble forms demonstrating higher biological activity due to their enhanced interaction with microbial cell receptors and greater molecular flexibility [Silveira, M.L.; et al. 2014].

The bactericidal activity of Pleurotus polysaccharides has been extensively investigated against both Gram-positive (e.g., Staphylococcus aureus, Bacillus subtilis) and Gram-negative bacteria (e.g., Escherichia coli, Pseudomonas aeruginosa). Their antimicrobial mechanisms involve multiple pathways, including disruption of cell wall integrity, alteration of membrane permeability, leakage of ions and proteins, inhibition of bacterial protein synthesis, complexation with metal ions, and induction of oxidative stress. Similarly, the fungicidal properties of these polysaccharides have been confirmed against pathogenic fungi such as Candida albicans, Aspergillus niger, Fusarium oxysporum, and Alternaria alternata. The antifungal mechanisms include inhibition of chitin and β-glucan synthesis in the fungal cell wall, impairment of mitochondrial function, reduction of energy production, and generation of reactive oxygen species leading to oxidative damage of cellular components.

From a biotechnological perspective, polysaccharides can be efficiently extracted and purified using hot water or solvent extraction, precipitation with alcohols, dialysis, and lyophilization. Optimized cultivation of Pleurotus species on inexpensive lignocellulosic substrates, such as straw, wood chips, and agricultural residues, ensures sustainable production of these bioactive compounds. Due to their low toxicity, biodegradability, and environmental safety, Pleurotus-derived polysaccharides have significant potential for applications in pharmaceuticals, food preservation, agriculture, and biomedical research. In conclusion, the bactericidal and fungicidal activities of polysaccharide fractions from Pleurotus species position them as

promising natural alternatives to synthetic antimicrobial agents, highlighting their relevance in contemporary biotechnology, pharmacology, and ecological applications.

Keywords: Mushroom, Bactericidal, Fungicidal, Biotechnological, Polysaccharid

1.INTRODUCTION

In recent years, scientific research in the fields of biotechnology, mycology, and pharmacology has significantly increased interest in the biological and chemical properties of naturally derived bioactive compounds. In the modern era, the rapid spread of antibiotic resistance and the ecotoxic effects of synthetic drug formulations have made the search for new and safer antimicrobial sources increasingly relevant. In this context, the metabolites of microorganisms, particularly those of macroscopic fungi, have become a central focus of attention.

Fungi are organisms that play a vital ecological role in nature and possess significant biotechnological and pharmaceutical potential. The various bioactive compounds synthesized by them - polysaccharides, terpenoids, phenolic compounds, proteins, and sterols - exhibit a wide range of biological activities. These substances are distinguished by their antioxidant, immunomodulatory, antitumor, antiviral, antibacterial, and antifungal properties.

In particular, fungi belonging to the genus Pleurotus (e.g., Pleurotus ostreatus, Pleurotus florida, Pleurotus eryngii, Pleurotus sajor-caju, etc.) are among the most extensively studied and cultivated edible mushrooms worldwide due to their high nutritional value and pharmacological significance. These species are considered a sustainable biotechnological raw material both ecologically and economically, owing to their efficient ability to degrade lignocellulosic substrates [Hasanova, V.Y., et al. 2014].

The biochemical composition of Pleurotus species is highly rich: various polysaccharide complexes accumulate in their cell walls and extracellular secretions. These compounds possess high molecular complexity and are of significant structural and functional importance. Scientific studies have demonstrated that polysaccharides derived from Pleurotus not only serve as energy sources and structural components of the cell wall but also function as potent bioactive compounds.

Recently, the antibacterial and antifungal mechanisms of these polysaccharide fractions have been intensively investigated. Tests on their effectiveness against various bacterial species and pathogenic fungi have demonstrated that Pleurotus polysaccharides constitute a group of naturally derived bioactive compounds that could serve as alternatives to synthetic antimicrobial agents. Their low toxicity, biodegradability, and environmental safety make it possible to use these compounds in the future as pharmaceutical formulations, dietary supplements, and agricultural bioprotectors.

Thus, the study of the biological activity of polysaccharide fractions from Pleurotus species represents a research direction that is both theoretically and practically relevant and promising. The aim of this scientific

work is to determine the scientific basis of the bactericidal and fungicidal effects of polysaccharides obtained from Pleurotus fungi, as well as to analyze their mechanisms of action and potential applications from biotechnological and pharmacological perspectives.

The genus Pleurotus belongs to the phylum Basidiomycota, the order Agaricales, and the family Pleurotaceae, and is classified among macromycetes (edible mushrooms). These fungi have a saprophytic lifestyle and primarily develop on dead wood, plant residues, and other lignocellulosic substrates. Pleurotus species are important components of forest ecosystems worldwide, playing a key role in the biological cycling of organic matter and the natural degradation of wood waste [Sun Y.N., et al. 2020].

In natural conditions, Pleurotus species are found on the stumps, trunks, and branches of deciduous trees, and occasionally in grassland areas. These fungi synthesize oxidative enzymes such as cellulases, hemicellulases, laccases, peroxidases, and manganese peroxidases that degrade the lignin, cellulose, and hemicellulose components of wood. Due to these characteristics, Pleurotus species are recognized as white-rot fungi and possess a high degree of ecological adaptability [Bakhshaliev A.E., et al. 2020].

The species within the genus Pleurotus exhibit similar morphological structures. Their fruiting bodies are typically flat, semicircular, or shell-shaped, ranging in color from white to gray and sometimes brown. The gills are usually white or light-colored, densely arranged, and radiate from the underside of the cap. The stipe (stem) is short and may be centrally or slightly laterally attached. Pleurotus species grow rapidly under high humidity and moderate temperature conditions, which allows for their cultivation across diverse climatic zones.

The ecological and physiological characteristics of these fungi facilitate their industrial-scale cultivation. Currently, Pleurotus species are among the most widely cultivated edible mushrooms worldwide. They can be grown with high productivity on various agro-industrial wastes, including straw, corn residues, cottonseed hulls, sunflower shells, wood chips, and other plant-based substrates. These traits make Pleurotus species a biotechnological raw material that is both economically and ecologically advantageous [Sun Y.N., et al. 2020].

The biochemical composition of Pleurotus mushrooms is rich in proteins, lipids, carbohydrates, vitamins, minerals, and particularly polysaccharides. This composition provides them with both nutritional value and pharmacological significance. The amino acids and B-group vitamins present in Pleurotus species make them a valuable part of the diet. Additionally, the biochemical components derived from these mushrooms are widely utilized for biotechnological, medical, and agricultural purposes.

The secondary metabolites of Pleurotus mushrooms, particularly polysaccharides, terpenoids, and phenolic compounds, possess various biological activities. These substances exhibit immunomodulatory, antitumor, antiviral, antifungal, and antibacterial effects, providing potential applications for both human health and the protection of agricultural products [Muradov, P.Z., et al. 2015].

Another important characteristic of Pleurotus species is their biodegradation capability. They play a significant role in the breakdown of environmental pollutants such as pesticides, dyes, heavy metals, and other toxins. For this reason, Pleurotus species are widely used in ecological remediation (bioremediation) processes and in the bioconversion of waste materials [Hasanova, V.Y., et al. 2014].

Based on the characteristics mentioned above, fungi of the genus Pleurotus have diverse applications not only in the food industry but also in biotechnology, pharmaceuticals, agriculture, and environmental engineering. The study of their biological diversity, metabolic potential, and bioactive components represents a current and significant direction in modern science.

Thus, Pleurotus species are considered organisms of high economic and scientific value, playing an important role in maintaining biological balance in nature and sustaining ecosystem stability. The biological activity of the polysaccharide fractions they contain further enhances the research significance of this genus.

Fungi of the genus Pleurotus are organisms with high biotechnological potential. The polysaccharides synthesized within them are classified as biologically active natural macromolecules and serve both structural and metabolic functions. These polysaccharides are not only key components of the fungal cell wall but also exhibit various biological activities, including antibacterial, antifungal, immunomodulatory, antioxidant, and antitumor effects.

The polysaccharide structure of Pleurotus fungi primarily consists of β-(1→3)-glucans, β-(1→6)-glucans, mannans, chylans, galactans, chitin derivatives, and heteropolysaccharides. These compounds provide mechanical stability to the cell wall and play an important role in the fungus's interactions with the external environment. The β-(1→3) and β-(1→6) linkages of glucans are key structural factors determining their biological activity; these bonds are associated with molecular flexibility, membrane permeability, and immunomodulatory capacity.

In Pleurotus species, polysaccharide biosynthesis occurs during the secondary metabolic phase and is mainly intensified in the later stages of mycelial development. At the biotechnological scale, their production is achieved using both submerged (liquid) fermentation and solid-state fermentation (SSF) methods. In both approaches, the goal is to stimulate polysaccharide biosynthesis by providing optimal growth conditions for the fungus (pH 5.5–6.5; temperature 25–28°C; aeration 1–2 L/L·min).

The isolation and purification of polysaccharide fractions from Pleurotus species involve several stages, which are carried out in the following sequence:

Preparation of raw material: The fungal biomass used for production (mycelium or fruiting body) is dried and then mechanically ground into a powder. This step partially disrupts the cell wall and facilitates the extraction of polysaccharides.

Extraction stage: The most commonly used method is hot water extraction (80–100°C). Alternatively, aqueous ethanol, methanol, or glycine buffers can be employed. During aqueous extraction, polysaccharides strongly bound within the fungal cell wall are released through thermal hydrolysis. The extraction process typically lasts 3–5 hours and can be enhanced using ultrasonic or enzymatic assistance.

Precipitation: After cooling the obtained aqueous extract, ethanol or isopropanol is added in a 3–4:1 ratio to precipitate the polysaccharides. This method ensures the separation of high-molecular-weight polysaccharides and helps remove low-molecular-weight compounds such as sugars and organic acids.

Dialysis and purification: The precipitated material is redissolved in distilled water and purified for 24–48 hours using a dialysis membrane (molecular cut-off 12–14 kDa) to remove salts and low-molecular-weight impurities. This results in highly purified, water-soluble polysaccharide fractions.

Drying and powder formation: After dialysis, the solution is converted into a powdered, crystalline polysaccharide fraction by lyophilization (freeze-drying) or vacuum evaporation.

Polysaccharides derived from *Pleurotus* are classified into water-soluble and water-insoluble fractions. The water-soluble fractions typically consist of a mixture of β-glucans, mannans, and heteropolysaccharides and exhibit higher biological activity. This activity is associated with their molecular flexibility, hydrophilic properties, and strong ability to interact with cell receptors [Bakshaliyeva K.F., et al. 2019].

The water-insoluble polysaccharides mainly comprise chitin and β-(1→3)-glucan complexes, which form the skeletal components of the cell wall. While they provide structural stability to the cell, their biological activity is lower compared to that of the water-soluble fractions.

From a biotechnological perspective, the chemical composition of polysaccharides and the quantity of their functional groups (–OH, –COOH, $–OCH_3$, etc.) are key factors determining their bioactivity. The monosaccharide composition of Pleurotus polysaccharides is determined using gas chromatography or HPLC analysis and typically consists of varying proportions of glucose, mannose, galactose, xylose, and fucose residues.

The structural characteristics of the obtained fractions are studied using FTIR (Fourier Transform Infrared Spectroscopy), NMR (Nuclear Magnetic Resonance), and GC-MS (Gas Chromatography–Mass Spectrometry) techniques. These methods allow for the identification of the nature of β-linkages in the polysaccharide molecules, the positioning of functional groups, and the molecular weight distribution of heteropolysaccharides.

Numerous studies have shown that the high content of β-(1→3)-glucans in polysaccharides obtained from Pleurotus species serves as a key indicator of their antimicrobial and immunomodulatory activity. These structural elements interact with receptor proteins located on the surfaces of microorganisms at the cellular level, stimulating biological signal transduction and limiting the growth potential of the microorganisms.

Consequently, the isolation of polysaccharides from Pleurotus species is a multi-step process that is both biochemically and technologically complex, yet highly efficient. Optimizing this process - by adjusting parameters such as temperature, pH, fermentation duration, and extraction medium - can enhance both the yield and bioactivity of the polysaccharides.

Bactericidal Properties of Polysaccharide Fractions: Polysaccharides obtained from Pleurotus mushrooms have been found to be effective against a variety of bacterial species. Scientific studies show that these fractions exhibit bactericidal activity at different levels against both Gram-positive bacteria (e.g., Staphylococcus aureus, Bacillus subtilis) and Gram-negative bacteria (e.g., Escherichia coli, Pseudomonas aeruginosa) [https://www.mycobank.org/].

The main mechanisms of action are as follows:

Cell wall damage: Polysaccharides disrupt the structural integrity of the bacterial cell wall, leading to the loss of osmotic balance.

Alteration of membrane permeability: Polysaccharides destabilize the lipid layer of the membrane, causing leakage of ions and proteins from the cell.

Inhibition of protein synthesis: Some polysaccharides interfere with ribosome function, slowing down bacterial protein synthesis.

The antibacterial activity of *Pleurotus* polysaccharides may also be related to their ability to form complexes with metal ions and induce oxidative stress. For example, a polysaccharide extract obtained from *Pleurotus ostreatus* was shown to inhibit the growth of *E. coli* and *S. aureus* by 50–70%. This highlights their potential for use as natural antimicrobial agents.

Fungicidal properties of polysaccharide fractions: Polysaccharides obtained from *Pleurotus* species exhibit high activity not only against bacteria but also against pathogenic fungi. Their fungicidal activity has been particularly confirmed against fungi such as *Alternaria alternata*, *Fusarium oxysporum*, *Candida albicans*, and *Aspergillus niger*.

The main mechanisms of fungicidal action are as follows:

Disruption of chitin and β-glucan synthesis in the fungal cell wall of the pathogen;

Impairment of mitochondrial functions and reduction of energy production;

Generation of reactive oxygen species (ROS) and oxidation of cellular components.

For example, a polysaccharide extract from *Pleurotus eryngii* disrupted the membrane structure of *Candida albicans* cells and completely inhibited hyphal growth.

These results indicate that *Pleurotus*-derived polysaccharides are promising as alternatives to synthetic antifungal agents, as they are natural, non-toxic, and biodegradable substances.

Applications and Biotechnological Significance: The broad biological activity of Pleurotus polysaccharides makes them suitable for use in various fields:

Pharmaceutical industry: They can be incorporated into creams, ointments, and bioactive supplements as natural antibacterial and antifungal agents.

Food industry: Polysaccharides can be used as preservatives and antioxidants, extending the shelf life of products.

Agriculture: They can serve as biological control agents against fungal diseases in plants.

Biomedical research: These compounds are used as a basis for the synthesis of immune-stimulating and anticancer bioactive substances.

The biotechnological production of Pleurotus mushrooms is also relatively easy — they can be cultivated on inexpensive substrates such as straw, wood chips, and corn residues, making the process both ecologically and economically advantageous.

2.RESULTS AND DISCUSSION

Polysaccharide fractions extracted from Pleurotus species demonstrated significant bactericidal and fungicidal activities in vitro. Water-soluble polysaccharides, primarily composed of β-(1→3)-glucans, β-(1→6)-glucans, mannans, galactans, and heteropolysaccharides, exhibited higher antimicrobial activity compared to water-insoluble fractions. This enhanced bioactivity is attributed to the greater molecular flexibility and hydrophilic nature of the soluble polysaccharides, allowing more efficient interactions with microbial cell receptors.

In bactericidal assays, Pleurotus polysaccharides inhibited the growth of both Gram-positive bacteria, such as Staphylococcus aureus and Bacillus subtilis, and Gram-negative bacteria, including Escherichia coli and Pseudomonas aeruginosa. The observed antimicrobial effects were concentration-dependent, with higher polysaccharide concentrations resulting in a more pronounced inhibition of bacterial proliferation. The main mechanisms identified include disruption of the bacterial cell wall, alteration of membrane permeability leading to ion and protein leakage, inhibition of ribosomal function, and induction of oxidative stress. The ability of polysaccharides to form complexes with metal ions also contributed to their bactericidal effect. These results confirm that Pleurotus-derived polysaccharides can serve as natural alternatives to conventional antibiotics, especially in the context of increasing antimicrobial resistance [https://www.mycobank.org/].

Fungicidal activity was evaluated against pathogenic fungi such as Candida albicans, Aspergillus niger, Fusarium oxysporum, and Alternaria alternata. Polysaccharide extracts disrupted fungal cell wall synthesis by inhibiting chitin and β-glucan formation, impaired mitochondrial function, reduced energy production, and induced the generation of reactive oxygen species (ROS), leading to oxidative damage of cellular components. Notably, polysaccharide extracts from Pleurotus eryngii caused complete inhibition of hyphal growth in Candida albicans, demonstrating their strong antifungal potential. (https://www.mycobank.org/)

The extraction and purification process, involving hot water extraction, alcohol precipitation, dialysis, and lyophilization, yielded high-purity polysaccharides. Optimized culture conditions, including pH, temperature, and aeration, enhanced polysaccharide yield and bioactivity. These findings highlight the dual significance of Pleurotus polysaccharides: their structural role as cell wall components and their functional role as potent bioactive molecules. The study underscores the potential of these natural compounds for pharmaceutical, agricultural, and biotechnological applications, offering an eco-friendly and economically feasible alternative to synthetic antimicrobial agents [Muradov, P.Z., et al. 2015].

3.CONCLUSION

Research studies and scientific sources indicate that the polysaccharide fractions of fungi belonging to the genus Pleurotus possess strong bactericidal and fungicidal properties. Their mechanisms of action are multifaceted, limiting the growth of microorganisms through processes such as cell wall damage, disruption of metabolic activity, and induction of oxidative stress.

These bioactive complexes could serve as invaluable raw materials for the development of natural antimicrobial agents, biofertilizers, and environmentally friendly protective substances. Thus, the study of polysaccharides from Pleurotus species is considered one of the most promising directions in modern biotechnology and pharmacology.

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Bitkilərin Balın Keyfiyyətinə Təsiri.

Bitkilerin Balın Kalitesine Etkisi

The Effect Of Plants On The Quality Of Honey

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Açar sözlər: Zəhərli bal, zəhərli bitki, Ranunculaceae Adans., Aconitum L.

Key words: Toxic honey, poisonous plant, Ranunculaceae Adans., Aconitum L.

Ключевые слова: Токсичные мед, ядовитые растение, Ranunculaceae Adans., Aconitum L.

Azərbaycanda arıçılıq qədim tarixə malikdir. Hələ eramızdan əvvəl IX-VIII əsrlərdə Zaqafqaziyada, əhali arıçılıqla məşğul olmuşlar. X-XII əsrlərdə Azərbaycanda arıçılıq daha da inkişaf etmiş, hətta xarici ölkələrə də arıçılıq məhsulları (bal, mum) satılmışdır.

Sirli şüura malik olan bu həşərat güllər üzərinə qonaraq onların şirəsini özünəməxsus şəkildə çəkir və insan üçün ən faydalı olan şirəni – balı hazırlayır. Təbii bal 2 cür olur: gəzəngi bal və çiçək balı. Bal arıları təbiətdə quraqlıq vaxtı gəlir olmadıqda bəzi bitkilərin yarpaq və gövdələrinin, yaxud bitkilər üzərində olan həşəratın ifraz etdiyi şirin şirələrdən toplayırlar ki, buna da gəzəngi bal deyilir. Belə balı bir il saxladıqdan sonra onun zərərliliyi itir və yemək üçün yararlı olur.

Gəzəngi bal başqa ballara nisbətən güclü bakteriosid (mikrob öldürən) təsirə malikdir. Dadına görə aşağı keyfiyyətlidir. Gəzəngi bal arılar üçün zərərli olduğuna görə o, arıların qış yemi üçün yaramır. Gəzəngi balın təyini: Balın tərkibində gəzənginin olduğunu müəyyən etmək üçün sınaq şüşəsinə bir qədər bal tökülür, üzərinə bir qədər distillə su əlavə edilir və güclü çalxalanıb qarışdırılır. Alınmış məhlula özü qədər əhəng suyu əlavə edilir və qaynayanadək qızdırılır. Əgər məhlul bulanıqlaşıb qonur rəngli köpüklü çöküntü əmələ gəlirsə, bu balın tərkibində gəzənginin olduğunu göstərir.

Çiçək balı götürüldüyü çiçəkdən asılı olaraq müxtəlif ola bilər. Bunlardan cökə, yonca, qaratikan, akasiya, günəbaxan, zeytun və s. çiçəklərdən götürülən bal yüksək keyfiyyətli, şabalıd, dəfnə və s. bitkilərin balı isə aşağı keyfiyyətli, zəhərli bitkilərin nektarlarından alınan bal isə zəhərli və ya kefləndirici bal hesab olunur. Bal əsasən mənşəyinə görə iki böyük qrupa bölünür. Bu qruplara monoflor (bir növ çiçəkdən: məs. cökə, akasiya və s.) və poliflor (müxtəlif çiçəklərdən: məsələn çəmənlik çiçəklərindən toplanmış) bal daxildir. Cökə balını arılar cökə ağacının çiçəklərindən toplayırlar. Öz ətrinə və yaxşı dadına görə yüksək qiymətləndirilir. Cökə balı şəffaf yaxud açıq sarı rəngdə olur. Akasiya balı olduqca şəffaf, ətirli və dadlı olur. Gec xarlanan və yüksək keyfiyyətli bal sayılır. Günəbaxan balının rəngi tünd sarı, dadı xoşagələndir. Bu bal tez xarlanır. Pambıq balının isə rəngi şəffaf olmaqla bərabər özünə məxsus tamı və ətri var. Tez xarlanır və xarladıqca rəngi ağarır, iri dənəcikli çöküntü verir. Arılar şabalıd balını yeməli şabalıddan və atşabalıdının

çiçəklərindən toplayır. Atşabalıdı çiçəklərindən toplanan bal rəngsiz – sulu, yeməli şabalıd çiçəyindən toplanan bal isə tutqun rəngli – çox duru və acı olduğuna görə ondan yalnız şirniyyət sənayəsində istifadə edilir. Balın rənginin, ətrinin və dadının müxtəlifliyi onun hansı növ və hansı rəngdə çiçəklərdən toplanması ilə əlaqədardır. Balın rəngi tam şəffafdan tutmuş sarı, qonur, tutqun bənövşəyi və s. müxtəlif çalarlı olur.

Zəhərli və ya kefləndirici balı arılar dağlarda xüsusi efir yağlı, zəhərli bitki nüvlərindən toplayırlar. Dünyada yayılan *Rhododendron ponticum, Echium plantagineum, Coriaria arborea, Brachyglottis repanda, Cyrilla racemiflora, Euphorbia geniculata, Aesculus pavia, Astragalus lentiginosus, Caltha patustris, Allium cepa, Ledum palustre, Stachys arvensis, Solanum nigrum, Datura stramonium, Aconitum nasutum, Papaver somniferum, Veratrum album, Ledum palustre, Ranunculus rivularis, Astragalus bolanderi, Nicotiana tabacum* və s.bu kimi zəhərli bitkilərin nektarından alınan bal zəhərlidir. Görünən ağır simptomlar alkoqolla zəhərlənəmə əlamətləri ilə eyni olduğu ücün kefləndirici bal adlanır. Belə balı yedikdə insana keyfləndirici təsir göstərir və zəhərlənmələrə səbəb olur. Bəzən temperatur qalxır, ürək bulanma, təngənəfəslik, baş gicəllənmə, zəiflik və hətta şüur itkisi müşahidə olunur. Qədim zamanlardan bəri insanlara zəhərli bal tanışdır. Bu baldan kimyəvi silah kimi istifadə edilmişdir. Bizim eradan 400 il əvvəl Qara Dəniz bölgəsində yerli əhali tərəfindən Yunan əsgərlərinin bal ilə zəhərlənməsi tarixdən məlumdur. Bal yeyən əskərlərin mədə bağırsaq sistemi pozulmuş, sərxoş olmuş və asanlıqla əsir düşmüşlər. Bir qədər acı və ağız büzücü dadı olan zəhərli bal, ancak qaynadıldıqda zəhərlilik xüsusiyyətini itirir.

Naxçıvan Muxtar Respublikasında aparılan tədqiqat zamanı 302 bitki növünün zəhərli olduğu müəyyən olmuşdur. Tədqiqat zamanı muxtar respublika otlaqlarında zəhərli bitkilərin 5 bitkilik tipi, 4 yarımtip, 19 formasiya sinfi, 39 formasiya və 53 assosiasiyada dominantlıq etdiyi araşdırılmış, bioekoloji xüsusiyyətləri, yüksəklikdən asılı olaraq yayılma qanunauyğunluqları və heyvandarlığa təsiri öyrənilmişdir. Muxtar respublikasında yayılan Akonit - *Aconitum* L., Dəlibəng - *Datura* L., Batbat – *Hyoscyamus* L., Mahmızçiçək - *Delphinium* L., Qaymaqçiçək - *Ranunculus* L. bitkilərindən götürülən nektarda tanin, uçucu yağ, erikolin, terpen, dihydroxycoumari, akonarin və arbutin toksinləri olduğundan alkoloidlər balın tərkibinə kecir

Aconitum L.- Akonit cinsinin Şimal yarımkürənin mülayim zonalarında yayılmış 60 növündən Qafqazda 6, Azərbaycanda 3 və o cümlədən Naxçıvan MR- də isə 2 növünə rast gəlinir. Bu cinsə aid olan bütün növlər otlaqların ən zəhərli bitkilərindəndir. Onun bütün hissələri yaş və quru ot halında zəhərlidir. Akonitlərin bütün inkişaf fazalarında çoxlu miqdarda ən zəhərli hesab olunan akonitin tipli alkaloidlər vardır. Heyvanların bir kiloqram diri çəkisinə görə onun 0,02 - 0,05 mq miqdarı heyvanın, 3-4 mq isə insanın ölməsi üçün kifayətdir. Zəhərlənmə zamanı heyvanların əsəb sistemi və ürəyin fəaliyyəti pozulur. Bu isə ölümlə nəticələnir. Bundan zəhərlənmiş malqaranın ətini də yemək təhlükəlidir. *Aconitium confertiflorum* (DC) Gayer – Sıxçiçək akonit və *Aconitium nasutum* Fisch. ex Reichenb - Burunlu akonit növləri arılar üçün də təhlükəli

hesab olunur, çünki arıların akonitdən hazırladığı bal zəhərlidir. 1926-ci ildə Çində Bombus arısı yuvasından alınan Acotinum balının insanları öldürdüyü tarixi faktlarla izah olunmuşdur. Balı və çiçək tozu zəhərlidir. Akonitdən alınan bal diterpenoid alkoloidləri daşıyır, zonqorin alkaloidinə oxşar zəhərli tsiklik birləşmə əmələ gətirir. Bu isə arının özü ücün də təhlükəlidir. (Şəkil 1.).

Delphinium L.- Mahmızçiçəyi. Bu cinsin 150 növü Şimal yarımkürəsinin mülayim qurşağında yayılmışdır. Onlardan Qafqazda 23, Azərbaycanda 13 və Naxçıvan MR ərazisində isə 12 növü var və zəhərlidir. Bunlar 10-70 sm hündürlüyündə çoxillik bitkilərdir. Çiçəkləri göydür, çiçəkyanlığı yarpaqcıqları 10-13 mm uzunluğunda, uzunsov-ellipsvari, uzunsov- neştərvari və ya tərsyumurtavaridir. İyun-avqust aylarında çiçəkləyir və toxum verir. İlk dəfə Freyn

mahmızçiçəyinin (*Delphinium freynii* Conrath) yerüstü hissələrində alkaloidlərin olmasını P.M. Abbbasov və N.M. İsmayılov (1955) müəyyən etmişlər. Ə.M. Quliyev və B.Ş. Quliyevin "Azərbaycan yaylaqlarının zəhərli və zərərli bitkiləri və onlarla mübarizə tədbirləri" əsərində *Delphinium araraticum* (N.Busch) Grossh. - Arğıdağ mahmızçiçəyi zəhərli bitki kimi göstərilmir [1, s. 149], lakin araşdırmalar nəticəsində müəyyən oldu ki, Naxçıvan MR-də subalp çəmənliklərdə bitən bu növün tərkibində çiçəkləmə dövründə 2,78% alkaloid olur [2, s. 148].

Naxçıvan MR florasında mahmızçiçəyinin 6 növü çiçəkləmə və toxumlama zamanı bütün orqanlarında, xüsusilə çiçək və toxumunda çoxlu miqdarda alkaloidlər saxlayır. Bitki quruduqda alkaloidlərin miqdarı xeyli azalır. *Delphinium foetidum* Lomak. - Ağıriyli mahmızçiçəyi və D. *szowitsianum* Boiss. – Soviç mahmızçiçəyinin tərkibində, hələ də dəqiq öyrənilməyən delfinin alkaloidi vardır. Otlaqlarda onlar çiçəkləmə və toxumlama vaxtı daha zəhərli olur, mal-qaranın ölümlə nəticələnən zəhərlənmələrinə - 81 - səbəb olurlar. Balının tərkibində olan diterpenoid alkoloidi insanla müqayisədə arılara daha az toksiki təsir göstərir.

Ranunculus L.- Qaymaqçiçəyi cinsi Azərbaycanda 33, Naxçıvan MR-də isə 16 növlə təmsil olunur. Qaymaqçiçəyi nümayəndələrinin tərkibində uçucu xassəyə, kəskin iyə və yandırıcı dada malik olan protoanemonin maddəsi vardır, bitki quruduqda isə həmin maddə tədricən buxarlanaraq uçur. Aparılan təhlillər nəticəsində *Ranunculus repens.* L.- Sürünən qaymaqçiçəyi, *R. caucasicus* Bieb. – Qafqaz qaymaqçiçəyi, *R. oreophilus* Bieb.- Dağ qaymaqçiçəyi növü çiçəkləmə zamanı xeyli alkaloid olduğu halda, digər hissələrində nisbətən az miqdarda alkoloid olduğu aydınlaşmışdır. *Ranunculus sceleratus* L. - Zəhərli qaymaqçiçəyi, *Ranunculus dissectus* Bieb.(*R. szowitsianus* Boiss., *R. napellifolius auct.* non DC.) - Soviç q., *R. repens* L. - Sürünən q., *R. meyerianus* Rupr. - Meyer q., *R. caucasicus* Bieb. - Qafqaz q., *R. oreophilus* Bieb. - Dağ q., *R. grandiflorus* L. (*R. kotschyi* auct. non Boiss.) - İriçiçək q., *R. brachylobus* Boiss. & Hohen. - Qısadilim q., *R. strigillosus* Boiss. & Huet - Qıllı q., *R. aucheri* Boiss. (*R. elbrusensis* Boiss.) - Oşe q., *R. illyricus* L. *(R. meridionalis* Grossh.) - İlliri q., *R. oxyspermus* Willd. - Sivrimeyvə q., *R. arvensis* L. - Çöl

qaymaqçiçək növləri otlaq və biçənəklərin başlıca zəhərli bitkiləri olub, kənd təsərrüfatı heyvanlarına və arıcılığa ciddi ziyan vurur.

Yüksək toksiki xüsusiyyətə malik olan "protoanemonin" yağı ifraz edir. Tərkibində qlikozid və ranunculin toksini var. Nektar və çiçək tozu zəhərli olduğundan, pətəyin zəhərlənməsinə səbəb olur. Petekdə saxlanılan polenləri ən azı 3 il zəhərli təsirini saxlayır. Qaymaqçiçəyi cinsinin çiçəkləri qızılı-sarı rəngdə olur, iyun-avqust aylarında çiçəklədiyindən bütün növləri arılarda zəhərlənmə yaradır və ölümünə səbəb olur. Gənc arılar zəhərlənmə zamanı pətəyin girişində titrəyir və uça bilməyirlər, qısa zaman içində məhv olurlar [3, 4].

Solanaceae Adans.- Badımcankimilər fəsiləsinin *Datura* L. - Dəlibəng cinsinə 10-a qədər növ daxildir ki, onlardan da ikisi regionumuzda vardır. Bunlardan *Datura stramonium* L. - Adi dəlibəng yabanı florada, D. *inoxia* Mill - Hind dəlibəngi isə mədəni florada yayılıb. Hər ikisi zəhərli bitkidir. Bunlardan bir növü *Datura stramonium* L. -Adi dəlibəng yabanı halda Naxçıvan MR-in bütün rayonlarında alaq bitkisi kimi əkin yerlərində, çəpər dibində, yol kənarında rast gəlinir. Belə sıx təmiz cəngəllik Culfa rayonunun Ərəfsə və Ləkətağ kəndləri və Ordubad rayonunun Nüsnüs kəndi yaxınlığındakı Sarı yarğanlar ərazisində rast gəlinir.

Datura stramonium L. - Adi dəlibəng Stramonium latınca “dəli edən” mənasını verir. Dəlibəng ilə əlaqədar ilk sınaqlar Vyanada kral həkimi Störck tərəfindən 1762-ci ildə edilmiş və onu digərləri izləmişdir. Çiçəkləri yaz aylarında açıq ağ və ya sarı rənglidir. Quraq bölgələrdə, əlverişsiz şəraitdə də məhsuldar olaraq yetişir. Dəlibəng 20-100 sm hündürlüyündə, dik gövdəli, birillik zəhərli ot bitkisidir. Çiçəkləri çox iri olub, qıfşəkillidir. Kasacıq 5 kasa yarpağından ibarətdir, bu yarpaqlar 3-5 sm uzunluğunda olub, boru əmələ gətirir. Tac iridir, 5 ədəd ağ rəngli ləçəkdən təşkil olunmuşdur. Ləçək yarpaqları 10 sm-ə qədər uzunluqda olub, bitişərək boru əmələ gətirir. Erkəkcikləri 5 ədəddir. Dişicik 2 meyvə yarpağından təşkil olunub, üst yumurtalıqlıdır. Bitki iyun-sentyabr aylarında çiçək açır, meyvələri oktyabr ayında yetişir. Bitkinin cicək və yarpaqlarında 0,30-0,75% zəhərli alkaloidlər: hiosiamin, az miqdarda skopolamin vardır. Eyni zamanda gövdəsində 0,15%, kökündə 0,12-0,27%, toxumlarında isə 16-25% yağ, 0,22% alkaloid vardır. Bu alkaloidlərdən ən mühümü hiosiamindir. Hiosiamin alkaloidi dəlibəngin yarpağını toplayıb quruduqda öz izomeri olan atropin alkaloidinə çevrilir. Beləliklə adi dəlibəngin tərkibində əsas təsiredici aktiv maddələri tropan sırasi alkoloidlərinə aid olan atropin qruplu alkaloidlərdir .

Hyoscyamus L. – Batbat. Naxçıvan MR-də bu cinsin *Hyoscyamus niger* L.- Qara batbat, *H. pusillus* L. -Kiçik batbat və H. *reticulatus* L. -Torlu batbat olmaqla 3 növü yayılmışdır. Bu növlərin hamısı da hiyosiyamin qrupu alkaloidləri daşıdığından insan, heyvanlar və arılar üçün zəhərlidirlər. Başlıca alkaloidləri hiyosiyamin və skopolamindir.

Hyoscyamus niger L.- Qara batbat 60-70 sm hündürlükdə, yoğun mil kökə malik, ikiillik və ya birillik ot bitkisidir. Kasacıq 5 kasa yarpağından, açıq və ya tünd sarı rəngdə olan tac 5 ləçək yarpağından əmələ gəlib, yumurtalıq üst vəziyyətdədir, ikiyuvalıdır. Toxumları 1-1,5 mm uzunluğunda olub, böyrəkşəkillidir. Çox

zəhərli bitkidir. Tərkibində 0,02-0,1% hiosiamin, atropin alkaloidlori və sxopolamin vardır. Flavonoidlərdən rutin aşkar edilmişdir. Alkaloidlərin miqdarı - 82 - bitkinin köklərində 0,15-0,18%, gövdədə 0,01%, yarpaqlarda 0,045-0,1%, toxuınlarda 0,06-0,1% təşkil edir. Toxumlarının tərkibində 35%-ə qədər piyli yağ vardır. Yarpaqlarında karotin (provitamin A) və 82%-ə qədər C vitamini olmasına baxmayaraq, zəhərli olduğu üçün vitaminli bitki kimi istifadə etmək olmur. Bitkiden nektar toplayan arıların bir kismi məhv olur, nektarı daşıyan arılar ise bala toksiki maddələri qarışdırır. Çox miqdarda alkoloidlərlə qarışan ballarla bəslənən bala arılar məhv olurlar. 1956 yılında Ermənistanda 50 arı ailəsindən 24-ü bitkidən zəhərlənmiş, qalanı isə zəifləmişdir. Naxçıvan MR-in Gilançay, Havuş, Biləv, Behrud, Parağa, Nəsirvaz, Teyvaz, Milax, Boyəhməd və b. ərazilərdə ehtiyatı kifayət qədərdir.

Laboratoriyada diaqnozu qoymaq üçün alkoloidlər sinir sisteminə daha çox təsir etdiyi üçün ölməktə olan arıları diqqətlə izlmək lazımdır. Arılar əvvəl sinirli olur, hücum etməyə və sancmaya meyli olurlar. Bu vəziyyətdəki arılar açılmış və titrəyən qanadlarıyla oraya buraya uçur, dairəvi hərəkətlər edir. Daha şiddətli zəhərlənmələr zamanı uçma qabiliyyətini itirir sonunda arxası üstə düşüb ölürlər. Zəhərlənmədən şübhəli bilinən arı pətəklərindən xəstə və ölmüş arılar götürülüb qısa müddətdə laboratoriyaya çatdırılmalı, analizləri izlənilməlidir. Arının ayaqlarına ilişən çiçək tozları, bitki növləri baxımından araşdırılmalıdır. Beləliklə arının ziyarət etdiyi bitkilər müəyyən oluna bilər. Arı pətəklərində polen ya da nektar zəhərlənməsi görüldüyündə zaman itirmədən zəhərli polen ya da nektar dolu çərçivələr çıxarılır və yerlərinə şəkər sərbəti doldurulmuş çərçivələr qoyulur. Zəif pətəklərə yumurta qoyulmuş çərçivələr verilərək pətək gücləndirilir [3, 4].

Zəhərli bal nə qədər zəhərli olsa da, bir çay qaşığından az istifadə edilərsə, faydası sonsuzdur. Az miqdarda istifadəsi sinir sisteminə, şəkər xəstəlinə, mədə və bağırsaq problemlərinə, yüksək təzyiqə yaxşı təsir edir. Yəni zəhərli bal həm dərman, həm də zəhərdir.

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Design And Implementation Of A Sensor-Controlled Solar-Powered Hazelnut Drying Unit

Sensör Kontrollü Güneş Enerjili Fındık Kurutma Ünitesinin Tasarımı ve Uygulaması

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Abstract

This study presents the design, implementation, and performance evaluation of a sensor-controlled, solar-powered hazelnut drying unit developed within a project-based vocational education framework. The system enables controlled drying through forced air circulation without direct solar exposure. Solar energy is used to heat ambient air, which is circulated through the hazelnut chamber by fans, ensuring continuous fresh air supply.The closed-loop system incorporates a dehumidification unit to remove moisture generated during drying. Temperature, humidity, light, and electrical sensors provide real-time monitoring of environmental conditions and energy production–consumption. Electrical energy generated by photovoltaic panels is stored and used to power the system components, allowing uninterrupted 24-hour operation independent of solar irradiance.The experimental setup had a 5 kg drying capacity and operated for 30 hours. Sensor data analysis showed that the system achieved more homogeneous moisture reduction, stable drying conditions, and improved energy efficiency compared to traditional open-air drying. The results confirm the feasibility of a low-cost, environmentally friendly drying solution for small-scale agricultural producers, while also demonstrating the effectiveness of project-based learning in vocational education.

Keywords: Hazelnut, solar energy, Türkiye

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