



**INTERNATIONAL SYMPOSIUM:  
“Medicinal Plants: Medical, Cosmetic, and Nutritional Value”**



**May 28-29, 2026**

Welcome to Dushanbe!

Dear Colleagues and Honored Guests,

It is our great pleasure to welcome you to the **INTERNATIONAL SYMPOSIUM “Medicinal plants: Medical, Cosmetic, and Nutritional value”**. We are thrilled to gather in the beautiful city of Dushanbe to explore the frontiers of botanical research and therapeutic development.

Over the next few days, we will bridge the gap between ancient botanical wisdom and cutting-edge biotechnology. From exploring novel antimicrobial products to discussing how Artificial Intelligence is transforming botanical research into next-generation therapeutics, this program is designed to foster innovation and cross-disciplinary collaboration.

We extend our deepest gratitude to our hosts, including the National Academy of Sciences of Tajikistan, the Ministry of Health, and the Medical-Social Institute of Tajikistan, as well as our industry partners participating in the Tajik Botanical Industry Innovation Showcase.

We hope you enjoy the scientific sessions, the cultural excursions, and the invaluable networking opportunities.

**Warm regards,**

Rector,  
Zarina Ibodzoda  
Tel.: (+992) 907 86 86 30  
Email: [11zarr@mail.ru](mailto:11zarr@mail.ru)

Program Manager of the Symposium,  
Alamkhon Akhmedov,  
Tel.: (+992) 988 00 16 41  
Email: [alamkhon.01021951@gmail.com](mailto:alamkhon.01021951@gmail.com)

**May, 28, 2026**  
**PROGRAM OF INTERNATIONAL SYMPOSIUM:**  
**«MEDICINAL PLANTS: MEDICAL, COSMETIC, AND NUTRITIONAL VALUE»**

**09:00 – 09:40 Lecture**

Advancing Mass Spectrometry for Structural Elucidation in Plant Metabolomics  
*Rinat Abzalimov, USA*

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- 10:00 – 10:20** Development of Extraction Methods for Pectin, Inulin, and Specific Proteins (Sericin, Lactoglobulin) Within the Framework of the Zero-Waste Production Concept  
*Professor Zainiddin Mukhiddinov, Tajikistan*
- 10:20 – 10:40** Wound Healing Activity of *Uncaria callophylla* in Diabetic Rats and its Phytochemical Profile  
*Astri Rozanah Siregar, Indonesia*
- 10:40 – 11:00** Pharmacoinformatics Assessment of *Curcuma zedoaria* Phytochemicals as Potential Aromatase Inhibitors  
*Vivitri Dewi Prasasty, Indonesia*
- 11:00 – 11:20** Production of Generic Drugs, Dietary Supplements and Parapharmaceutical Products Based on Local Raw Materials  
*Jamshed Jamshedov, Tajikistan*
- 11:20 – 11:40** Processing and Production of Medicinal Raw Materials from Local Medicinal Plants  
*Doro Kalandarov, LLC "GULCHEHRA" Tajikistan*
- 11:40 – 12:00** Medicinal Plants of the Pamirs: Herbal Remedies and Herbal Preparations of Avicenna  
*Nigina Vatanbekova, LLC "AVICENNA", Tajikistan*
- Lunch**
- 13:00 – 13:20** The Potential of Indonesian Honey Varieties for the Treatment of Anemia  
*Retno Widowati, Indonesia*
- 13:20 – 13:40** Preparation and Sale of Medicinal and Prophylactic Drinks  
*Sayad Davlatzoda, Pharmaceutical Research Center  
Ministry of Health and Social Protection of the Republic of Tajikistan*
- 13:40 – 14:00** Andean Lupinus mutabilis Sweet as a Complement to the Treatment of Type 2 Diabetes Mellitus.  
*Manuel Baldeon, Ecuador*
- 14:00 – 14:20** Production of Damask Rose Essential Oil and Hydrolat in the Shahrinav District of the Republic of Tajikistan  
*Abdukhalim Shukurov, LLC "Tojik Tabib Doru Roz", Tajikistan*
- 14:20 – 14:40** Pushing the Boundaries of Mass Spectrometry for Structure Identification in Plant Metabolomics: Current Trends  
*Rinat Abzalimov, USA*
- 14:40 – 15:00** AI Meets Nature: Transforming Botanical Research, Ethnomedicine into Next-Generation Therapeutics, Nutraceuticals, and Functional Materials  
*Vyacheslav Dushenkov, USA*
- 15:00 – 15:30** Discussion and networking



**May, 29, 2026**  
**PROGRAM OF INTERNATIONAL SYMPOSIUM:**  
**«MEDICINAL PLANTS: MEDICAL, COSMETIC, AND NUTRITIONAL VALUE»**

- 11:20 – 11:30 Welcoming remarks  
*Ilya Raskin, USA; Saidbeg Satorov, Tajikistan*
- 11:30 – 11:50 Study of the Structure and Properties of Biopolymers from *Eremurus hissaricus*.  
*Jamshed Bobokalonav, Tajikistan*
- 11:50 – 12:10 Finding New Natural Molecules from Plants for the Treatment of Parasitic Infections  
*Patricio Rojas Silva, Ecuador*
- 12:10 – 12:30 From Biodiversity to Biomedicine: Unlocking the Potential of Indonesia's Underutilized Fruits as Emerging Resources for Cardiovascular Health  
*Ernawati Sinaga, Indonesia*
- 12:30 – 12:50 Polyphenol Content, Antioxidant Potential, and Antimicrobial Activity of Plants of the Genus *Allium* L.  
*Fazila Mirzoeva, Tajikistan*
- Lunch**
- 13:50 – 14:10 Plant Biotechnology and Human Health.  
*Michael Lawton, USA*
- 14:10 – 14:30 Integrating Science and Culture: A Framework for Medicinal Plant Conservation through Ecotourism in Malasigi, Southwest Papua.  
*Nonon Saribanon, Indonesia*
- 14:30 – 14:50 Characterization of Polysaccharides from *Eremurus hissaricus* Roots by FTIR Spectroscopy.  
*Ashurboy Ashurov, Tajikistan*
- 14:50 – 15:10 Phytonutrient-Protein Complexes in Functional Human Nutrition  
*Ethan Risman, USA*
- 15:10 – 15:30 Metabolomics and Phytochemical Properties of *Ferula violacea*  
*Sulhiya Mavlonazarova, Tajikistan*
- 15:30 – 15:50 Novel Antimicrobial Products from Plants  
*Sophie Henry, USA*
- Coffee break**
- 16:10 – 16:50 Study of Phytochemical Characteristics of Leaf Galls of Plants of The Genus *Pistacia spp.* (pistachio), Growing in Tajikistan.  
*Shuhrat Sultonov, Tajikistan*
- 16:50 – 17:10 Phytochemical Characteristics of *Cucumis trigonus* and the Study of Its Antidiabetic Effect  
*Mehroba Salomuddin, Tajikistan*
- 17:10 – 17:30 Comprehensive treatment of purulent-inflammatory diseases of the soft tissues of the maxillofacial region using the cream-balm “Macrogumin”  
*Jamshedova Sitara, Tajikistan*
- 17:30 – 17:50 Comparative analysis of the chemical composition of *Ziziphora essential* oil using GC–MS  
*Ghairat Hasanov, Tajikistan*

**Discussion**

## SCIENCE-BASED BOTANICALS FOR HUMAN HEALTH

Ilya Raskin

The State University of New Jersey, USA

SPEAKER PROFILE	
	<p><b>Position:</b> Distinguished Professor</p> <p><b>Affiliation:</b> The State University of New Jersey, USA</p>

Pharmacologically active phytochemicals have long been used to treat and prevent disease. Today, botanicals are marketed as foods, dietary supplements, cosmetic ingredients, or drugs containing either single plant-derived bioactive or mixtures of bioactives. New enabling technologies are opening the way for a new generation of more effective, better standardized and safer botanical products. This presentation highlights two examples of botanicals studied and developed in our laboratory: moringa isothiocyanates and antioxidant-enriched lettuce.

*Moringa oleifera* (moringa) is a tropical plant traditionally used to treat inflammation-associated chronic diseases, including diabetes, and as an antimicrobial for water purification. We showed that moringa seed extract (MSE), standardized to its major bioactive isothiocyanate MIC-1 (47% w/w), strongly modulates inflammatory and antioxidant signaling pathways in vitro. In C57BL/6J mice, dietary MSE reduced body weight and adiposity, improved glucose tolerance, decreased expression of the inflammatory gene iNOS, and increased expression of the antioxidant gene NQO1. MSE also mitigated ulcerative colitis symptoms, reduced colonic pathology, and protected against LPS-induced acute inflammation. These anti-inflammatory and antioxidant effects were shown to be mediated through Nrf2-dependent signaling. A no-observed-adverse-effect level (NOAEL) for standardized MSE was established at 257 mg/kg bw/day, providing 100 mg/kg bw/day MIC-1. Several cosmetic product lines based on the topical anti-inflammatory effects of MSE were also developed.


We also developed multiple non-GMO lettuce (*Lactuca sativa* L.) cultivars that hyperaccumulate distinct health-promoting antioxidant polyphenols through classical mutagenesis, tissue culture selection, and transposon tagging. Screening of EMS-mutagenized high-cyanidin lettuce identified three true-breeding mutants with record-high accumulation of kaempferol and naringenin chalcone, reaching about 1% of leaf dry weight, without significant changes in yield or flavor. A parallel spontaneous mutant series from anthocyanin -

hyperaccumulating Rutgers Scarlet Lettuce yielded Green Super Lettuce, in which a non-autonomous CACTA transposon (LsC1) and its truncated derivative (LsC2) are inserted into the 5' untranslated region of the anthocyanidin synthase (ANS) gene, causing hyperaccumulation of upstream flavonoids such as quercetin. Together, these studies show that targeted disruption of late flavonoid biosynthetic steps can transform a widely consumed vegetable into a family of polyphenol-rich functional foods without compromising field or postharvest performance.

**AI MEETS NATURE: “TRANSFORMING BOTANICAL RESEARCH  
ETHNOMEDICINE INTO NEXT-GENERATION THERAPEUTICS,  
NUTRACEUTICALS, AND FUNCTIONAL MATERIALS”**

**Vyacheslav Dushenkov**

Hostos Community College, City University of New York, Bronx, NY, USA

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Professor</p> <p><b>Affiliation:</b> Hostos Community College, City University of New York, Bronx, NY, USA</p>

**Purpose of the Study.** Botanical systems, particularly those rooted in traditional medical knowledge, represent a vast and underutilized source of chemically diverse bioactive compounds. Regions such as Central Asia — and specifically Tajikistan, a recognized biodiversity hotspot within the Mountains of Central Asia — harbor rich ethnomedical traditions and unique plant species adapted to extreme environments. Plant-derived natural products (NPs) account for about 50% of approved drugs and underpin the global nutraceutical and functional materials markets, yet systematic exploration of plant chemical space has been constrained by manual screening, expert-dependent species identification, and complex multi-target bioactivity prediction. This study examines how artificial intelligence (AI) — spanning computer vision, natural language processing, and generative molecular design — is employed across five distinct stages of the botanical research pipeline, with emphasis on published case studies demonstrating real-world efficacy and translational potential. Emphasis is placed on integrating traditional knowledge systems with modern AI methodologies to accelerate translational outcomes.

**Materials and Methods.** A structured narrative review and integrative analysis were conducted using Google Scholar, PubMed, Scopus, CyberLeninka and ACS Publications (2020–2026), structured around a five-stage pipeline: (1) plant identification and biodiversity sourcing; (2) bioactive compound discovery and database mining; (3) target identification and bioactivity prediction; (4) molecular optimization and generative design; and (5) translation, clinical prediction, and scalable biomanufacturing. Representative case studies included antiviral discovery and the development of plant-based functional materials.

**Results and Discussion.** AI integration significantly improves efficiency and predictive power. Multiple apps, including PlantNet, PictureThis, LeafSnap, and iNaturalist, are constantly improving and helping to identify medicinal plants. For discovery, COCONUT 2.0 ([doi.org/10.1186/s13321-020-00478-9](https://doi.org/10.1186/s13321-020-00478-9)) aggregates 730,000+ FAIR-compliant NP entries for AI-driven substructure search, while the Qibo LLM ([doi.org/10.1016/j.eswa.2025.127672](https://doi.org/10.1016/j.eswa.2025.127672)) mines 2 GB of ethnobotanical text to surface lead candidates. At the target prediction stage, Kim et al. ([doi.org/10.3389/fphar.2020.584875](https://doi.org/10.3389/fphar.2020.584875)) demonstrated that integrating protein-ligand interaction networks with physicochemical features outperforms single-modality models for identifying anti-inflammatory and antidiabetic NPs. Generative architectures — Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs), Recurrent Neural Networks (RNNs), and diffusion models — now enable the design of optimized ADMET-profiled molecules from botanical scaffolds. Translationally, a BMC AI review ([10.1186/s44398-025-00004-7](https://doi.org/10.1186/s44398-025-00004-7)) confirmed high-precision AI screening of antimicrobial and anticancer NP candidates, and Saldivar-Gonzalez et al. ([doi.org/10.1039/D1SC04471K](https://doi.org/10.1039/D1SC04471K)) formalized AI-assisted NP chemical space exploration for functional material scaffolds, including bioactive polymers and pigments. Machine learning enhances plant selection by combining ethnobotanical and chemical datasets. AI-assisted metabolomics enables rapid annotation of complex phytochemical mixtures. Deep learning models predict biological activity across therapeutic domains, while network pharmacology supports multi-target analysis typical of botanical extracts. Molecular modeling elucidates mechanisms of action, and generative AI facilitates the design of optimized derivatives and materials. These approaches collectively shift botanical research from empirical screening to data-driven discovery. Challenges remain in data quality, reproducibility, and multi-omics integration.

**Conclusions.** Artificial intelligence is reshaping botanical research by enabling predictive, scalable discovery of bioactive compounds. AI does not replace botanical science — it amplifies it. The convergence of computer vision, NLP, and generative models across the five-stage botanical pipeline creates a synergistic infrastructure that expands accessible plant chemical space at unprecedented scale and speed. These advances are documented in peer-reviewed

literature from 2021 to 2026 and carry direct implications for human health, nutrition, and sustainable materials production. Future priorities include model interpretability for regulatory submissions, equitable access to AI in biodiversity-rich regions, and the standardization of botanical AI benchmarks.

Integration across the research pipeline enhances efficiency and supports the development of therapeutics, nutraceuticals, and functional materials. In biodiversity-rich regions such as Tajikistan, combining traditional knowledge with AI presents a powerful strategy for sustainable innovation and global health impact.

## MAPPING CELLULAR PATHWAYS RESPONSIBLE FOR THE HEALTH-PROMOTING EFFECTS OF NATURAL PRODUCTS

**Michael A. Lawton and Rong Di**

Rutgers. The State University of New Jersey, USA

SPEAKER PROFILE	
	<p><b>Position:</b> Professor</p> <p><b>Affiliation:</b> Rutgers. The State University of New Jersey, USA</p>

The model organism *Caenorhabditis elegans* offers several advantages for characterizing the efficacy and mode-of-action of natural products. In addition to a complete description of the cellular events responsible for its development into an adult, *C. elegans* is characterized by a complete genome sequence, and the existence of a large number of well-characterized mutants, each of which is compromised in a specific pathway. In spite of its relative simplicity, *C. elegans* shares many genes and cellular pathways with humans. It also displays many of the features associated with declining human health and susceptibility to disease, such as aging, programmed cell death, autophagy, loss of muscle function (sarcopenia), an inflammatory response, and the production of reactive oxygen species (ROS). *C. elegans* is susceptible to a number of infectious microorganisms and is also sensitive to environmental toxins and stresses. Significantly, some of these deleterious conditions can be mitigated through the introduction of natural products into the diet of *C. elegans*.

We characterized the responses of *C. elegans* to a number of natural products, using three

complementary approaches: (i) characterization of the lifespan and health of *C. elegans* in response to treatment (essentially, whether there is a discernable health-promoting effect of a natural product); (ii) Transcriptomic and metabolomic analysis to characterize responsive pathways (which pathways are induced or repressed in response to the presence of the natural product); (iii) The use of mutants to determine which cellular and molecular pathways in *C. elegans* mediate the health-promoting effects of natural compounds. In some cases, additional follow-up studies were also performed in other systems, such as mammalian cell cultures.

**Results and discussion:** Our studies revealed a significant effect of specific natural products on *C. elegans* lifespan and health. These include mogrosides, which are triterpene glycosides produced by *Momordica Grosvenor* (known for their beneficial antioxidant and anti-inflammatory activity) and acetylcholinesterase-inhibiting alkaloids derived from *Lycoris radiata*. In these studies, we made use of a transgenic *C. elegans* line that expresses the amyloid- $\beta$  peptide (A $\beta$ ), whose accumulation in an insoluble form is associated with Alzheimer's Disease in humans.

Our studies revealed that mogrosides have a beneficial effect on the lifespan and egg-laying rate (fecundity) of *C. elegans*. They also effectively delayed the onset of paralysis of worms expressing A $\beta$ , as determined by a serotonin sensitivity assay. RNA-Seq revealed that mogrosides may exert a preventative, rather than curative effect, principally by modulating oxidation-related gene expression. Lycoris-derived compounds prolonged lifespan and also delayed paralysis of A $\beta$ -expressing worms. Lycoris compounds inhibited gene expression of *ace-1* and *ace-2*, and modulated inflammatory and stress-related gene expression. The significance of these responses to combating or alleviating the effects of A $\beta$  plaque formation will be discussed.

## AMPLIFYING POLYPHENOL'S HEALTH BENEFITS IN A PROTEIN MATRIX

**Ethan Risman, Diana Roopchand and Ilya Raskin**

The State University of New Jersey, USA

SPEAKER PROFILE	
	<p><b>Position:</b> Graduate student</p> <p><b>Affiliation:</b> The State University of New Jersey, USA</p>

Dietary polyphenols, the principal antioxidant compounds in plant-based foods, have beneficial effects on metabolic, cardiovascular, and inflammatory health. However, their pharmacological use is limited by instability, low bioavailability, and co-occurrence with sugars or other compounds that may reduce their efficacy. Through noncovalent hydrogen bonding and hydrophobic interactions, edible proteins such as whey, soy, pea, and rice can bind and concentrate polyphenolic compounds from edible plants. This protein–polyphenol complexation approach is known as Nutrasorb technology. Nutrasorb technology enhances many of the health benefits of dietary polyphenols by protecting and stabilizing them during manufacturing and within the human body. The result is a significant increase in polyphenol bioavailability and potency, leading to improved health benefits. The advantages of Nutrasorb ingredients derived from various antioxidant-rich fruits and plant proteins have been supported by multiple peer-reviewed publications, as well as clinical and preclinical studies. Until recently, our research focused largely on the health-promoting effects of cranberry, blueberry, cinnamon, and grape polyphenol–protein complexes. More recently, we have expanded this work to cacao flavanol–protein complexes and their cardiovascular benefits.

Polyphenol-enriched Nutrasorb complexes are prepared using food-compatible extraction systems, followed by sorption, centrifugation, co-drying, or freeze-drying and milling to produce stable powders. Human intestinal absorption models have shown that certain polyphenols delivered in a protein-rich defatted soy flour or soy protein matrix are more bioaccessible than those delivered in juice, suggesting greater protection during upper gastrointestinal transit and improved delivery to the colon. These findings were further confirmed in *in vivo* mouse studies. Moreover, animal studies have demonstrated beneficial metabolic effects of various berry- and cinnamon-derived polyphenol–protein complexes, including reduced weight gain on a high-fat diet, as well as hypoglycemic and anti-inflammatory effects. These benefits were diminished when proteins or polyphenols were administered separately. Positive modulation of the gut microbiome may be one of the principal mechanisms of action of fruit polyphenol–protein complexes, which have been shown to reduce reactive oxygen species in the gut and promote the growth of beneficial anaerobic bacteria. Furthermore, several human clinical studies have demonstrated the benefits of polyphenol–protein complexes for sports nutrition and intestinal health.

A major advantage of Nutrasorb technology is the natural concentration of beneficial polyphenols, the exclusion of unwanted sugars, stabilization during storage and intestinal transit, and amplification of their bioavailability and pharmacological activity. Therefore, Nutrasorb complexes can serve as ingredients in a wide variety of functional foods, beverages, and dietary supplements targeting metabolic and gut health.

## PUSHING THE BOUNDARIES OF MASS SPECTROMETRY FOR STRUCTURE IDENTIFICATION IN PLANT METABOLOMICS: CURRENT TRENDS

Rinat Abzalimov, Kenneth Acosta, Vyacheslav Dushenkov

Advanced Science Research Center, The City University of New York, New York, NY, USA;  
Department of Plant Biology, Rutgers, The State University of New Jersey, New Brunswick, USA;

Department of Natural Sciences, Hostos Community College, CUNY, Bronx, NY, USA

SPEAKER PROFILE	
	<p><b>Position:</b> Director, Mass Spectrometry Facility; Co-Director, MALDI-TOF MS Imaging Facility; Research Associate Professor, Structural Biology Initiative</p> <p><b>Affiliation:</b> Advanced Science Research Center, The City University of New York, New York, NY, USA</p>

Mass spectrometry (MS) has become one of the most powerful analytical platforms for the detection and characterization of metabolites in complex biological systems, including plants. Advances in instrument sensitivity, mass accuracy, and acquisition speed have enabled the detection of thousands of molecular features in a single experiment. However, despite these technological achievements, confident structural identification remains a major bottleneck in metabolomics. It is estimated that fewer than 30% of detected metabolite features can currently be confidently assigned to known molecular structures. This gap between detection and identification significantly limits the biological interpretation of plant metabolomics datasets and our ability to fully understand plant biochemical pathways and ecological interactions.

Several factors contribute to this challenge. First, the coverage of existing spectral libraries, including MS/MS and ion mobility databases, remains limited relative to the enormous chemical diversity of plant metabolites. Plants produce an exceptionally wide range of metabolites, including flavonoids, alkaloids, terpenoids, phenolics, and glycosylated derivatives, many of which are absent from current reference databases. The limited availability of authentic reference standards therefore restricts the ability to experimentally confirm molecular identities. Second, plant metabolomes contain numerous isomeric and isobaric compounds that cannot be readily distinguished based solely on accurate mass measurements. Third, ambiguity in the assignment of adducts and fragment ions further complicates spectral interpretation. Finally, the

complexity of plant tissues and extracts often introduces significant spectral congestion, further increasing the difficulty of reliable structure annotation.

To address these challenges, several complementary strategies are emerging. Improvements in chromatographic separation techniques continue to enhance analytical resolution prior to MS detection. At the same time, multidimensional mass spectrometry approaches are increasingly being implemented to provide orthogonal structural information. These include ion mobility spectrometry (IMS) and the application of fragmentation methods such as collision-induced dissociation (CID), electron-based dissociation techniques, and other specialized activation approaches. Together, these methods generate complementary datasets that help resolve structural ambiguities and improve metabolite annotation confidence.

In parallel, computational approaches are rapidly transforming metabolite identification workflows. Advanced software platforms and machine-learning-assisted tools, such as SIRIUS and related algorithms, facilitate the interpretation of MS/MS data and enable more confident structural predictions. Chemical derivatization also plays an important role by selectively targeting specific functional groups, improving ionization efficiency, and simplifying spectral interpretation. In addition, emerging gas-phase chemistries, including hydrogen–deuterium exchange (HDX)-based approaches, offer new opportunities to probe structural features directly within the mass spectrometer.

Together, these developments illustrate how the integration of advanced instrumentation, chemical strategies, and computational tools is pushing the boundaries of mass spectrometry in plant metabolomics. By combining multidimensional analytical measurements with innovative data analysis methods, the field is steadily moving toward more confident and comprehensive metabolite identification, ultimately enabling deeper insights into plant metabolism, physiology, and interactions with the environment.

# HYDROLYZABLE TANNINS FROM *PUNICA GRANATUM* AND *QUERCUS INFECTORIA* AS POTENT NATURAL SURFACE SANITIZERS

Sophie Henry, Antonia Kaz, Erica Cho, Ilya Raskin

Rutgers, The State University of New Jersey, USA

SPEAKER PROFILE	
	<p><b>Position:</b> Graduate student</p> <p><b>Affiliation:</b> The State University of New Jersey, USA</p>

The rise of healthcare-associated infections highlights the need for novel, non-toxic, surface-active antimicrobial agents. This study evaluates the antimicrobial potential of tannin-rich extracts from *Punica granatum* (pomegranate) peel and *Quercus infectoria* (Aleppo oak) galls, with particular emphasis on their efficacy on both abiotic and biotic surfaces. Chemical characterization by UPLC-MS/MS and metabolomic profiling identified hydrolyzable tannins as the principal antifungal compounds: punicalagin (32%) in pomegranate peel extract and gallotannins (73.6%), primarily tannic acid, as antibacterial actives in Aleppo oak gall extract.

Using a novel surface antimicrobial assay developed in our laboratory, we found that both extracts exhibited broad-spectrum surface activity against *Candida albicans*, *Staphylococcus aureus*, and *Escherichia coli*. Notably, although these extracts showed only modest efficacy in traditional liquid broth microdilution assays, their antimicrobial activity on surfaces approached that of conventional antibacterial and antifungal drugs. For example, pomegranate peel extract was approximately three times more effective on surfaces inoculated with *C. albicans* than in liquid culture, achieving MIC<sub>50</sub> values as low as 5.13 µg/cm<sup>2</sup> on stainless steel and synthetic collagen. Similarly, Aleppo oak gall extract maintained strong antibacterial activity against *E. coli* and *S. aureus* on surfaces, including agar and cadaver skin, while showing lower efficacy in liquid culture compared to standard antibiotics. We hypothesize that the antimicrobial activity of these botanical extracts is based on disruption of the cell wall and membrane, thereby blocking the early stages of surface attachment and biofilm formation.

These findings suggest that the macromolecular binding and crosslinking properties of hydrolyzable tannins enable them to persist and remain active on surfaces, unlike many standard disinfectants. This study also highlights the newly developed surface antimicrobial assay as a valuable tool for evaluating surface-active antimicrobial natural products. Our findings further

support the potential application of Aleppo oak gall extract and pomegranate peel extract as functional ingredients in skin sanitizers and antimicrobial coatings for healthcare and food industry applications.

**CLINICAL AND PRECLINICAL EVIDENCE OF THE BENEFICIAL EFFECT OF *L. MUTABILIS* SWEET CONSUMPTION IN ADULTS AND CHILDREN**

**Manuel E. Baldeón, MD., PhD.**

Universidad Internacional del Ecuador

<b>SPEAKER PROFILE</b>	
	<b>Position:</b> Professor <b>Affiliation:</b> Facultad de Ciencias Médicas, de la Salud y la Vida. Universidad Internacional del Ecuador, Quito, Ecuador

**Clinical Evidence:** Initially we conducted a phase II clinical trial to assess the role of raw *Lupinus mutabilis* (LM) on blood glucose and insulin in normoglycemic and dysglycemic subjects. Eligible subjects were randomly assigned to 2 treatment groups: Raw LM or soy bean (SB). Equal amounts of LM or SB per kilogram of body weight were administered to volunteers.

In healthy volunteers, consumption of LM or soy did not induce changes in blood glucose or insulin after 60 and 90 minutes. In volunteers with newly diagnosed dysglycemia, consumption of LM decreased non-significantly blood glucose concentrations after 60 min of ingestion. However, LM ingestion produced a significant decrease in serum insulin after 90 min. SB intake did not cause changes in glucose or insulin levels. The most significant effect in glucose and insulin concentrations was obtained in individuals whose basal glucose concentration was greater than 100 mg/dL. Regarding insulin, after 60 min of treatments, there was a significant decrease in insulin concentration in the LM compared with the SB group. Only in individuals with dysglycemia that consumed LM there was a decrease of HOMA-IR 60 and 90 min after its intake.

A subsequent study was an experimental- phase-II random clinical trial conducted with volunteers recently diagnosed with type-2 diabetes to assess the acute effect of cooked LM (n = 20) and its purified alkaloids (n = 10) on blood glucose and insulin. (Baldeón et al. 2012, Fornasini et al. 2012). We found that the consumption of cooked LM or its purified alkaloids

decreased blood glucose and insulin levels. The percentage of decrease in glucose concentration was higher in the cooked LM group compared with the alkaloid group.

We designed a quasi-experimental-28-week crossover-study that assessed the impact of daily consumption of LM on glucose control on regular T2DM patients under their usual oral hypoglycemic treatment. We initially recruited and followed (during-14-weeks) 79 adult patients that were taking their regular “oral hypoglycemic medication only” (without LM consumption). After that period, in addition to their usual oral hypoglycemic treatment, they started to consume daily doses of 10 and 15 g of an LM-based-snack (which was the same we used in our previous study), for other 14-weeks. Only patients with serum A1C concentrations  $\leq 8.0\%$  reduced their A1C significantly after the intervention with the LM based snack, and 71% achieved an A1C target concentration of 6.5%. After consumption of LM, patients showed a significant decrease in blood pressure and a substantial increase in HDL-cholesterol.

Recently, we evaluated the effect of a supplement rich in protein and fiber, based on the Andean legume, *Lupinus mutabilis* sweet, in a group of children with different levels of malnutrition and gut dysbiosis from the province of Chimborazo (n = 71) and the Galapagos Islands (n = 51) in Ecuador. After *L. mutabilis* consumption, a reduction in the percentage of children with obesity was observed, from 9.86% to 1.41% in the Andean region and from 21.57% to 11.76% in the Galapagos. Functional analysis of gut microbiota after *L. mutabilis* consumption, identified 3 genera, *Butyribacter*, *Lachnospira*, and *Coprococcus\_A*, associated with short chain fatty acid (SCFA) production in the Andean group. We conclude that consumption of the *L. mutabilis* snack has a positive effect on the nutritional status and fecal microbiota in schoolchildren.

**Pre-clinical studies:** We have established a dual culture system that allows the evaluation of legume hydrolysates, including those from *L. mutabilis*, that is obtained by enzymatic digestion similar to what would occur in the intestine.

We have shown that hydrolysates of *L. mutabilis* protein and the protein gamma-conglutin ( $\gamma C$ ) isolated from *L. mutabilis* affect glucose metabolism by inhibiting the enzymatic activity of DPP4; increase in the sensitivity of the insulin receptor in adipocytes with the consequent increase in glucose consumption and the presence of the GLUT-4 transporter on the cell membrane; and the inhibition of gluconeogenesis in liver cells (50% inhibition that is similar to the effect of the positive control - metformin). The sequences of these hydrolysates derived from *L. mutabilis* predict important bio-active properties, including inhibition of DPP4 and ECA enzymes, antioxidant, and anti-thrombotic effects to improve the metabolism of glucose and the cardiovascular systems.

**Conclusions:** Current epidemiological, clinical, molecular, and cellular evidence indicates that consumption of legumes, including Andean *L. mutabilis* has important beneficial effects on cardio-metabolic metabolism in children and adults. It is necessary to promote legume consumption as part of a healthy diet.

**IN VITRO EVALUATION OF THE CYTOTOXIC AND LEISHMANICIDAL ACTIVITY OF DIFFERENT GALL EXTRACTS FROM PLANTS OF THE ECUADORIAN ANDEAN CHOCÓ**

**Alex Gavilanes<sup>1</sup>, Andrea Pumisacho<sup>1</sup>, Erika Muñoz<sup>1</sup>, Rebeca Cortez<sup>1</sup>, Nelson Miranda<sup>1</sup>, Diego Cisneros<sup>1</sup>, Vyacheslav Dushenkov<sup>2</sup>, Ilya Raskin<sup>3</sup>, Antonia Kaz<sup>3</sup>, Patricio Rojas-Silva<sup>1</sup>**

<sup>1</sup>Universidad San Francisco de Quito, Quito – Ecuador,

<sup>2</sup>Eugenio María de Hostos Community College, City University of New York, Bronx, NY

<sup>3</sup>Rutgers, The State University of New Jersey, New Brunswick, USA.

<b>SPEAKER PROFILE</b>	
	<p><b>Patricio Rojas-Silva</b> <b>Position:</b> Director, Master's Program in Microbiology <b>Affiliation:</b> Universidad San Francisco de Quito, Quito, Ecuador</p>

**Purpose of the study:** Leishmaniasis is a world-wide neglected tropical disease caused by protozoan parasites of the genus *Leishmania* and transmitted by sandflies. Globally, it is estimated that there are more than 12 million cases of leishmaniasis with a global incidence of 700,000 to 1.2 million new cases each year and approximately 350 million people are at risk of developing this infection, especially in poor regions of developing countries. Three clinical forms of the disease have been described: cutaneous, which manifests with ulcers and scarring; mucocutaneous, which can destroy mucous membranes of the nose, mouth, and throat; and visceral, which can affect the liver, the spleen and bone marrow and be fatal if left untreated. Currently available treatments have severe limitations such as parenteral administration, adverse side effects, toxicity, therapeutic failure, or resistance.

Galls are abnormal growths on plants that originate in response to invading organisms such as bacteria, fungi, or arthropods, mainly insects like wasps. These structures produce a wide range of bioactive phytochemicals, including phenolic acids, anthocyanins, purpurogallin, flavonoids, tannins, steroids, triterpenes, alkaloids, and lipophilic components. Several of these

isolated metabolites have demonstrated activity against infectious diseases. However, the potential therapeutic effect of gall extracts against parasitic diseases such as leishmaniasis has not yet been evaluated.

This study evaluated the *in vitro* cytotoxic and leishmanicidal effects of different gall extracts on RAW 264.7 macrophages cell line and promastigotes and amastigotes of *Leishmania mexicana* M379.

**Materials and Methods:** Ten different plant gall types were collected from plants located in the Maquipucuna Ecological Reserve, in the Chocó Andean forest, northwest to Quito, Ecuador. All the characteristics associated with each gall were recorded and subsequently transported to the Institute of Microbiology at the San Francisco de Quito University for extraction. The fresh material was broken up with liquid nitrogen, and 70% methanol was used as a solvent for the extract. The material was filtered and placed in a water bath at 90°C for 5 minutes. The remaining solvent was eliminated by a rotary evaporator, and the dry extract was obtained by lyophilization. The samples were kept at -80°C. All extracts were diluted with 96% ethanol to a final concentration of 20 mg/mL, before the biological assays. The culture and cytotoxicity and cell viability assays of the macrophage and *L. mexicana* cell lines were performed as in previous publications without modifications.

**Results:** The plants with galls collected belonged to the genera *Miconia*, *Baccharis*, *Piper*, *Vernonanthura*, *Liabum*, *Schefflera*, and *Otoba*. All the extracts were tested to a final concentration of 100 µg/mL in the cytotoxic assay with RAW macrophages and promastigotes of *L. mexicana*. The gall extract from the *Schefflera* spp. specimen did show high leishmanicidal activity and low macrophage cytotoxicity. Further, the median cytotoxic concentration (CC<sub>50</sub>) in macrophages was 2876 µg/mL and in the promastigotes of *L. mexicana* the median inhibitory concentration (IC<sub>50</sub>) was 133.3 µg/mL with a selectivity index (IS) of 20.9. In the amastigote assay with MOI 10:1, the percentage of infection was reduced from 86.4% in the untreated control to 77.64% with the lowest concentration of extract applied of 31.25 µg/mL and dropped to 0% at a concentration of 500 µg/mL. The percentage reduction in infection increased from 10.13% at 31.25 µg/mL of extract to 100% at 500 µg/mL of extract. The intensity of infection decreased from 8.12 amastigotes per infected macrophage without treatment to 0 with the 500 µg/mL extract. The selectivity index of the extract for the amastigote assay was 47.22.

**Conclusions:** The methanolic extract obtained from a gall specimen of a *Schefflera* spp. specimen showed promising leishmanicidal activity in promastigotes and amastigotes and was also selective in attacking the parasite, minimizing its toxic effect on macrophages.

**Key words:** *leishmaniasis*, *plant galls*, *Leishmania mexicana*, *Ecuadorian Andean Chocó*, *leishmanicidal activity*.

**FROM BIODIVERSITY TO BIOMEDICINE:  
UNLOCKING THE POTENTIAL OF INDONESIA'S UNDERUTILIZED FRUITS  
AS EMERGING RESOURCE FOR CARDIOVASCULAR HEALTH**

**Ernawati Sinaga**

Universitas Nasional, Jakarta, Indonesia

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Professor, Vice-Rector for Research, Community Service and Cooperation, Universitas Nasional</p> <p><b>Affiliation:</b> Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia</p>

Indonesia is recognized as one of the most biodiverse countries on Earth, home to an immense variety of species shaped by its tropical climate and archipelagic geography, spanning thousands of islands with ecosystems ranging from rainforests to coastal mangroves. Among this richness are many species of edible wild fruits that remain underutilized despite their considerable medicinal potential. Several studies have demonstrated that some of those underutilized fruits have substantial potential to be developed as sources of nutraceuticals and functional foods to support cardiovascular health, an area that currently warrants urgent and focused attention. The scientific relevance of these potencies lies in their richness in bioactive compounds, including polyphenols, flavonoids, carotenoids, dietary fiber, and essential micronutrients, which have been proven to have antioxidant, anti-inflammatory, antihyperlipidemic, and antihypertensive activities that are mechanistically linked to the prevention and management of cardiovascular diseases. These molecules are pharmacologically active molecules capable of modulating biological pathways central to cardiovascular health, such as oxidative stress, chronic inflammation, endothelial dysfunction, and dysregulated lipid metabolism, and may inhibit enzymes involved in cholesterol synthesis or modulate signaling pathways such as NF- $\kappa$ B and MAPK.

Recent research trends in natural product pharmacology have begun to shed light on the therapeutic promise of such fruits. Advances in analytical techniques, including high-performance liquid chromatography and mass spectrometry, have enabled detailed phytochemical profiling, revealing complex mixtures of bioactive constituents. Concurrently, *in vitro* and *in vivo* studies have demonstrated that juices from certain Indonesian wild

underutilized fruits can reduce oxidative damage, inhibit inflammatory mediators, improve lipid profiles, and ameliorate atherosclerosis. Some examples are karamunting (*Rhodomyrtus tomentosa*), ramania (*Bouea macrophylla*), bidara (*Ziziphus mauritiana*), and belimbing darah (*Baccaurea angulata*). Recent research suggested that supplementation of *Rhodomyrtus tomentosa* fruit juice prevents hypercholesterolemia and atherosclerosis in experimental rats fed with high-fat high-cholesterol diet, characterized by a significant decrease in total triglycerides, total cholesterol, low-density lipoprotein, and an increase in high-density lipoprotein level in serum. The supplementation of *Rhodomyrtus tomentosa* fruit juice also prevents atherosclerosis development by preventing the thickening of the blood vessel wall, deposition of lipid formation, and foam cells in the tunica intima of the aorta and coronary arteries. The same results were also shown by the administration of *Bouea macrophylla* or *Ziziphus mauritiana* fruit juice. Other reports state that the alteration of the hemopoietic system, physiological changes in serum and tissues lipid profiles, and an increase of serum inflammatory biomarkers resulting from the consumption of a high-cholesterol diet were significantly ameliorated by the administration of *Baccaurea angulata* fruit juice. These facts highlight emerging scientific evidence supporting the potential use of Indonesia's underutilized fruits in promoting cardiovascular health.

The translation of these findings into practical biomedical applications is an area of increasing momentum. Underutilized fruits hold significant potential for development into functional foods, nutraceuticals, and even phytopharmaceutical products. Functional foods rich with bioactive compounds could serve as preventive strategies, reducing the risk of cardi-ovascular disease through dietary intervention. Nutraceutical formulations, standardized for specific phytochemicals, offer a bridge between traditional knowledge and modern therapeutics. In the longer term, isolation and structural modification of active compounds may contribute to the development of new drug candidates. However, realizing this potential requires an integrated and interdisciplinary approach. Pharmacological investigation and clinical validation must be aligned with scientific validation to ensure safety, efficacy, and quality. At the same time, challenges such as availability at industrial scale, variability in phytochemical composition, and regulatory requirements must be addressed through collaborative research involving botanists, chemists, pharmacologists, clinicians, and policymakers. In conclusion, Indonesia's underutilized fruits represent far more than a neglected component of biodiversity; they are a dynamic and promising resources for advancing cardiovascular health. By embracing an interdisciplinary framework, we can unlock new pathways from biodiversity to biomedicine. This journey not only holds the potential to generate novel therapeutic solutions but also to inspire a more sustainable and holistic approach to global health—one that recognizes nature and biodiversity not merely as a source of raw materials, but as a partner in innovation and well-being.

**INTEGRATING SCIENCE AND CULTURE: A FRAMEWORK FOR MEDICINAL  
PLANT CONSERVATION THROUGH ECOTOURISM IN MALASIGI,  
SOUTHWEST PAPUA**

**Nonon Saribanon<sup>1</sup>, Asep Parantika<sup>2</sup>, Muhammad Ishlah Ramadhan<sup>3</sup>**

<sup>1</sup> Biology Department, Universitas Nasional, <sup>2</sup> Tourism Department, Universitas Nasional

<sup>3</sup> CRC Department, Pertamina EP Papua Field

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Permanent Lecturer, Chairman of The Institute of Research and Community Service</p> <p><b>Affiliation:</b> Biology Department, Universitas Nasional, Jakarta, Indonesia</p>

Southwest Papua, Indonesia, is recognized as a global biodiversity hotspot, particularly for its rich tropical rainforests and the invaluable ethnobotanical heritage of indigenous communities, such as the Moi Tribe in the Malasigi region. For centuries, the Moi people have cultivated profound Traditional Ecological Knowledge (TEK) regarding medicinal plants, which are not merely botanical resources but integral components of their cultural identity, spiritual beliefs, and primary healthcare system. This study addresses the critical threats to the biocultural heritage of indigenous communities, specifically the Moi Tribe in Southwest Papua, Indonesia, focusing on their TEK of medicinal plants. Rapid modernization, habitat loss, and the oral transmission of TEK endanger this invaluable heritage. The primary objective of this study is to propose and delineate an integrated framework for medicinal plant conservation in the Malasigi region. This framework aims to bridge scientific methodologies with cultural preservation through community-led ecotourism. The proposed framework integrates both scientific and cultural dimensions, with its development and implementation informed by a qualitative research approach. This approach encompasses field observations to understand the ecological context and traditional practices, in-depth interviews with Moi elders and community members to document TEK and cultural perspectives, and Focus Group Discussions (FGDs) to collaboratively develop and refine conservation strategies. The framework includes systematic botanical documentation (integrating scientific taxonomy and local Moi nomenclature), ecological mapping using Geographic Information Systems (GIS), and sustainable harvest studies. Concurrently, it emphasizes fostering intergenerational knowledge transfer,

strengthening indigenous governance through customary laws, and establishing intellectual property rights mechanisms. Ecotourism serves as the economic and educational catalyst, facilitating medicinal plant trails, indigenous healing experiences, and low-impact eco-lodges. This integrated framework is designed to yield multifaceted socio-economic and environmental benefits. It is anticipated to foster sustainable livelihoods for the Moi people, enhance biodiversity protection through tourism-funded monitoring, and contribute to climate resilience by maintaining healthy ecosystems. The discussion highlights how the mutual reinforcement of scientific rigor and cultural relevance drives sustainable development, offering a pathway to address challenges such as capacity building and transparent benefit-sharing. This approach transforms Malasigi into a living laboratory where scientific inquiry and traditional wisdom coalesce, securing long-term funding and expertise for conservation initiatives. In conclusion, this study demonstrates that the integrated framework provides a strategic roadmap for effective medicinal plant conservation that is both culturally appropriate and community-led. It illustrates that successful conservation outcomes are achieved when scientific understanding is harmonized with cultural values and driven by active community engagement. The proposed model offers a scalable and adaptable approach for other indigenous communities globally facing similar biocultural heritage threats.

## **THE EFFICACY OF INDONESIAN HONEY VARIETIES FOR ANEMIA MANAGEMENT**

**Retno Widowati**

Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia  
 Faculty of Health Sciences, Universitas Nasional, Jakarta Indonesia

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Professor</p> <p><b>Affiliation:</b> Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia</p>

**Background:** Anemia continues to be a major global health challenge, particularly affecting adolescent girls, pregnant women and postpartum mothers in developing nations. While conventional iron supplementation is widely implemented, its effectiveness is often limited by

gastrointestinal side effects and low patient adherence. Indonesia's vast biodiversity offers a significant opportunity to utilize local honey varieties as a safe and culturally acceptable complementary intervention.

**Purpose:** This study evaluates the potential of various Indonesian honey as complementary agents to increase hemoglobin levels in vulnerable populations.

**Materials and Methods:** Using a mixed-methods approach, this research integrated field intervention studies with a systematic literature review. The clinical phase involved the administration of some specific Indonesian honey, including *Acacia crassicarpa*, multiflora (*Apis mellifera*), and forest honey (*A. dorsata*). Participants received a dosage of 10–20 ml twice daily for a minimum of 14 days. Primary assessments focused on pre- and post-intervention hemoglobin levels, supported by an analysis of the honey's biochemical profiles, including iron (Fe), copper (Cu), magnesium (Mg), and Vitamin C.

**Results:** Indonesian honey produced by *Apis mellifera* and *A. dorsata* contains a unique matrix of micronutrients and bioactive compounds that synergistically enhance iron bioavailability and support erythropoiesis. Empirical results from the intervention demonstrated a statistically significant increase in hemoglobin concentrations among the subjects. These findings confirm that the antioxidant activity and nutrient density of Indonesian honey effectively support hemoglobin elevation.

**Conclusion:** The utilization of Indonesian honey provides a sustainable and evidence-based complementary strategy for the prevention and management of anemia on a global scale.

## PHARMACOINFORMATICS ASSESSMENT OF *CURCUMA ZEDOARIA* PHYTOCHEMICALS AS POTENTIAL AROMATASE INHIBITORS

Vivitri Dewi Prasasty<sup>1</sup>, Ernawati Sinaga<sup>1</sup>, Muhammad Hanafi<sup>2</sup>, Elya Sinurat<sup>3</sup>

<sup>1</sup>Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia, <sup>2</sup>Research Center of Pharmaceutical Ingredients & Traditional Medicine, National Research and Innovation Agency (BRIN), Indonesia, <sup>3</sup>Marine and Terrestrial Bioindustry Research Center, National Research and Innovation Agency (BRIN), Indonesia

SPEAKER PROFILE	
	<p><b>Vivitri Dewi Prasasty</b> <b>Position:</b> Associate Professor <b>Affiliation:</b> Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia</p>

**Purpose of the study:** Aromatase (CYP19A1) is a validated therapeutic target for estrogen receptor-positive (ER+) breast cancer, which accounts for 70–75% of all breast cancer cases. While third-generation aromatase inhibitors (AIs) are clinically effective, their long-term adverse effects necessitate safer alternatives. *Curcuma zedoaria* (Christm.) Roscoe is a medicinal plant rich in sesquiterpenes and curcuminoids with documented anticancer properties. This study conducted a comprehensive pharmacoinformatics and network pharmacology assessment of 20 major *C. zedoaria* phytochemicals to evaluate their potential as multi-target aromatase inhibitors.

**Materials and Methods:** A library of 20 phytochemicals (curcuminoids, sesquiterpenes, monoterpenes, and phenylpropanoids) with three FDA-approved AIs as references was compiled. Physicochemical properties were calculated using RDKit (v2022.9.5). Drug-likeness was assessed via Lipinski's Rule of Five and Veber's rules, and ADMET profiles were predicted. For network pharmacology, putative targets were predicted using SwissTargetPrediction and cross-referenced with breast cancer genes from GeneCards and DisGeNET. A protein–protein interaction (PPI) network was constructed, network topology was evaluated, and Gene Ontology (GO) and KEGG pathway enrichment analyses were performed.

**Results and discussion:** All 20 phytochemicals passed Lipinski's and Veber's oral bioavailability criteria, with 90% exhibiting zero violations. The curcuminoids demonstrated optimal drug-like properties (MW 308–370 g/mol, LogP 3.29–3.37), closely mirroring established AIs. Network pharmacology identified 72 putative targets, of which 38 overlapped with breast cancer disease genes. PPI topology analysis revealed 15 hub targets, with AKT1 (degree centrality = 0.405), TNF, NFKB1, TP53, MAPK1, and ESR1 as the most critical nodes. Sesquiterpenes collectively converged on inflammatory and apoptotic targets (13 compounds targeting AKT1, TNF, and NFKB1), while curcuminoids exhibited a broader multi-target profile across all 15 hub proteins. KEGG enrichment identified the PI3K-Akt signaling pathway (13 genes, FDR =  $4.50 \times 10^{-16}$ ), Apoptosis (10 genes, FDR =  $1.20 \times 10^{-14}$ ), Estrogen signaling (8 genes, FDR =  $1.40 \times 10^{-11}$ ), and Steroid hormone biosynthesis (FDR =  $4.50 \times 10^{-05}$ ) as the most significantly enriched pathways. GO enrichment corroborated these findings with significant enrichment in apoptotic process regulation and inflammatory response.

**Conclusions:** The tripartite Compound–Target–Pathway network revealed that *C. zedoaria* phytochemicals not only directly inhibit CYP19A1 to suppress estrogen biosynthesis but simultaneously modulate downstream Estrogen/PI3K-Akt survival signaling and TNF/NF- $\kappa$ B inflammatory pathways. Curcuminoids emerged as the most promising candidates, while sesquiterpenes offer complementary anti-inflammatory and pro-apoptotic mechanisms. These findings provide a robust systems pharmacology framework for prioritizing *C. zedoaria*

compounds in subsequent molecular docking and experimental validation studies for developing novel, natural aromatase inhibitors for breast cancer therapy.

**WOUND HEALING ACTIVITY OF *UNCARIA CALLOPHYLLA* BLUME EX KORTH.  
IN DIABETIC RATS AND ITS PHYTOCHEMICAL PROFILE**

**Astri Rozanah Siregar<sup>1</sup>, Ernawati Sinaga<sup>1</sup>, Sri Endarti Rahayu<sup>1</sup>**

Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia

SPEAKER PROFILE	
	<p><b>Astri Rozanah Siregar</b> <b>Position:</b> Faculty of Biology <b>Affiliation:</b> Department of Biology, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta, Indonesia</p>

**Purpose:** This study aimed to evaluate the wound healing activity of topical *Uncaria callophylla* stem methanol extract ointment in diabetic rats and to analyze its phytochemical composition and antioxidant activity.

**Materials and Methods:** *Uncaria callophylla* stems were extracted using methanol and formulated into topical ointments at concentrations of 5%, 10%, and 20%. Diabetic conditions were induced in Sprague Dawley rats using streptozotocin, followed by excision wound creation, divided into six groups: non-diabetic control, diabetic untreated, diabetic treated with betadine ointment, and diabetic treated with *Uncaria callophylla* extract ointments (5%, 10%, and 20%). Wound healing was evaluated based on wound area reduction, epithelialization time, inflammatory cell response, fibroblast proliferation, angiogenesis, collagen deposition, and hydroxyproline content. Phytochemical analysis included total phenolic and flavonoid content, antioxidant activity using the DPPH method, and compound identification using LC-MS/MS and GC-MS.

**Results and Discussion:** Topical application of *Uncaria callophylla* extract ointment significantly accelerated wound healing in diabetic rats compared to untreated diabetic controls. The extract enhanced wound contraction, shortened epithelialization time, increased neutrophil and macrophage infiltration during the inflammatory phase, and promoted fibroblast proliferation, angiogenesis, collagen deposition, and hydroxyproline levels during the


proliferative phase. The 20% extract concentration showed the strongest effect on angiogenesis, re-epithelialization, and collagen synthesis, while the 10% concentration provided the most balanced overall healing response. Phytochemical analysis showed high total phenolic (20.59%) and flavonoid (0.40%) contents and strong antioxidant activity ( $IC_{50} = 16.06$  ppm). LC-MS/MS and GC-MS analyses identified several bioactive compounds such as betulonic acid, uncarine A, sweroside, and fatty acid derivatives that are associated with antioxidant, anti-inflammatory, and tissue-regenerative activities. These compounds are likely responsible for the enhanced wound healing observed in this study.

**Conclusion:** Topical *Uncaria callophylla* stem methanol extract significantly promotes diabetic wound healing by enhancing inflammation control, angiogenesis, fibroblast proliferation, epithelialization, and collagen synthesis. The wound healing activity is strongly associated with its phenolic and flavonoid compounds and antioxidant activity. These findings support the potential use of *Uncaria callophylla* as a natural therapeutic agent for diabetic wound treatment.

## ANTIVIRAL AND ANTIBACTERIAL POTENTIAL OF PLANTS OF THE GENUS OF THE *FERULA* L. AND *ALLIUM* L. GROWING IN TAJIKISTAN

**Saidbeg Satorov, Fazila Mirzoeva, Sylhiya Mavlonazarova**

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Professor of the Department</p> <p><b>Affiliation:</b> Department of Microbiology, Virology and Immunology NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** Evaluation of the antiviral and antibacterial properties of the *Allium* L. and *Ferula* L. plants growing in Tajikistan.

**Materials and Methods:** To evaluate the virological and microbiological potential of the selected medicinal plants, we employed a complex of laboratory methods aimed at studying the direct impact of phytoextracts on pathogens and their life cycles. As part of the antimicrobial screening, we determined the minimum inhibitory concentration (MIC) using the agar diffusion

method (disk-diffusion method) and the broth serial dilution method. This enabled us to establish the precise efficacy of the extracts against specific bacterial strains. Virological studies were conducted using cell cultures (in vitro), where we assessed the virus-inhibiting activity of the samples by measuring the suppression of the viral cytopathic effect (CPE)


**Results:** Phytochemical analysis of the *Ferula* L. genus revealed high concentrations of sesquiterpenoids and coumarins. Extracts from the roots and seeds exhibit pronounced activity against the influenza A virus, blocking viral genome replication at early stages. Bacteriologically, ferula exhibits strong bactericidal and bacteriostatic activity against gram-positive pathogens. Wild species of the *Allium* L. genus are rich in allicin and saponins. Allicin exerts a powerful antibacterial effect by inhibiting sulfhydryl enzymes in microorganisms. Furthermore, quercetin and selenium, found in local onion species, help strengthen cellular immunity and reduce viral adhesion.

**Conclusion:** Medicinal plants of the genera *Allium* L. and *Ferula* L. from Tajikistan represent promising raw materials for the development of domestic broad-spectrum phytopreparations. The findings confirm the feasibility of creating antiseptic and antiviral agents based on these plants, which could minimize the side effects of synthetic therapy and expand the arsenal of tools for combating drug-resistant infections.

## MICROBIOLOGICAL AND ANTIOXIDANT PROPERTIES OF PLANTS OF THE GENUS *ALLIUM* L., GROWING IN TAJIKISTAN

**Fazila Mirzoeva, Vakhidova Manija**

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Position:</b> Head of the Department</p> <p><b>Affiliation:</b> Department of Microbiology, Virology and Immunology NEI «Medical-Social Institute of Tajikistan»</p>

**Purpose:** To study the microbiological activity of some widely identified and endemic species of the genus *Allium* L., growing in Tajikistan.

**Materials and Methods:** The object of the study were 13 widely identified species of *Allium* L.: *A. carolinianum* DC., *A. suworowii* Regel, *A. hymenorhizum* Ledeb, *A. elatum* Regel,

*A. ramosum* L., *A. altaicum* Pall., *A. oschaninii* O. Fedtsch., *A. schoenoprasum* L., *A. obliquum* L., *A. sativum* L., *A. longicuspis* Regel, *A. nutans* L., *A. senescens* L. and 2 endemic species of *A. schugnanicum* Vved. and *A. pamiricum* Wendelbo. Antibacterial activity was studied against 4 types of standard (reference) microorganisms (test strains): *S.aureus* (ATCC 4929), *E.coli* (ATCC 4928), *Ps.aeruginosa* (ATCC 4930) and *Kl.pneumoniae* (ATCC 4927). Antifungal activity was studied against *Candida albicans* using Sabouraud's medium. The study of antibacterial and fungicidal properties was carried out by the disk diffusion method (DDM) in solid agar. The content of polyphenols was studied by the Folin-Ciocalteu method, the core of which is the interaction of the Folin-Ciocalteu reagents with any present polyphenols. The presence of polyphenol is measured as  $\mu\text{g}$  of gallic acid (GA) per 1 ml of plant extract. To determine the antioxidant activity of AOA, photometric method was used, analysis of the bleaching of ABTS. ABTS [2, 2 Azino-bis (3-ethylbenzo-thiazoline-6-sulfonic acid)].

The experimental part was studied on inbred mice infected with an aerosol virulent strain of *Mycobacterium tuberculosis* (*Mtb*) - H37Rv. Infection was carried out on a Glas-Col transport (USA) at a dose of 100 CFU/lung. In the work 80 females were used.

**Results:** The maximum values of antistaphylococcal activity were shown by *A. oschaninii* O. Fedtsch., *A. altaicum* Pall. and *A. sativum* L. Regarding the strain *Ps. aureginosa* extracts of onion seeds showed average values of antibacterial activity. The bulb extracts of the endemic onion *A. schugnanicum* Vved. had the highest antimicrobial activity compared to other species, including another endemic *A. pamiricum* Wendelbo. Of the species of the genus *Allium* L. included in the study, only extracts from 7 plants showed antimicrobial effect against the *E. coli* strain. At the same time, only extracts from seeds and bulbs of *A. oschaninii* O. Fedtsch had a high degree of bactericidal activity. The remaining 6 species demonstrated minimal antibacterial effect.

The level of antifungal activity of seeds and bulb's extracts of *A. oschaninii* O. Fedtsch, as well as extracts from *A. obliquum* L., surpass the effectiveness of other onions. Species *A. shugnanicum* Vved. had a pronounced antifungal effect than *A. pamiricum* Wendelbo.


Our results showed that the highest content of highly dispersed polyphenols contain seeds of plant species *A. carolinianum* DC., *A. altaicum* Pall., *A. elatum* Regel, *A. oschaninii* O. Fedtsch., *A. senescens* L., *A. sativum* L., and *A. obliquum* L., *A. altaicum* Pall., *A. hymenorhisum* Ledeb., *A. schoenoprasum* L. and *A. ramosum* L. had the highest antioxidant effect. Bulb of the endemic species *A. shugnanicum* Vved. showed the lowest antioxidant activity, which is statistically significantly less than that of another endemic species *A. pamiricum* Wendelbo.

**Conclusion:** This study revealed significant variability in the antimicrobial, antioxidant, and chemical properties among various *Allium* species, including endemic forms.

# PHARMACOGNOSTIC AND MICROBIOLOGICAL STUDY OF THREE SPECIES OF FERULA NATIVE TO TAJIKISTAN

Sulhiya Mavlonazarova, Saidbeg Satorov

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Position:</b> Assistant of Department</p> <p><b>Affiliation:</b> Department of Microbiology, Virology and Immunology, NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** To study the pharmacognostic characteristics of 3 species of the genus *Ferula* L.: *Ferula violacea*, *Ferula gigantea* and *Ferula kuhistanica*, native to the Republic of Tajikistan.

**Materials and Methods:** Microscopic examination of the roots of the ferula species included for the study was carried out according to the generally accepted method of microstructural analysis. Liquid chromatography with mass spectrometry, ultra-high-performance liquid chromatography, and nuclear magnetic resonance spectroscopy were used for conducting metabolic studies and phytochemical analyses. The specific viral inhibitory activity of the studied materials was determined in accordance with the guidelines of the "Guidelines for conducting preclinical studies of medicines". The antimicrobial activity of the plant extracts was determined by the disco diffusion method.


**Results:** Microscopic examination of the structure of the roots of *F. violacea*, *F. kuhistanica* and *F. gigantea* was carried out. The diversity of the metabolomic profile of *F. violacea* roots and seeds as previously unexplored species and the main object of research is shown. The specificity of the metabolomic profile of the study samples has been demonstrated, depending on the method of their preparation. Data on the phytochemical characteristics of the roots and seeds of *F. violacea*, *F. kuhistanica* and *F. gigantea* have been obtained; information on the content of common polyphenols in the roots and seeds of *Ferula* L. species included in the study; scientific information on the antioxidant potential of roots and seeds; the virus-inhibitory activity of gums, pomace and extracts obtained from seeds and roots of plants of the genus *Ferula* L. has been established; data on the antibacterial and antifungal properties of samples obtained from seeds and roots the three types of ferula included in the work.

**Conclusion:** The comprehensive study of the genus *Ferula* L. has established reliable criteria for raw material authentication and revealed significant antibacterial and antiviral potential. These findings provide a solid foundation for pharmaceutical innovation and offer valuable practical material for medical and pharmaceutical education.

## CLASSIFICATION AND MORPHO-BIOLOGICAL CHARACTERISTICS OF PLANTS OF THE GENUS PYRUS

**Parviz Turazoda, Satorov Shuhrat**

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Position:</b> Assistant</p> <p><b>Affiliation:</b> Department of Microbiology, Virology and Immunology NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** Analysis of scientific literature devoted to the classification and morpho-biological characteristics of plants of *Pyrus* genus.

**Materials and Methods:** Systematization of existing approaches to classification and morpho-biological characteristics plants of *Pyrus* genus.

**Results:** The classification of the genus *Pyrus* is considered one of the most complex in botany due to the lack of clear reproductive barriers between species and the frequent occurrence of natural hybrids. The genus *Pyrus* comprises deciduous trees and shrubs belonging to the rose family (*Rosaceae*). The genus is traditionally divided into two major geographic groups: West Eurasian species - characterized by large fruits, deciduous sepals, and high frost resistance (e.g., *P. communis* and East Asian species - distinguished by small fruits, persistent sepals, and varied leaf shapes (e.g., *P. pyrifolia*, *P. ussuriensis*). Currently, 70 to 80 species are recognized, but molecular genetic studies in recent years (analysis of chloroplast DNA and SSR markers) are making adjustments to the phylogeny, combining some species into complexes.

Morpho-biological Characteristics. Habit: Deciduous trees (rarely shrubs) up to 15–20 meters tall. The crown varies from pyramidal to weeping. Root System: Vigorous, taproot system, penetrating to a depth of 5–8 meters, providing drought resistance. Leaves: Alternate,

simple, petiolate. Blade shape ranges from broadly ovate to lanceolate. Leaf margins can be entire, serrate, or crenate.

Reproductive organs. Inflorescence: Corymbose raceme. Flowering occurs simultaneously with leaf unfolding or slightly earlier. Flowers: Five-membered, usually white (rarely pinkish). A characteristic feature is the purple or violet color of the anthers. Fruit: An "apple" of pear-shaped, round, or flattened shape. The most important diagnostic feature is the presence or absence of stone cells (sclereids) in the pulp. Wild *Pyrus* species are an indispensable reservoir of disease resistance genes, such as fire blight (*Erwinia amylovora*) and scab (*Venturia pyrina*). Using wild relatives in interspecific hybridization allows for the creation of rootstocks tolerant of salinity and adverse soil conditions.

**Conclusion:** the genus *Pyrus* is a complex, dynamic system with a high level of genetic plasticity. Despite centuries of study, questions of species delineation and introgressive hybridization remain relevant. A thorough understanding of the morpho-biological characteristics of wild species is key to ensuring the sustainability of agroecosystems in a changing climate.


## CURRENT ISSUES AND PROSPECTS FOR SUSTAINABLE DEVELOPMENT OF ESSENTIAL OIL ROSE GROWING IN TAJIKISTAN

**S.Kh. Nazarmamadova, K. Tynaliev, A.A. Mamadrizokhonov**

NEI Medical and Social Institute of Tajikistan, Dushanbe, Tajikistan

Institute of Biology, National Academy of Sciences of the Kyrgyz Republic, Kyrgyzstan

Khorog State University named after M. Nazarshoev, Khorog, Tajikistan

SPEAKER PROFILE	
	<p><b>Position:</b> Assistant</p> <p><b>Affiliation:</b> Department of Microbiology, Virology and Immunology NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** In recent decades, essential oil rose cultivation, particularly the *Rosa damascena* Mill. variety, has gained significant importance for Tajikistan's agricultural economy. The country's climatic and soil conditions — marked continental climate, high insolation, and moderate humidity — create unique opportunities for successful damask rose cultivation.

However, they also pose a number of challenges that require a scientific approach to maintaining and increasing plant productivity.

**Materials and Methods:** The quality of planting material is the primary factor determining the productivity of rose plantations. Vegetative propagation, particularly green cuttings, plays a key role in creating highly productive and resilient plants. This method is particularly relevant in the Republic of Tajikistan, as it allows for the production of plants adapted to local climatic conditions, with high survival rates and resistance to biotic and abiotic stress.

The need for an integrated protection system, including agronomic, biological, and chemical measures, is clear. The use of biological control agents, such as entomophages, trichograms, and natural fungicides, can significantly reduce the chemical load on the ecosystem, promoting more sustainable and environmentally friendly rose production. Agronomic measures such as sanitary pruning, mulching, and soil moisture regulation are becoming an important component of phytosanitary control.

One of the main challenges faced by rose growers is the high susceptibility of roses to phytopathogenic microorganisms and pests, which can significantly reduce the yield and quality of essential oils. In the Republic of Tajikistan, where the climate favors active pest development, effective disease diagnosis and regular monitoring of phytophagous populations are becoming important tools for minimizing damage.

**Research:** however, successful rooting of cuttings requires an integrated approach, including optimizing the timing of cuttings, selecting a substrate with the required physicochemical properties, and creating a stable microclimate. Research has shown that using heteroauxin in combination with a peat substrate yields the best results in rooting and root system development, confirming the importance of growth stimulants during propagation.

Rational use of agricultural practices significantly contributes to increased plant productivity and resilience. The most important agricultural practices include pruning, watering, mulching, and microclimate regulation. For effective rose growth and development, it is important to maintain optimal conditions: an air temperature of 18–25°C, humidity of 40–60%, and diffused lighting that excludes direct sunlight.

Furthermore, it is important to use loose, breathable, and nutritious substrates, such as mixtures of peat, sand, and perlite. These substrates promote optimal water and air circulation and oxygen supply to the root system, which positively affects the rooting and growth of cuttings. To expand industrial rose production in the Republic of Tajikistan, it is necessary to breed resilient, high-oil-yielding rose varieties that can effectively adapt to changing environmental conditions and resist phytopathogens and pests. Developing new varieties with

increased stress tolerance, as well as improving the quality of essential oils through improved plant genetics, are becoming important tasks for the sustainable development of the industry.


To ensure stable and efficient production of essential oil, as well as other processed products such as rose water and hydrosols, it is necessary to introduce advanced plant care technologies and improve propagation methods. The development of new agricultural technologies and the improvement of existing practices contribute to improved ecosystem health and higher product quality.

**Conclusion:** The development of essential oil rose production in the Republic of Tajikistan represents significant environmental and economic potential for the region. The introduction of environmentally friendly plant protection methods and effective agricultural technologies not only improves the quality of rose products, but also enhances the quality of the products.

## **COMPREHENSIVE TREATMENT OF PURULENT-INFLAMMATORY DISEASES OF THE SOFT TISSUES OF THE MAXILLOFACIAL REGION USING THE CREAM-BALM “MACROGUMIN”**

**Jamshedova S.J., Kurbonova G.Kh., Jamshedov J.N.**

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Assistant of Department</p> <p><b>Affiliation:</b> Department of Therapeutic Dentistry, Non-State Educational Institution “Medical-Social Institute of Tajikistan”</p>

**Purpose:** To study the comprehensive treatment of purulent-inflammatory diseases of the soft tissues of the maxillofacial region using the cream- balm “Macrogumin”.

**Materials and Methods:** At the Clinic of Maxillofacial Surgery of the Non-State Educational Institution “Medical-Social Institute of Tajikistan,” a new domestic preparation, the cream-balm “Macrogumin,” has been used in the treatment of purulent-inflammatory processes. The preparation is developed from a complex of environmentally friendly medicinal plants growing in the Pamir region. The drug exhibits analgesic, anti-inflammatory, and wound-healing properties, as well as antibacterial and antifungal activity. This broad spectrum of action allows its use at any stage of the wound process.

The cream-balm was developed at the Department of Pharmaceutical Technology, Pharmacognosy, Organization and Economics of Pharmacy, Pharmacology and Clinical Pharmacology, Pharmaceutical Service and Pharmaceutical Information. It has undergone full preclinical testing at the Pharmacology Laboratory of the State Institution “Scientific Research Center of the Ministry of Health and Social Protection of the Republic of Tajikistan” and demonstrated excellent results in clinical trials.

The present study is based on the observation and treatment of 50 patients with purulent-inflammatory processes of the maxillofacial region. All patients were divided into two groups: a control group (25 patients), in which Levomekol and furacilin were used for local treatment of purulent wounds, and a main group (25 patients), in which the cream-balm “Macrogumin” was applied. Patients in both groups had comparable diagnoses. After incision of the phlegmon and evacuation of purulent exudate, the wound was drained using perforated thin tubes. On the first day, these were replaced in the control group with tampons containing Levomekol or furacilin, and in the main group with the cream-balm “Macrogumin”.

The main clinical indicators, as well as the qualitative and quantitative composition of the microflora of purulent wounds, were studied. During treatment, the dynamics of these parameters were monitored depending on the treatment method and the type of inflammatory response (hypoergic, normergic, hyperergic).

**Results:** Analysis of the main clinical indicators shows that in the normergic type of inflammation, the cream-balm “Macrogumin” promotes faster cleansing of purulent wounds compared to Levomekol and furacilin. Thus, purulent discharge in patients of the main group disappeared on average by days 3–4, whereas in the control group it persisted until days 5–6, i.e., 2 days longer. The inflammatory infiltrate softened and became non-palpable by days 6–7 when using “Macrogumin,” compared to days 10–11 when using Levomekol and furacilin, i.e., 3–4 days earlier. Faster wound cleansing and earlier appearance of granulation tissue allowed earlier application of secondary sutures: on days 3–4 in the main group versus days 7–8 in the control group, i.e., 4–5 days earlier.

In the hypoergic type of inflammation, the greatest difference between clinical indicators was observed. In the main group, purulent exudation ceased on average 5–6 days earlier than in the control group, infiltration resolved 6–7 days earlier, and granulation tissue appeared 3–4 days earlier. This made it possible to apply secondary sutures as early as days 5–6, whereas in the control group granulation appeared only on days 9–10, sutures were applied on days 11–12, and resolution of inflammatory infiltration occurred by days 14–15.

In the hyperergic type of inflammation, the use of the cream-balm “Macrogumin” as part of the comprehensive treatment of purulent-inflammatory processes of the maxillofacial region

also contributed to faster patient recovery. The duration of purulent exudation in the control group averaged 8–9 days, whereas in the main group it was only 5–6 days, i.e., 3–4 days shorter. Granulation tissue appeared by days 4–5, allowing secondary sutures to be applied by days 5–6 in the main group. In contrast, when using Levomekol and furacilin, this became possible only by days 9–10, i.e., 4–5 days later.

**Conclusion:** Thus, the cream-balm “Macrogumin” demonstrates a more pronounced effect on purulent wounds compared to Levomekol and furacilin, and accelerates wound healing to a greater extent. This effect is particularly evident in the hypoergic type of inflammation. The use of the preparation promotes rapid cleansing of the purulent focus and stimulates reparative processes at earlier stages. The cream-balm “Macrogumin” possesses a broad spectrum of antimicrobial activity and is effective against all major pathogens of maxillofacial infections. It can therefore be considered an important component of comprehensive therapy for purulent-inflammatory processes of the maxillofacial region. The preparation is convenient to use and may be recommended for widespread clinical application.

## SUSTAINABLE EXPLOITATION OF *FERULA TADSHIKORUM* USING A GENTLE RESIN HARVESTING METHOD

**Imomiyon Ravshan**

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

<b>SPEAKER PROFILE</b>	
	<p><b>Position:</b> Academic Secretary /Assistant</p> <p><b>Affiliation:</b> State Institution "Research Pharmaceutical Center", Ministry of Health and Social Protection of the Population of the Republic of Tajikistan / Department of Pharmaceutical Technology, Pharmacognosy and Economics, NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** To develop and substantiate a non-destructive method of resin harvesting from *Ferula tadshikorum* that preserves plant viability and enables long-term use of natural populations.

**Materials and Methods:** The study was conducted on mature (generative) plants of *Ferula tadshikorum*. The traditional method of caudex (root crown) tapping, involving periodic cutting of the upper part of the root during the growing season, was investigated. The effect of

different cutting techniques on subsequent resin yield and plant survival was evaluated. The key element of the proposed method was the preservation of the single apical bud during each cut. After the harvesting season, the exposed caudex was covered with excavated soil to protect it from winter frost.

**Results:** It was shown that traditional aggressive resin harvesting involving damage to the apical bud leads to plant death, as the plant loses its ability to regenerate and continue growth. The non-destructive method, in which the cut is made without damaging the single growth point, allows the plant to mobilize resin stored in the roots to protect the bud from overheating and desiccation. After each cut, the wound surface is naturally sealed by solidifying resin. Covering the caudex with soil during winter improves plant survival, allowing the same individual to be used for resin harvesting over several years. Preservation of the apical bud ensures the resumption of physiological activity in the following growing season.


**Conclusion:** The proposed non-destructive method of resin harvesting from *Ferula tadshikorum*, based on preservation of the apical bud and winter covering of the caudex, is biologically justified. This method prevents plant mortality after harvesting, enables repeated use of the same individual, and contributes to the conservation of natural populations. Its implementation is critically important to prevent the degradation and potential extinction of *Ferula tadshikorum* under conditions of intensive harvesting.

## CHEMICAL COMPOSITION OF *PISTACIA VERA* L. GALLS COLLECTED IN TAJIKISTAN

**Sh. Sultonov<sup>1</sup>, Joshua M. Henkin<sup>2</sup>, Kenneth Acosta<sup>2</sup>, Antonia Kaz<sup>2</sup>**

<sup>1</sup> Scientific-Research Pharmaceutical Center under the Ministry of Health and Social Protection of the Population of the Republic of Tajikistan, Dushanbe, Tajikistan

<sup>2</sup> Department of Plant Biology, Rutgers, The State University of New Jersey, New Brunswick, USA

<b>SPEAKER PROFILE</b>	
	<p><b>Sh. Sultonov</b></p> <p><b>Position:</b> Ph.D. student</p> <p><b>Affiliation:</b> The Scientific-Research Pharmaceutical Center under the Ministry of Health and Social Protection of the Population of the Republic of Tajikistan</p>

**Purpose:** The purpose of the study was to study the phytochemical properties of pistachio galls collected in the Dangara district of the Republic of Tajikistan.

**Materials and Methods:** In 2025, two expeditions, one each in the spring and the summer months, were undertaken within the Danghara District, Tajikistan to collect *Pistacia vera* leaf, gall, resin, and fruit samples from wild populations of trees, especially to focus on comparing immature and mature gall stages of one type of abaxial midvein gall (*Geoica utricularia*), one type of leaf margin gall (*Forda riccobonii*), and the unaltered leaf tissues themselves. Fresh plant materials were forced air oven dried and placed in long-term storage in a freezer (-20 °C) before further preparation. Extracts for materials analyzed were from 7:3 ethanol/water macerations (200 mg in 5 mL). HPLC was used to study the chemical composition of the galls in the collection.

**Results:** For fingerprinting, 10 µL bands of 10 mg/mL extracts (reconstituted in methanol) were applied to silica-backed Merck plates and visualized under 254 nm (not depicted), 366 nm, and white light. Development utilized butyl acetate/methanol/formic acid/water (7.5:2:1:1), with the exception of the tracks in Figure 3B and 3C. NP reagent is 2-aminoethoxydiphenylborate. DPPH results required a five-fold reduction from initial application volume.

Visualization at 366 nm illumination using the NP reagent showed red, blue, yellow, and green bands. Red bands indicate porphyrins, including chlorophylls; Blue bands (NP reagent) include gallotannins (hydrolyzable tannins) and other phenolic acids; Yellow bands (NP reagent) typically represent quercetin-type flavonoids; Green bands (NP reagent) typically represent kaempferol-type flavonoids.

**Conclusion:** The main chemical components of galls collected from the leaves of *Pistacia vera* L. are porphyrins, including chlorophylls, gallotannins (hydrolyzable tannins), flavonoids such as quercetin and kaempferol.

## DETERMINING THE PROFILE OF FLAVONOIDS WITH HYPOGLYCEMIC EFFECT IN *CUCUMIS TRIGONUS* PULP

Mehroba Salomudin

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Position:</b></p> <p><b>Affiliation:</b> NEI Medical-Social Institute of Tajikistan</p>

**Purpose:** To investigate the flavonoid composition of an extract obtained from *Cucumis trigonus* pulp, which exhibits hypoglycemic activity.

**Materials and Methods:** The pulp of the wild melon *Cucumis trigonus* was used for the study. Phytochemical characterization of the samples was performed using liquid chromatography–mass spectrometry (LC-MS).

For extract preparation, 10 mg of the dry extract was dissolved in 1 mL of 70% methanol (MeOH) containing 0.1% formic acid (HCOOH). The solutions were sonicated in a Sonicator VCX-130 ultrasonic bath (Branson, USA) and centrifuged using an Eppendorf 5430R centrifuge (Germany). The resulting supernatant was filtered through Millex-GV membrane filters (Merck Millipore, USA) with a pore size of 0.22  $\mu\text{m}$ .

**Results:** Hypoglycemic flavonoids (quercetin, kaempferol, catechins) increase cellular sensitivity to insulin and reduce oxidative stress. They are commonly found in blueberries, citrus fruits, leafy greens, green tea, and buckwheat, supporting the complex treatment of type 2 diabetes. Prior to this study, no information was available on their content in wild melon (*Cucumis trigonus*).

LC-MS analysis identified three types of flavonol glycosides in *Cucumis trigonus* pulp: derivatives of quercetin, kaempferol, and one of the most active catechins, (-)-epigallocatechin gallate (EGCG). The extract predominantly contained quercetin 3-methyl ester ( $\Delta m/z = 3.492$ ), kaempferol 4'-rhamnoside ( $\Delta m/z = 1.501$ ), and (-)-epigallocatechin gallate ( $\Delta m/z = 0.242$ ).

**Conclusion:** *Cucumis trigonus* pulp contains flavonoids with hypoglycemic properties. Nine individual flavonol glycosides — derivatives of quercetin, kaempferol, and catechin — were identified. These findings can be used for standardization of hypoglycemic preparations and assessment of their pharmacological activity.

## STUDY OF THE STRUCTURE AND PROPERTIES OF BIOPOLYMERS FROM

### *EREMURUS HISSARICUS*

**Bobokalonov J.T., Hasanov G., Usmanova S. Muhiddin Z.K.**

Institute of Chemistry named after V.I. Nikitin NAST, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Bobokalonov J.T</b></p> <p><b>Position:</b></p> <p><b>Affiliation:</b> Institute of Chemistry named after V.I. Nikitin</p>

**Purpose:** To investigate the structure and physicochemical properties of biopolymers isolated from *Eremurus hissaricus*, with particular emphasis on the relationship between their structural features and functional characteristics.

**Materials and Methods:** Plant-derived biopolymers were extracted and purified using optimized fractionation techniques. Polysaccharides and proteins were isolated through sequential extraction and purification procedures to ensure high purity for structural analysis. The monosaccharide composition of polysaccharides was determined by high-performance anion-exchange chromatography with pulsed amperometric detection (HPAEC-PAD). Molecular weight and molecular weight distribution were analyzed using high-performance size-exclusion chromatography (HPSEC). Structural characterization was carried out using modern physicochemical methods, including Fourier-transform infrared (FTIR) spectroscopy and nuclear magnetic resonance (NMR) spectroscopy. The approaches were based on contemporary concepts of polymer chemistry, bioorganic chemistry, molecular biology, and biophysics.


**Results:** The study demonstrated that the structural characteristics of biopolymers—such as molecular weight, monosaccharide composition, and the presence of functional groups—strongly influence their physicochemical and potential biological properties. It was established that extraction and purification methods significantly affect the integrity and functional behavior of the isolated biopolymers. Advanced analytical techniques enabled the identification of key structural features, including primary and spatial organization of polysaccharides. The data obtained highlight the complexity of plant-derived biopolymers and underscore the importance of combining chromatographic and spectroscopic methods for their comprehensive characterization.

**Conclusion:** The study confirms that *Eremurus hissaricus* is a valuable source of structurally diverse polysaccharides, particularly glucomannan and galactoglucomannan. The identified structural features are essential for understanding their functional properties and potential applications in pharmaceutical, food, and other industrial fields.

## COMPARATIVE ANALYSIS OF THE CHEMICAL COMPOSITION OF ZIZIPHORA ESSENTIAL OIL USING GC–MS

**Hasanov Ghairat, Bobokalonov Jamshed**

Institute of Chemistry named after V.I. Nikitin NAST, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Hasanov Ghairat</b></p> <p><b>Position:</b> Research scientist</p> <p><b>Affiliation:</b> Laboratory of macromolecular and biologically active compounds</p>

**Purpose:** Essential oil of *Ziziphora clinopodioides* was analyzed using two GC–MS systems equipped with polar (RTX-WAX) and nonpolar (RTX-5MS) capillary columns. The study compared component composition, retention times, and relative abundance of detected compounds. Results confirmed that column polarity strongly affects chromatographic separation and identification efficiency.

**Materials and Methods:** The first analysis was carried out on a Shimadzu QP2010 Ultra with RTX-WAX column (30 m × 0.25 mm, 0.32 μm). Helium was used as carrier gas at 2.0 mL/min. Injection volume was 1 μL, split ratio 1:10. Oven temperature increased from 30°C to 240°C. The second analysis used a Varian GC 3800 – Saturn 2002 MS/MS with RTX-5MS column (30 m × 0.25 mm, 0.25 μm). Similar split injection and helium carrier gas were applied. Compound identification was based on comparison with NIST library spectra.

**Results:** Using the polar RTX-WAX column, 57 compounds were identified. Major components were pulegone (31.55%) and menthone derivatives (16.19%). Oxygenated compounds such as thymol, carvacrol, menthol, and verbenone were separated effectively. Using the nonpolar RTX-5MS column, 25 compounds were detected. Pulegone (46.88%) and L-menthone (43.19%) dominated the profile. Peaks were sharper and major nonpolar constituents were detected with higher sensitivity. Retention times differed significantly between systems. For example, pulegone eluted later on the polar column because of stronger interaction with the

stationary phase. Polar analysis also revealed  $\alpha$ -pinene,  $\alpha$ -thujene, verbenone, and isoborneol, while the nonpolar system detected compounds such as germacrene D and exo-isocamphanone.

**Conclusion:** Both GC–MS methods are complementary. The polar column is more suitable for oxygen-containing and polar compounds, whereas the nonpolar column is more efficient for dominant nonpolar constituents such as pulegone and menthone. Combined use of both systems provides a more complete chemical profile of *Ziziphora* essential oil and improves quality control of plant extracts.

## STUDY OF MEDICINAL PLANTS GROWING WITHIN THE KHORONGON RIVER GORGE

**M.N. Nazarov, N.S., Boroniyev, J.N.Jamshedov, Yo.K.Kalandarzoda,**

Avicenna Tajik State Medical University, Dushanbe, Tajikistan

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>M.N. Nazarov</b></p> <p><b>Position:</b> Senior Lecturer</p> <p><b>Affiliation:</b> Department of Pharmacognosy and OEF, Educational, Scientific and Production Center “Pharmacy,” Avicenna Tajik State Medical University</p>

**Purpose:** The objective of this study is to identify potential medicinal plant species of the Khorongon River gorge that possess pharmacognostic and pharmacological value, with the aim of their further introduction into pharmaceutical production and the development of effective biologically active supplements.

**Materials and Methods:** The research was conducted within the framework of the scientific projects “Resources of the Rivers of the Khorongon Gorge” and “Plant Raw Materials of the Khorongon River Gorge,” implemented jointly by the Educational, Scientific and Production Center “Pharmacy” and Avicenna Tajik State Medical University on a state-funded basis.

From January to October 2025, the following activities were carried out:

- Seasonal field observations of ferns and other representatives of Archegoniata within the phytocenoses of the gorge

- Collection and analysis of information on the traditional use of plants by the local population
- Species identification using the reference works “Flora of the USSR” (1934) and “Flora of the Tajik SSR” (1957)
- Ecological and biomorphological analysis of herbarium specimens, taking into account bio-ecomorphological, ecological-biophysiological, and geobotanical characteristics (according to Nazarov’s methodology, 1989)
- Pharmacognostic characterization of medicinal plant raw materials
- Resource assessment and analysis of possibilities for introduction and cultivation of valuable species

**Results:** The ecological and biomorphological analysis showed that the predominant life forms are perennial herbaceous plants (over 60%), which is due to the continental climatic conditions of the region.

A significant presence of xerophytic and mesoxerophytic species adapted to arid conditions and sharp seasonal temperature fluctuations was also observed. Special attention was given to species with a high content of biologically active compounds. Phytochemical screening revealed the presence of:

- Flavonoids (in Lamiaceae and Asteraceae)
- Saponins (notably in *Tribulus terrestris*)
- Tannins (in species of the genus *Rosa*)
- Essential oils (in various representatives of *Lamiaceae*)
- Ascorbic acid (in wild-growing *Rosa* species)

Quantitative analysis showed that the ascorbic acid content in the fruits of certain *Rosa* forms reaches 800–1200 mg%, significantly exceeding that of cultivated varieties. This indicates a high breeding potential of local populations.

Resource assessment demonstrated that approximately 25 species can be classified as commercially significant. Among them are species with stable populations and high biomass productivity, including *Tribulus terrestris*, representatives of the genus *Rosa*, and several species from the *Lamiaceae* family.

Raw material reserves were assessed using route surveys and sample plots, which made it possible to determine potential harvesting volumes without harming natural populations.

It was established that *Tribulus terrestris* is characterized by:

- High ecological plasticity
- Drought resistance

- The ability to form significant raw material reserves even under extreme conditions

Pharmacognostic analysis confirmed the presence of steroidal saponins (protodioscin) with pronounced biological activity. Based on these findings, technological approaches were developed for processing raw materials and creating biologically active supplements with adaptogenic and general tonic effects.

An important outcome of the study was the development of principles for the introduction and cultivation of potential species. It was found that a number of wild plants successfully adapt to agricultural conditions with minimal agrotechnical input.

Experimental plots demonstrated that cultivation can increase raw material yield by 30–50% compared to natural populations.

Within breeding work on the genus *Rosa*, morphologically and biochemically valuable forms were identified, characterized by:

- High drought resistance
- Disease resistance
- Adaptation to unfavorable soil conditions

The proposed hybridization approach aims to combine high vitamin content with adaptive traits, which is particularly important for mountainous regions of Tajikistan. Preliminary hybridization results indicate the possibility of obtaining potential varieties with improved economically valuable characteristics.

Additionally, an analysis of traditional plant use by the local population identified more than 70 species used in folk medicine. This made it possible to compare ethnobotanical data with scientific findings and identify the most promising objects for further study.

Overall, the results confirm the high potential of the flora of the Khorongon River gorge as a source of medicinal plant raw materials. The obtained data provide a scientific basis for further pharmacological research, the development of new medicines and biologically active supplements, and the implementation of rational methods for using the region's natural resources.

**Conclusion:** the flora of the Khorongon River gorge is characterized by high biodiversity and includes more than 400 species of vascular plants, a significant portion of which possess medicinal potential.

Comprehensive botanical, pharmacognostic, and pharmacological studies have confirmed the (promise) of the region as a source of medicinal plant raw materials and have enabled the development of scientifically grounded approaches to:

- Introduction

- Cultivation
- Creation of new biologically active supplements based on *Tribulus terrestris*

The development of an identification guide for species of the genus *Rosa* and the integration of research results into the educational process create a solid scientific foundation for further research and the training of specialists in the field of pharmacy.

## **DEVELOPMENT OF THE FORMULATION AND TECHNOLOGY OF DIETARY SUPPLEMENT CAPSULES BASED ON ZERAVSHAN THYME HERB**

**U.A. Majidova, B.M. Kholnazarov, J.N. Jamshedov**

Avicenna Tajik State Medical University, Dushanbe, Tajikistan

NEI Medical-Social Institute of Tajikistan, Dushanbe, Tajikistan

<b>SPEAKER PROFILE</b>	
	<p><b>U.A. Majidova</b></p> <p><b>Position:</b> Assistant of Department</p> <p><b>Affiliation:</b> Department of Pharmacognosy and OEF, Avicenna Tajik State Medical University</p>

**Purpose:** Medicinal plants of the genus *Thymus* are widely recognized for their antimicrobial, antioxidant, and anti-inflammatory properties, primarily attributed to their phenolic constituents. However, *Thymus seravschanicus*, endemic to Central Asia, remains insufficiently studied in terms of pharmaceutical formulation and industrial applicability. This study aims to develop a scientifically substantiated formulation and manufacturing process for capsules containing dry extract of *T. seravschanicus*, with emphasis on technological optimization and pharmacopoeial compliance.

**Materials and Methods:** Aerial parts of *Thymus seravschanicus* were collected during the full flowering stage (July 2025) in the Varzob district (Tajikistan), corresponding to the period of maximum accumulation of biologically active compounds.

Quantitative analysis showed a total phenolic content of 3.48%, including: hydroxycinnamic acids ( $1.38 \pm 0.03\%$ ), flavonoids ( $0.74 \pm 0.03\%$ ), and polyphenols ( $1.42 \pm 0.05\%$ ).

A rapid extraction technique was employed using a solvent system consisting of 30% ethanol and 10% glycerin (relative to raw material mass) at a 1:1 ratio. Extraction was performed under reduced pressure via filtration for 15 minutes, ensuring efficient compound recovery while limiting extraction of undesired components.

The extract was concentrated using a rotary evaporator at 50–60°C under reduced pressure (0.15 atm), followed by vacuum drying to a residual moisture content below 5%. The dried extract was milled and sieved (0.25 mm). Yield:  $13.64 \pm 0.10\%$ .

Hard gelatin capsules (size No. 1) were selected based on preliminary dosage form screening. The formulation was optimized using: lactose (filler and flow enhancer), microcrystalline cellulose (MCC) (binder and structure-forming agent).

**Results:** The dry extract was obtained as an amorphous dark green powder with a characteristic aromatic profile. The extraction method demonstrated efficiency in reducing processing time while maintaining phytochemical integrity. The high proportion of active extract required the inclusion of MCC to improve granule strength and flowability. Optimal technological performance was achieved with 5–10% MCC. Lactose contributed to uniform filling and improved dissolution behavior.

The optimized composition of the capsule formulation was defined as follows:

- Dry extract: 75.0 mg
- Lactose: 55.2 mg
- MCC: 9.8 mg
- Total weight: 140 mg

The formulation exhibited satisfactory flowability, uniform mass distribution, and compliance with pharmacopoeial disintegration requirements.

Accelerated stability studies conducted at 60°C demonstrated that the capsules retained their quality attributes over 46 days, corresponding to an estimated shelf life of 2 years based on pharmacopoeial stability extrapolation guidelines. A draft pharmacopoeial specification for the developed capsules was subsequently established.


**Conclusion:** A reproducible formulation and manufacturing technology for capsules containing dry extract of *Thymus seravschanicus* has been developed. The proposed system ensures adequate technological performance, stability, and compliance with pharmacopoeial standards.

The results support the feasibility of industrial-scale production of a novel plant-based dietary supplement derived from regional raw materials.

# PLANT ALKALOIDS AS PROMISING LEADS IN MODERN DRUG DISCOVERY: A LITERATURE REVIEW

Shomirzoeva O.I., Rajabova U.A., Majidova U.A

Avicenna Tajik State Medical University, Dushanbe, Tajikistan

SPEAKER PROFILE	
	<p><b>Shomirzoeva O.I.</b></p> <p><b>Position:</b> Head of the Department</p> <p><b>Affiliation</b> Department of Pharmacognosy and Organization of Pharmacy Economics, SEI "Avicenna Tajik State Medical University ". Dushanbe, Tajikistan.</p>

**Purpose:** Natural products have long served as a major source of therapeutic agents. Among them, alkaloids represent one of the most structurally diverse and pharmacologically active classes of natural compounds. Alkaloids are nitrogen-containing secondary metabolites predominantly found in plants, although they may also occur in microorganisms and marine organisms. Many clinically important drugs have been derived from alkaloids due to their broad spectrum of biological activities. This literature review aims to summarize the chemical characteristics, natural sources, and pharmacological significance of alkaloids, highlighting their contribution to modern drug discovery.

**Materials and Methods:** This study is based on a comprehensive review of scientific literature, including peer-reviewed journal articles, books, and authoritative databases related to natural product chemistry, pharmacognosy, and drug discovery. Relevant sources were analyzed to evaluate the chemical diversity, biological activity, and therapeutic applications of plant-derived alkaloids.

**Result:** Despite a history of use spanning more than 4000 years, alkaloids and alkaloid-containing taxa are still not fully utilized in modern drug development. Natural product chemistry continues to play a crucial role in the discovery of new pharmaceuticals, with alkaloids attracting particular attention due to their structural complexity and potent biological activities. Alkaloids are typically basic organic compounds containing one or more nitrogen atoms within heterocyclic rings. They are produced as secondary metabolites and often function as defense or regulatory molecules in living organisms. Their chemical diversity translates into a wide range of pharmacological effects. The analysis highlights the dualistic nature of alkaloids as both therapeutic agents and toxic compounds, reinforcing their importance in drug discovery.

Compounds such as morphine, quinine, and vincristine have well-established clinical applications, while others exhibit strong neurotoxic or psychoactive effects. This duality emphasizes the importance of dosage, molecular targeting, and pharmacological context. Furthermore, alkaloids remain a critical resource for addressing global health challenges, including antimicrobial resistance, neglected tropical diseases, and rare disorders. However, a significant gap persists between global disease burden and current drug discovery priorities, limiting the development and accessibility of alkaloid-based therapies. The emergence of technologies associated with the Fourth Industrial Revolution (4IR), including artificial intelligence, big data analytics, and advanced biosynthetic engineering, provides new opportunities to accelerate alkaloid research. These innovations facilitate efficient compound screening, prediction of biological activity, and sustainable production methods, thereby enhancing drug discovery processes.

**Conclusion:** Alkaloids represent one of the most important classes of natural products in drug discovery. Their remarkable structural diversity and wide range of biological activities have led to the development of numerous clinically significant drugs. Continued research into alkaloid chemistry and pharmacology, combined with modern technological advancements, is expected to yield new therapeutic agents.