Agriculture and Food

6th International Conference on Research of Agricultural and Food Technologies

I-CRAFT 2026

Agricultural and Food Technologies

ISSN: 3062-3235

ESP 10



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6th International Conference on Research of Agricultural and Food Technologies

I-CRAFT 2026

Abstract book

22–24 October 2026
Almaty Kazakhstan

Proceedings of the I-CRAFT
ISSN 3062-3235

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6th International Conference on Research of Agricultural and Food Technologies (I-CRAFT'2026)

We wish to begin by expressing our sincerest gratitude for your invaluable contributions to the promotion of Turkiye, both domestically and globally, and for your unwavering support of public diplomacy and research within the vital **agricultural and food sectors**.

It is with great pleasure and pride, made possible by your support, that we announce the successful conclusion of the **"6th International Conference on Research of Agricultural and Food Technologies (I-CRAFT 2026),** which was hold on 22–24 October 2026 jointly with the **National Academy of Sciences under the President of the Republic of Kazakhstan (NAS) and Kazakh National Agrarian Research University (KazNARU) in Almaty, Kazakhstan."**

We were deeply honored by the participation of the President of National Academy of Sciences under the President of the Republic of Kazakhstan, which underscored the importance of this prestigious organization. The conference successfully brought together stakeholders from universities, producers, manufacturers, and affiliated organizations to foster critical dialogue on the future of our industry.

A total of **144 papers** were submitted to the system, and following a rigorous referee process, **105 scientific papers** were ultimately accepted. With **53 foreign papers** and **52 papers from Turkish participants**, the I-CRAFT'2026 achieved a remarkable **50% international participation rate**, firmly establishing itself as a truly international scientific platform. During the conference both from NAS and KAZNARU University over 400 person attanded the conference and made great effort for finalizing of conference. We apreciated to their valuble contrubiton.

To facilitate this significant global collaboration, the **Organizing Committee** covered the travel and accommodation expenses for 14 individuals.

The richness of I-CRAFT'2026's scientific content, the high level of international engagement, and the resulting concrete collaboration outcomes demonstrate that we successfully fulfilled our mission to encourage **innovation in agricultural and food technologies** for the benefit of all participating nations, especially Turkiye and other countries.

We once again extend our thanks for your esteemed support that made this successful organization possible, and we respectfully submit this comprehensive report for your information.

Sincerely,

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ID 384 Agricultural Technology

Evaluation of different light conditions for extending the shelf life of lettuce

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Abstract. This study aimed to determine the effects of different light conditions on the postharvest quality and nutritional properties of lettuce (Lactuca sativa L.) and to assess the potential application of LED technology in domestic refrigeration systems. Lettuce samples were stored for three days under four different lighting conditions: darkness, daylight (1603 lux), blue LED light (843 lux), and red LED light (245.2 lux). Changes in weight loss, SPAD value, chlorophyll and carotenoid contents, total phenolic content (TPC), total flavonoid content (TFC), and total antioxidant capacity (TAC) were evaluated. The lighting conditions significantly affected the postharvest quality and bioactive composition of lettuce. Weight loss ranged from 6.74% to 10.48%, with the lowest value recorded under darkness and the highest under daylight. Blue LED light produced the most favorable overall response, increasing TPC and TAC by 14.30% and 16.85%, respectively, while limiting the reductions in SPAD value, carotenoid content, and chlorophyll-a content to 8.89%, 10.63%, and 24.23%, respectively. Under blue LED light, TFC decreased by 8.40%. Red LED light increased TPC and TAC by 7.34% and 14.30%, respectively, and resulted in the smallest reduction in TFC (1.17%). Darkness increased TPC and TAC by 6.76% and 13.76%, respectively, and provided the greatest preservation of total chlorophyll, with a reduction of 23.32%. In contrast, daylight caused pronounced reductions in TPC (21.32%), TFC (44.11%), TAC (21.24%), carotenoid content (65.36%), chlorophyll-a (60.98%), chlorophyll-b (56.46%), and total chlorophyll (60.07%). These findings demonstrate that the light spectrum plays an important role in regulating the physiological and nutritional quality of lettuce during short-term postharvest storage. Although darkness was most effective in limiting weight loss and preserving total chlorophyll, blue LED light showed greater potential for maintaining or enhancing bioactive compounds and preserving carotenoid content, chlorophyll-a, and SPAD values. Overall, the results provide preliminary evidence that spectrum-specific lighting, particularly blue LED light, could be integrated into domestic refrigeration systems as a promising approach to maintaining the nutritional and physiological quality of fresh lettuce during short-term storage.

Keywords: LED lighting, Bioactive compounds, Antioxidants, Chlorophyll

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 385 Agricultural Technology

Artificial intelligence supported drones in precision agriculture

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Abstract. Rising food demand, climate variability and pressure on natural resources are pushing agriculture toward smarter, more efficient production systems. The integration of artificial intelligence (AI) with unmanned aerial vehicle (UAV) technologies offers one promising path. Unlike broad technology summaries, this review provides a thematic synthesis of AI supported drone applications in precision agriculture and identifies research gaps related to field scale validation, data integration and cost-effective adoption. The study discusses major AI approaches, including machine learning, deep learning, computer vision and autonomous decision making used for image based detection, predictive analytics and flight-path optimization. Evidence indicates that AI supported drones can increase yields, reduce input and water use and lower the environmental footprint of production, contributing to food security and sustainability goals. However, high initial costs, limited battery and payload capacity, data privacy concerns and shortages of trained operators remain important constraints, especially for small-scale producers. Overall, AI supported drones represent a transformative tool for sustainable and precision agriculture by enabling timely, site-specific and data-driven crop management.

Keywords: Artificial intelligence, Precision agriculture, Unmanned aerial vehicle.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 387 Agricultural Technology

Deep learning and anomaly detection in agriculture

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Abstract. The agricultural sector, which forms the foundation of historical, social, and economic development, is currently undergoing a transformation toward data-driven Precision Agriculture (PA) models due to the resource inefficiency and environmental costs of traditional methods. In this process, remote sensing, satellites, and unmanned aerial vehicles provide up-to-date data on large areas; meanwhile, decreasing hardware costs and increasing GPU capacities enable the processing of large-scale, multi-modal data using deep learning architectures. While traditional anomaly detection approaches demonstrate limited performance in the face of complex data structures and dynamic environmental factors in real agricultural environments, deep learning-based methods offer high scalability in the early detection of plant health issues, diseases, weed infestations, and developmental stresses. A review of the literature reveals that a VGG19-based transfer learning approach achieved an average accuracy of 96.08% in diagnosing rice plant diseases; the AGRI-YOLO model, developed with a focus on object detection, offered 84.7% sensitivity while significantly reducing model complexity, thereby providing technical support for deployment on edge devices; and the pixel-based U -Net segmentation architecture demonstrates strong geometric discrimination with 94.6% accuracy in sweet potato leaf diseases. Despite these significant achievements, chronic class imbalance stemming from the epidemiologically rare occurrence of disease instances in agricultural datasets, the high cost of labeling processes, and the morphological similarities between certain weeds and crop plants limit the generalization ability of deep learning models. To overcome these limitations, diffusion models that generate high-quality synthetic images using Self-Supervised Learning (SSL) methods are emerging as viable alternative solutions; in the future, it will be necessary to expand data pools, develop more compact programs, and design these advanced technologies with a direct focus on farmers to improve model accuracy.

Keywords: Precision Agriculture, Anomaly Detection, Deep Learning, Convolutional Neural Networks, YOLO, U-Net.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 388 Agricultural Technology

Development of a real time VPD based decision support system for automated irrigation and fertigation time management in soilless greenhouse strawberry production

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Abstract. Accurate irrigation and fertigation scheduling is a major challenge in soilless greenhouse production because crop water demand changes rapidly with the greenhouse microclimate. This study presents a real-time decision support and automation architecture in which vapor pressure deficit (VPD), derived from air temperature and relative humidity measurements, is used as an environmental demand indicator for irrigation and fertigation management. The system was implemented in the EC Agritech Academy experimental greenhouse in Arıklı, Tarsus, Mersin, Türkiye, where strawberries are cultivated under soilless conditions using an automated fertigation infrastructure. A field sensor measures air temperature and relative humidity and transmits data to the EC Agritech Control Center primarily through GSM communication; the electronic architecture is also compatible with Wi-Fi communication. VPD is calculated continuously from the measured variables and supplied to the decision layer. According to the configured operating logic, the resulting decision can either trigger the fertigation system automatically or generate an information notification for the user. The proposed architecture therefore combines environmental sensing, remote communication, real-time VPD calculation, decision support, and fertigation actuation within a single framework. Rather than claiming agronomic performance improvements without comparative field trials, this paper describes the design and greenhouse implementation of the system and discusses its relevance to demand-responsive irrigation in soilless strawberry cultivation. The architecture provides a practical basis for subsequent validation against conventional time-based or substrate-sensor-based irrigation strategies.

Keywords: Vapor pressure deficit, Greenhouse strawberry, Soilless Cultivation, Irrigation automation, Decision support system in Agriculture

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 389 Agricultural Technology

Use of GPS technology in agriculture and precision measurement techniques

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Abstract. The shrinking availability of agricultural land, coupled with the increasing demand for food security and sustainability and the escalating impacts of global climate change, has made the transition from conventional farming practices to advanced technology driven agricultural systems imperative. To fully realize the benefits of technological innovations introduced by Agriculture 4.0, agricultural operations and the data generated from these operations must be accurately integrated with global positioning information. Consequently, the Global Positioning System (GPS) has become a critical component of modern agricultural production and emerging agricultural technologies. This study comprehensively evaluates location based data acquisition, yield mapping, automatic guidance, and precision application techniques, while highlighting the key contributions of precision agriculture technologies in reducing input costs and improving crop productivity. Furthermore, current applications of GPS based precision agriculture technologies in Türkiye and worldwide are reviewed. The findings demonstrate that GPS technology serves not only as an operational tool but also as one of the fundamental corner stone of digital transformation in agriculture. In this context, the study proposes a strategic roadmap to promote the widespread adoption and effective utilization of GPS technologies among agricultural producers.

Keywords: Precision Agriculture, Spatial Data Analysis, Digitalization in Agriculture

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 393 Agricultural Technology

Smart farming practices in carbon footprint reduction

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Abstract. A revolutionary strategy for lowering the carbon footprint of agricultural operations whereas guaranteeing sustainable food supply is smart farming. Smart farming maximizes resource use and reduces environmental effects by combining innovative technology including the artificial intelligence (AI), precision agriculture, Internet of Things (IoT) and automated systems. By using these techniques, farmers can precisely apply fertilizers, insecticides, and irrigation while keeping an eye on weather, crop growth, water use, and soil health in existent time. This increases energy efficiency, decreases greenhouse gas emissions, and minimizes wasteful input consumption. Additionally, smart farming enhances soil carbon sequestration and energy conservation through data-driven decision-making, crop rotation, and conservation tillage, all of which support sustainable land management. Reducing agricultural emissions is further aided by the use of sophisticated waste management systems and equipment driven by renewable energy. Smart farming offers substantial promise for mitigating climate change, despite obstacles including high implementation costs and restricted access to technology in underdeveloped nations. All things considered, incorporating smart agricultural technology into modern agriculture provides a workable solution to reduce carbon footprints, boost agriculture production, and ensure long-term environmental sustainability.

Keywords: Carbon footprint, Smart farming, Artificial intelligence, Energy conservation, Agriculture production.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 394 Agricultural Technology

Digital agriculture solutions against climate change

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Abstract. Climate change is one of the most important challenges facing agriculture, which is the backbone of production for many countries around the world, especially in developing countries, and is closely linked to food security. Recently, digital agriculture has emerged, leveraging advanced technologies such as remote sensing, artificial intelligence, and Internet of Things, to benefit agricultural production. This study is a systematic literature review that analyses recent research on the role of digital agriculture in mitigating and adapting to climate change impacts. A structured methodology was employed including keyword-based screening and thematic analysis of selected studies. The primary objective of this study is to evaluate and synthesize how digital agriculture technologies contribute to climate change adaptation and mitigation, with a focus on improving resource-use efficiency, reducing environmental impact, and enhancing decision-making processes. The paper briefly discusses the use of these technologies within digital agriculture in the context of global climate change and highlights their significant role in maximizing agricultural production. The current surge in the use of modern technology in agriculture will significantly conserve effort and mitigate obstacles and issues confronting agricultural output. In the domain of climate change, providing data and projections on temperature and precipitation fluctuations will improve early warning systems. Despite their potential, the high cost of these technologies remains a significant obstacle, especially in developing areas. Therefore, it is crucial to support their widespread adoption to maximize benefits, particularly in reducing the effects of climate change. In conclusion, digital agriculture presents a scientifically validated pathway for strengthening agricultural resilience to climate change; however, its effectiveness depends on targeted policy support, investment in infrastructure, and capacity-building initiatives. These findings provide actionable insights for researchers, policymakers, and stakeholders aiming to integrate digital solutions into climate-smart agriculture strategies.

Keywords: digital agriculture, climate change, agricultural production.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 395 Agricultural Technology

2035 agricultural machinery projection for Türkiye's Southeastern Anatolia Region

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Abstract. This study examines the usage projections of agricultural machinery employed in agricultural operations in Southeastern Anatolia Region of Türkiye. The primary objective is to estimate the future trajectory of agricultural technology utilization based on data covering the period from 2016 to 2025. Changes in the use of 31 types of agricultural machinery, including equipment for tillage, sowing, fertilization, spraying, harvesting-threshing, and other agricultural operations, were analyzed for the study period. Projection coefficients were calculated using the 2016–2025 data and subsequently employed to estimate machinery usage trends for the period 2026–2035. The analysis was based on data obtained from the Turkish Statistical Institute and supported by findings from relevant literature. The results indicate that the projection coefficients for 30 of the 31 machinery types are positive, suggesting an increase in their use through 2035, whereas one machinery type exhibit negative projection coefficients, indicating a declining usage trend over the same period.

Keywords: Agricultural mechanization, Southeastern Anatolia Region, Projection

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 396 Agricultural Technology

Comparative evaluation of MARS and regression models for reference evapotranspiration estimation in Malatya province

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Abstract. In this study, monthly reference evapotranspiration (ET_0) values for Malatya Province were estimated using the Multivariate Adaptive Regression Splines (MARS) method, and the results were compared with linear (CRA_Lin) and exponential (CRA_Exp) regression models. All possible input scenarios were evaluated by considering different combinations of meteorological variables used to estimate ET_0, and a total of 1,022 models were developed for each modeling approach. The dataset, consisting of 576 observations, was divided into three subsets: 50% for training, 25% for validation, and 25% for testing. Model performance was evaluated using the Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Nash–Sutcliffe Efficiency (NS) coefficient. In addition, the agreement between observed and estimated ET_0 values was assessed using scatter plots. The results demonstrated that the MARS model achieved the highest predictive performance across all datasets. During the training, validation, and testing phases, the MARS model produced the lowest error values, with MSE of 0.00005, 0.00011, and 0.00179; RMSE of 0.00732, 0.01054, and 0.04230; and MAE of 0.00561, 0.00805, and 0.02306, respectively. The corresponding NS values were 0.99884, 0.99772, and 0.96015, indicating excellent model performance. The CRA_Exp model ranked second, while the CRA_Lin model showed comparatively lower predictive accuracy. Overall, the findings indicate that the MARS approach is the most effective method for estimating reference evapotranspiration in Malatya Province because it accurately captures complex nonlinear relationships among meteorological variables. These results suggest that the MARS model can serve as a reliable decision-support tool for irrigation planning and the sustainable management of water resources.

Keywords: Reference evapotranspiration, Multivariate Adaptive Regression Splines (MARS); Regression analysis; Modeling; Malatya.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 397 Agricultural Technology

Recent developments in biotic and abiotic stress research in strawberries

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Abstract. Strawberry (Fragaria × ananassa Duch.) is among the most valuable soft-fruit crops worldwide, yet its shallow root system, high leaf-area-to-root ratio and long harvest period make it unusually sensitive to environmental and biological constraints. This review summarises recent progress in understanding how biotic and abiotic stresses affect strawberry physiology, metabolism and fruit quality, and how breeding and biotechnology are being used to address them. Necrotrophic and soilborne fungi, notably Botrytis cinerea, together with Colletotrichum spp., Podosphaera aphanis, Fusarium oxysporum f. sp. fragariae, Macrophomina phaseolina and Verticillium dahliae, remain the dominant biotic constraints, while viruses, nematodes and phytophagous arthropods also cause substantial losses whose relative importance varies among production regions and systems. Among abiotic constraints, water deficit, salinity and supra-optimal temperature consistently reduce relative water content, photosynthetic quantum yield and chlorophyll concentration, and, under moderate stress, shift carbon partitioning towards soluble sugars, proline and phenolic compounds, although these pools decline again when stress is severe or prolonged. Because sugars, organic acids, anthocyanins and volatile esters jointly determine consumer-perceived quality, stress physiology and fruit quality cannot be evaluated independently. Recent work has combined physiological and biochemical screening with genomic resources, including chromosome-scale and haplotype-resolved octoploid assemblies, to accelerate the identification of tolerant genotypes. Genome editing and RNA interference-based crop protection have advanced rapidly but remain largely at the controlled-environment stage, with allo-octoploidy, homoeologue redundancy, dsRNA delivery and the weak correlation between controlled-environment screening and field performance as the principal bottlenecks. Integrating controlled-environment phenotyping with multi-site field validation is identified as the key priority for developing stress-resilient cultivars without sacrificing fruit quality.

Keywords: Fragaria × ananassa, Drought tolerance, Oxidative stress, Secondary metabolites, Genome editing.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 403 Agricultural Technology

Integrating genomics into pistachio breeding: progress, challenges, and future perspectives

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Abstract. Deciphering the genetic and physiological architecture of productivity in pistachio (Pistacia vera L.) remains one of the most challenging frontiers in perennial crop improvement. This review summarizes more than two decades of integrated research in our laboratory to accelerate pistachio breeding through molecular genetics, genomics, and functional biology. Early studies on genetic diversity using different DNA marker systems laid the foundation for germplasm characterization and breeding strategies. The subsequent development of genomic and transcriptome-derived simple sequence repeat (SSR) markers enabled high-resolution genotyping, genetic linkage mapping, and quantitative trait locus (QTL) analyses of key developmental traits. A major breakthrough came from identifying robust sex-linked SNP markers through next-generation sequencing, enabling early seedling sex diagnosis and facilitating marker-assisted breeding. Genome survey sequencing revealed the highly heterozygous nature of the pistachio genome; subsequent chromosome-level assemblies then provided insight into its organization and evolution, including its sex chromosomes. Integrative physiological studies, together with multi-omics, have further advanced the understanding of alternate bearing regulation. Future pan-genomic resources and genomics-assisted selection strategies should create opportunities to develop high-yielding, climate-resilient pistachio cultivars for sustainable production systems.

Keywords: Pistachio · Pistacia vera · Breeding · Sex determination · Molecular markers · Genome · Genetic mapping · QTL · Alternate bearing.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 406 Agricultural Technology

Efficacy of waste glycerol-derived rhamnolipids as biocontrol agents against fungal pathogens in pre- and post-harvest crop management

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Abstract. Postharvest and pre-harvest crop losses driven by fungal phytopathogens pose severe threats to global agricultural productivity, food security, and supply chain sustainability. Traditional disease management relies heavily on synthetic chemical fungicides; however, their excessive application causes ecological degradation, risks human health, and fosters pathogen resistance. Microbial biosurfactants, particularly rhamnolipids (RLs) produced by Pseudomonas aeruginosa RS6 using industrial waste glycerol, present a highly promising, eco-friendly biocontrol alternative that aligns with circular economy principles. This study synthesized findings on the broad-spectrum efficacy of RLs in controlling fungal infections, protecting plant development, and preserving postharvest quality across economically vital crops, including tomatoes (Solanum lycopersicum), cucumbers (Cucumis sativus), melons (Cucumis melo), and mangoes (Mangifera indica). In vitro microdilution assays revealed that RLs possess potent antifungal activity against a diverse array of aggressive phytopathogens, including Botrytis cinerea, Colletotrichum capsici, Phytophthora palmivora, Rigidoporus microporus, Pyricularia oryzae, and Ganoderma boninense. RLs effectively inhibited spore germination and mycelial growth at low minimum inhibitory concentrations (MICs ranging from 0.020 mg/mL to 0.156 mg/mL), frequently outperforming the commercial synthetic fungicide Benomyl 50 WP. Microscopic analyses (light microscopy, SEM, and TEM) demonstrated that RLs disrupt fungal structural integrity by destabilizing plasma membranes and cell walls, leading to severe morphological alterations such as mycelial shrinkage, pore formation, cytoplasmic lysis, and disintegration of essential intracellular organelles. Greenhouse field trials evaluated the application of cell-free RL fermentation broth (0.3-0.7 g/L) on cucumber and melon crops under commercial growing conditions. Weekly foliar treatments significantly reduced disease incidence, achieving up to 96% plant survival at 0.7 g/L, which matched or exceeded the protection provided by synthetic chemical fungicides like Antracol 70 WP. Additionally, 0.5 g/L RL treatment yielded the highest mean cucumber fruit weight (2.12 kg), indicating that RLs promote crop health without compromising yield performance. In postharvest evaluations, preventive RL applications mitigated decay severity, slowed physiological weight loss, and preserved key quality metrics across stored produce. By day six of storage, RL-treated cucumbers maintained a total soluble solids (TSS) content of 3.4 Brix under pathogen pressure, retaining higher sugar levels than untreated controls. However, in vivo studies highlighted that RLs function primarily as preventive biocontrol agents rather than curative treatments, as their efficacy was significantly higher when applied before fungal establishment. Overall, these findings demonstrate that waste-derived rhamnolipids are versatile, sustainable biofungicides capable of replacing synthetic chemicals, mitigating disease spread, and extending shelf life throughout the agricultural supply chain.

Keywords: Rhamnolipids, Biopesticides, Fungi, Pathogens, Biocontrol

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 407 Agricultural Technology

Mathematical modeling of the working process of a universal-frame fertilizer application machine for vegetable cultivation

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Abstract. Energy- and resource-saving mineral-fertilizer-application machinery is critical for sustainable vegetable cultivation, where global onion production alone exceeds 92.1 million tonnes and grows by 2–3% annually. This study develops and substantiates a mineral-fertilizer-application machine equipped with a universal seeder frame and a fluted-roller metering apparatus, intended for combined fertilization and inter-row cultivation of vegetable crops. Analytical expressions are derived for (i) the mass of fertilizer dispensed per one full revolution of the metering roller as a function of bulk density, fluted-roller geometry and active-layer thickness; (ii) the transmission ratio of the chain drive linking the support-drive wheel to the metering roller, in terms of working-body parameters and the prescribed fertilization rate; and (iii) the total traction-resistance force of the machine, based on similarity theory and accounting for mass variation, soil deformation and the oscillatory soil-reaction component. A three-factor multifactor experiment (Box–Wilson design) was carried out for ammonium nitrate, superphosphate and urea, with the metering-roller length , rotational speed and travel speed varied between three levels. Cochran, Student and Fisher criteria confirmed the homogeneity, significance and adequacy of the obtained second-order regression models. Field tests show that the developed machine reliably performs the prescribed agrotechnical process; optimal parameters are roller length 15–20 mm, rotational speed 50–60 rpm and travel speed 5 km/h. Compared with existing seeders, fuel consumption decreased by a factor of 1.3 and labour productivity rose by a factor of 1.8, while per-hectare operating expenditures and labour input decreased by 10.5% and 10%, respectively, yielding an annual economic effect of 10,451,273.18 UZS per machine.

Keywords: fertilizer-application machine; vegetable cultivation; fluted metering roller; transmission ratio; traction resistance; similarity theory; multifactor experiment; regression model; energy saving.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 414 Agricultural Technology

Aronia (Aronia melonacarpa) tissue culture biorector propagation: a review

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Abstract. Black aronia, belonging to the Rosaceae family, is a plant native to eastern North America and eastern Canada, known for its very modest cultivation requirements. Introduced to Russian botanical gardens in the early 20th century, aronia subsequently became established in the European part of the country. Recently, there has been an increase in its cultivation in Eastern European countries and Germany. Later, cultivation expanded to include the Central and Eastern European regions where it is now widely grown. Aronia cultivation is steadily increasing across vast regions of the country. Aronia melonacarpa is one of the fruit species whose cultivation has become increasingly widespread in recent years due to its high antioxidant content, rich bioactive components, and increasing economic value. To meet the growing demand for seedlings and to obtain high-quality and homogeneous plant material quickly, in vitro propagation techniques have gained importance. In this context, bioreactor systems stand out as an alternative to traditional tissue culture methods due to their high propagation capacity, reduced labor and production costs, and the possibility of standardized production. This compilation aims to contribute to research in this field by bringing together current information on the effective use of bioreactor technologies in aronia propagation.

Keywords: Aronia melanocarpa, micropropagation, bioreactor

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 415 Agricultural Technology

In vitro propagation techniques on citrus rootstocks: a review

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Abstract. Citrus fruits are a significant group of fruits with high vitamin C content, important for health, widely cultivated, with increasing production, significant export value, diverse uses, and widespread consumption. Citrus rootstocks are one of the fundamental elements in modern citrus cultivation, directly affecting yield, fruit quality, resistance to biotic and abiotic stresses, and orchard performance. The increasing need for high-quality seedlings necessitates the rapid production of disease-free and genetically uniform rootstock material. Due to limitations encountered in traditional propagation methods, such as time loss, low propagation rates, and the risk of pathogen contamination, in vitro propagation techniques have gained importance in recent years. This review aims to contribute to the compilation of current research on in vitro propagation in citrus rootstocks, summarize existing knowledge, and shed light on future research into more effective propagation protocols and breeding programs.

Keywords: Citrus, Rootstock, Tissue Culture, Plant Biotechnology

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 416 Agricultural Technology

Major challenges and solutions in the micropropagation of fig: a review

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Abstract. Fig (Ficus carica L.) is one of the most important edible fruits, having considerable nutritional, economic and medicinal value, particularly in the Mediterranean Basin. Türkiye is a world leader in the production and export of both fresh and dried figs. There are some traditional propagation methods used for fig propagation including seed propagation, cutting propagation, layering and grafting. However, the high heterozygosity and low vitality of fig seeds, low rooting success of cuttings, and the additional labor required for layering have limited the traditional breeding strategies in fig production. Furthermore, fungal, bacterial and viral diseases, as well as insect pests have negatively affected fruit quality and productivity. Therefore, there is a need to improve planting and propagation techniques to enhance fig production efficiency and fruit quality. In vitro micropropagation, a tissue culture-based method to enable the rapid production of numerous clonal and disease-free plants under aseptic conditions, could serve as a powerful tool to overcome these challenges. Nevertheless, several limitations are encountered at different stages of micropropagation of Ficus carica. This review summarizes the current research on challenges encountered during the micropropagation process of fig and evaluates underlying causes and potential solution strategies for these problems. In conclusion, it is believed that the solution strategies discussed considering the current literature will contribute to the development of a more efficient and sustainable in vitro micropropagation system for fig.

Keywords: Ficus carica, Micropropagation, Challenges, in vitro

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 419 Agricultural Technology

Visual assessment of genetic transformation efficiency in sunflower (Helianthus annuus L.) utilizing the RUBY reporter plasmid

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Abstract. Sunflower is a globally significant oilseed crop valued for its high oil content and diverse applications. However, its low regeneration capacity, genotype-dependent variability in response, and tissue resistance to transformation render sunflower one of the most challenging species for genetic modification. These limitations hinder the development of new varieties with enhanced resistance to biotic and abiotic stresses and increased yield through genetic engineering. Consequently, there is a critical need for optimized, rapid, and reliable transformation protocols. In this study, the RUBY reporter plasmid was employed to facilitate straightforward and rapid assessment of transformation efficiency. The RUBY system induces a red or purple coloration in transformed cells and tissues, enabling visual detection of transformation without the requirement for advanced equipment such as microscopy or fluorescence imaging. Through Agrobacterium tumefaciens-mediated vacuum infiltration, the RUBY plasmid was successfully introduced into sunflower leaves, resulting in a pronounced color change in the tissues post-infiltration, thereby confirming transformation. The findings indicate that this method provides a rapid and cost-effective preliminary screening strategy for transformation studies in sunflower. This approach is anticipated to support the development of stable transformation and gene editing protocols in future research.

Keywords: Sunflower (Helianthus annuus L.), RUBY reporter gene, genetic engineering

ID 425 Agricultural Technology

In vitro micropropagation of sweet cherry rootstocks via parallel organogenesis and assessment of their molecular genetic stability

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Abstract. This article highlights the optimization of in vitro micropropagation technology for foreign sweet cherry rootstocks resistant to abiotic stress factors (Gisela 6, Krymsk 5, MaxMa 14) and a local rootstock (*Prunus mahaleb*). Unlike the conventional two-step micropropagation method, an express technique was developed that facilitates simultaneous proliferation and rhizogenesis within a single vessel. The genetic stability of the explants and the risk of somaclonal variation were analyzed at the DNA level using SSR markers. This new technique reduced sapling production costs by up to 25–30%.

Keywords: Prunus avium*, rootstock, microclonal propagation, parallel organogenesis, SSR markers, genetic stability, localization.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 428 Agricultural Technology

Effect of irrigation regimes on the yield and soil properties of replanted sunflower

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Abstract. This study evaluated the effects of three pre-irrigation soil-moisture regimes (70-70-60%, 70-75-65%, and 70-80-70% of limited field moisture capacity, LFMC) on the growth, seed yield, water use, and selected physical properties of meadow (soz) soils under replanted sunflower cultivation in Central Fergana, Uzbekistan. Field experiments were conducted during 2020-2022 after winter wheat using the sunflower varieties "Jahongir" and "Yangi Zamon". The experiment comprised six treatments arranged in four replications. Soil physical properties were assessed in the 0-30 and 30-50 cm layers, while soil moisture was monitored through the 0-100 cm profile. Irrigation water was measured using a Chippoletti water meter, and the experimental data were statistically processed using Microsoft Excel and the field-experiment methodology of B. A. Dospekhov. The 70-75-65% regime produced the most favorable overall results. Under this regime, average seedling density reached 42.7 thousand plants ha−1 for "Jahongir" and 42.3 thousand plants ha−1 for "Yangi Zamon". For "Jahongir", the basket diameter reached 19.6 cm, 1000-seed weight was 57.1 g, and seed yield was 24.6 c ha−1; for "Yangi Zamon", the corresponding values were 18.9 cm, 43.1 g, and 22.4 c ha−1. In the 0-30 cm layer, soil bulk density at the end of the season under the 70-75-65% regime was 1.365 g cm−3, while soil porosity decreased by 1.88 percentage points from the beginning of the season. The recommended regime involved four irrigations with individual irrigation rates of 451-726 m3 ha−1 and seasonal irrigation rates of 2172-2204 m3 ha−1. Overall, maintaining pre-irrigation soil moisture at 70-75-65% of LFMC provided the most favorable combination of plant development, seed yield, and soil conditions for replanted sunflower under the studied Central Fergana conditions.

Keywords: replanted sunflower, irrigation regime, pre-irrigation soil moisture, LFMC, seed yield, water use, soil bulk density, soil porosity, Central Fergana

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 430 Agricultural Technology

Detection of spoilage in meat and meat products using electronic noses

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Abstract. Meat and meat products are highly perishable foods that spoil rapidly due to chemical reactions such as microbial growth and oxidation. During spoilage, meat releases volatile organic compounds (VOCs), including ammonia, hydrogen sulfide and various alcohols, which are responsible for spoilage-specific off-odors. Traditional methods used to determine freshness (microbial counting, chemical analyses and sensory evaluation) provide reliable results; however, these methods are time-consuming and costly. Electronic noses are systems designed to mimic the human sense of smell. They use an array of gas sensors that respond to the odor of a product and the signals obtained are interpreted using computer-based methods to classify the sample. This study examines the use of electronic noses in detecting spoilage in meat and meat products. Sensors respond to VOCs released from the sample; the signals are analyzed using statistical and machine learning methods to distinguish fresh meat from spoiled meat. Previous studies have shown that these systems can perform this classification with high accuracy. In conclusion, the electronic nose offers a fast and low-cost approach that can support the control of meat quality and safety.

Keywords: Electronic nose, Meat spoilage, Volatile organic compounds, Gas sensors, Food quality, Machine learning.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 431 Agricultural Technology

Monitoring spoilage in seafood using electronic noses

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Abstract. Seafood is among the most highly perishable foods and rapidly loses its freshness after harvesting due to microbial development and enzymatic reactions. During spoilage, fish and other seafood release volatile organic compounds such as trimethylamine, ammonia, hydrogen sulfide and biogenic amines, which cause characteristic fishy and off-odors. Freshness is traditionally assessed by microbiological, chemical (e.g., total volatile basic nitrogen, TVB-N) and sensory methods; although these approaches are reliable, they are time-consuming and costly. Electronic noses are systems designed to mimic the human sense of smell. They use an array of gas sensors that respond to the odor of a sample and the signals obtained are interpreted using computer-based methods to classify freshness. This study examines the use of electronic noses in monitoring spoilage in seafood. Sensors respond to volatile organic compounds released from the product; the signals are analyzed using statistical and machine learning methods to distinguish fresh products from spoiled ones and to monitor changes during storage. Previous studies have shown that these systems can perform this classification with high accuracy. In conclusion, the electronic nose offers a fast, low-cost and non-destructive approach that can support the monitoring of seafood quality and safety.

Keywords: Electronic nose, Seafood spoilage, Volatile organic compounds, Fish freshness, Gas sensors, Machine learning.

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ID 433 Agricultural Technology

Deep learning-based crop disease diagnosis with weather-aware farm advisory system

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Abstract. Crop disease detection using deep learning has advanced considerably, with many studies demonstrating the usefulness of image-based models for identifying plant diseases. However, identifying a disease is only one part of crop management. For farmers, the more important question is often what action should be taken after a disease has been detected and whether current environmental conditions support that action. This paper demonstrates a weather- aware crop disease decision helping framework for five major crops which is: cotton, groundnut, chilli, onion and coconut. The proposed system will use a transfer-learning-based convolutional neural network to identify diseases from crop images captured using a smartphone. The disease prediction will then be combined with location-specific weather data, containing temperature, relative humidity, rainfall and wind conditions. A crop-disease-weather knowledge base will be developed from verified agricultural advisories, including information from ICAR and Krishi Vigyan Kendra sources. An IF-THEN recommendation layer will use the predicted disease and weather context to provide a crop-specific management recommendation that can be traced to an underlying agronomic rule. Whole work is designed for as low-cost alternative to sensor-intensive agricultural monitoring systems, using smartphone images and external weather data without requiring dedicated field sensors in the basic workflow. And Deep learning component will be evaluated using standard classification measures such as accuracy, precision, recall, and F1-score, while the recommendation component will be evaluated for consistency with the underlying agricultural rules. This study aims to develop a practical connection between automated disease diagnosis, environmental context, and farmer-oriented crop-management advise.

Keywords: Crop disease detection, Deep learning, Transfer learning, Convolutional Neural Networks (CNN), Decision support system, Weather-aware recommendations, Agricultural advisories, Rule-based system, Smart farming, Low-cost precision agriculture.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 436 Agricultural Technology

The role of digital methods and technology in agricultural and food products marketing

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Abstract. The digital transformation of food systems is changing agricultural and food products marketing through e-commerce, social media, artificial intelligence, big data analytics and blockchain-based traceability. This study examines the contributions, opportunities and challenges associated with these digital methods based on a descriptive review of literature published between 2019 and 2026. Sources from Web of Science, Scopus and Google Scholar were reviewed and classified into five areas: e-commerce and direct-to-consumer channels, social media and short-video/live-stream commerce, blockchain-based traceability, big data and AI-driven personalization and barriers to digital adoption among small and medium-sized producers. The reviewed literature indicates that e-commerce can facilitate direct producer–consumer connections, while social media and live-stream commerce can increase product and brand visibility. Blockchain-based systems are associated with traceability and consumer trust, whereas big data and artificial intelligence provide tools for predicting consumer behavior and personalizing marketing strategies. The literature also identifies limited digital infrastructure, technical knowledge and investment capacity as barriers to adoption, particularly for small and medium-sized producers. These findings show that the benefits of digital transformation in agricultural and food products marketing depend partly on producers' access to digital infrastructure, skills and technological resources.

Keywords: Digital marketing, agricultural marketing, food products marketing, technology, e-commerce, traceability

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 437 Agricultural Technology

Food security and sustainability with digital agriculture

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Abstract. Food security is a major concerned issue in this progressing world, as Population is increasing and becomes a main reason of global warming and climate change. This climate change directly affect the Agricultural productivity, food security and sustainability. Living beings could not survive without food, so in this article we discussed how agriculture food productivity could be improved and increased. Digital agriculture is a transformative methodology that combined advanced technologies like the artificial intelligence, Internet of Things, robotics, remote sensing, drones and data analytics into farming systems. These innovative technologies facilitate precision agriculture, optimize resource use, reduce environmental impact, and enhance crop yields. Digital agriculture helps to provide water-saving, intelligent, high-quality, efficient, and non-polluting agriculture production. Digital agriculture presents a significant opportunity to substitute traditional farming practices with innovative technology and help farmers to get more yield within less time and with less effort. Digital agriculture helps to mitigate climate change effect by providing precise site specific water management, fertilizer management, and nutrient management according to crop and land requirement. However, many small-scale farmers are unable to take benefits of digital agriculture because of unequal access to necessary information and equipment. The expensive cost of deploying digital agricultural technology is another barrier that may prevent small-scale farmers with limited resources from adopting them.

Keywords: Food security, Agricultural production, Digital agriculture, Innovative technology, precise management.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 439 Agricultural Technology

Justification of the design and technological scheme of a potato harvester with an elastic intensifier

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Abstract. The article presents an improved structural and technological diagram of the working body of a potato harvesting machine with an elastic leveling intensifier, designed to increase the efficiency of soil separation from potato tubers in conditions of heavy loamy soils with low moisture content. The design of an intensifier, including sequentially arranged drive shafts with elastic working elements, which, when interacting with the pile, ensure its loosening, redistribution, and alignment along the width of the elevator bed, has been substantiated. Furthermore, theoretical studies have determined the relationship between the transverse displacement of potato pomace components, the kinematics of elastic element movement, and the structural parameters of the device. Based on the results of theoretical research, the rational parameters of the working body were established: the rotational frequency of the shafts not exceeding 74 rpm, the radius of curvature of the elastic elements 0.09 m, the working clearance under the first, second, and third shafts, respectively, 0.25; 0.20 and 0.15 m, the pitch of the shafts 0.20 m, and the number of working elements on one shaft is 5 pieces. The obtained results confirm the prospects of using the proposed design in the design and modernization of potato harvesting machines to increase separation completeness, reduce technological losses, and improve harvest quality.

Keywords. Potato harvester, soil separation, potato spool, elastic leveling intensifier, sieving elevator, elastic working elements, working clearance, harvesting efficiency.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 440 Agricultural Technology

Remote essessment of vegetation and water status using broad-band multi-spectral imagery

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Abstract. Simultaneous assessment of vegetation, water, and nitrogen status requires spectral measurements spanning the visible and short-wave infrared regions. However, compact multispectral cameras covering this range are limited, particularly for UAV applications. We propose a snapshot multispectral camera covering 0.4–1.7 μm using a single broad-band sensor and a replaceable multi-aperture lens–filter array. We selected four channels centered at 650 nm, 800 nm, 1500 nm, and 1600 nm for NDVI, MSI, and nitrogen-sensitive reflectance measurements. The camera was tested on healthy and water-stressed tomato leaves. The acquired images were used to generate NDVI and MSI maps and to analyze reflectance at 1500 nm. The camera can support field-scale detection of water stress, UAV-based mapping for site-specific crop management, and, after appropriate validation, assessment of nutrient-related plant status.

Keywords: Precision Agriculture, Snapshot Imaging, Multispectral Camera, Visible Spectral Range, Shortwave Infrared Spectral Range, Spectral Indices.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 443 Agricultural Technology

Annual metrics overstate frost-prediction skill in orchard monitoring: seasonal decomposition and baseline comparison

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Abstract. Frost during bloom decides an apple season, and machine-learning models for frost prediction are now standard in orchard monitoring. Their reported performance is high; this study asks what it measures. Using 2406 daily forecast origins from an operational deployment on a 10 ha commercial apple orchard in the foothills of the Zailiysky Alatau, covering 2019 to 2026, we evaluated a random forest predicting whether the next day's minimum air temperature falls below +2 degrees C. On a held-out 2024 season it reached F1 0.934. A persistence rule carrying today's observed minimum forward, requiring no fitting, reached 0.904 on the same rows, and a day-of-year climatology 0.867: the gain from machine learning is three points. The explanation is seasonal. The event occupies 100 % of days in January and none between June and August, so an annual metric largely rewards separating winter from summer, a distinction of no agronomic value. Restricted to April and May, from bud break to the end of flowering, the base rate falls from 38 % to 5.4 %, an always-negative predictor reaches 94.6 % accuracy, climatology carries no information, and persistence drops to F1 0.571. Three validation protocols - random five-fold, purged rolling-origin with a 48 h embargo, and a temporal hold-out - agreed within 0.7 points, indicating that the evaluation window matters more than the partitioning scheme. Agro-environmental prediction should report metrics inside the phenological window, with the base rate and at least a persistence baseline on identical rows.

Keywords: Frost prediction, Baseline comparison, Model evaluation, Phenological window, Apple orchard.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 444 Agricultural Technology

Continuous IoT soil-moisture monitoring of a hydrogel field trial in an apple orchard: irrigation frequency, soil biological activity and yield

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Abstract. Irrigated horticulture in south-eastern Kazakhstan faces a widening summer water deficit, and soil conditioners are among the few field-scale interventions available. Their evaluation usually rests on three to five gravimetric samplings per season, too coarse to resolve how long a treatment keeps the root zone within the optimal range. We report a field trial in a commercial apple orchard on dark chestnut soil, in which the hydrophilic polymer AQUASORB was applied at 20, 40 and 60 g per tree against an untreated control, with trees spaced 5 by 2 m. Capacitive probes at 10, 30 and 50 cm recorded soil water at 15 min intervals through the 2022 to 2024 seasons, alongside laboratory determinations of biological activity and plot-level yield accounting. The continuous record resolved drying curves that discrete sampling cannot. After furrow irrigation, control plots fell below 70 % of field capacity within 5 to 6 days; the intermediate rate took 9 to 10 days and the highest 11 to 12. Optimal root-zone moisture was extended by 80 to 120 %, irrigations per season fell from 7-8 to 4-5, and total water use by 26 to 32 %. CO2 emission rose from 185 to 262 mg per square metre per hour, cellulolytic activity from 28.1 to 45.2 %, and mean seasonal soil moisture correlated with CO2 emission at $r = 0.87$ ($p < 0.01$). Yield rose from 168 to 212 centners per hectare.

Keywords: Soil water regime, Hydrogel, IoT monitoring, Water use efficiency, Soil biological activity.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 445 Agricultural Technology

Modern genomic tools for wheat breeding in Kazakhstan

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Abstract. Wheat is the major cereal crop in Kazakhstan, where breeding for high productivity and adaptation is challenged by large environmental variation across growing regions. The integration of modern genomic technologies with conventional breeding provides new opportunities to accelerate genetic improvement and improve the efficiency of selection. Here, we summarize the application of genomic approaches to wheat breeding in Kazakhstan, including high-throughput SNP genotyping, genome-wide association studies (GWAS), development of molecular markers, genomic prediction, and the use of structured mapping populations. Over the past several years, diverse spring and winter wheat germplasm has been genotyped and phenotyped across multiple environments in Kazakhstan to identify marker–trait associations for adaptation, plant architecture, yield components, grain quality, and disease resistance. These studies have generated genomic resources for marker-assisted and genomics-based selection. A bread wheat nested association mapping (NAM) population represents an important resource within this framework. The population comprises 290 recombinant inbred lines derived from crosses between the common parent Paragon and 24 genetically diverse accessions, including 19 landraces from the A.E. Watkins collection, two CIMCOG lines, and three cultivars. The NAM population was initially analyzed using an Axiom SNP array and subsequently subjected to a high-density GWAS using 1,341,000 SNPs and multi-environment phenotypic data. The application of complementary GWAS models enabled the identification and prioritization of reproducible QTLs controlling agronomically important traits. Current analyses demonstrate particularly strong and stable genetic control of phenological traits, including heading and seed maturation dates, across contrasting environments. Integration of high-density genomic information with multi-environment phenotyping provides an opportunity to refine QTL regions, identify candidate genes and favorable alleles, and develop diagnostic markers for breeding. These results demonstrate the potential of combining genomic resources, association mapping, molecular marker technologies, and genomic prediction to support wheat improvement in Kazakhstan. Further integration of these tools with accelerated breeding approaches is expected to facilitate the development of productive and broadly adapted wheat cultivars for diverse agroecological environments.

Keywords: Triticum aestivum L.; wheat breeding; genomics; GWAS; nested association mapping; SNP markers; genomic selection; Kazakhstan.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 461 Agricultural Technology

Marker-assisted selection and QTL mapping for abiotic stress tolerance in wheat: a comparative approach

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Abstract. Abiotic stresses such as drought, heat, salinity, and cold are among the most significant constraints limiting wheat (Triticum aestivum L.) productivity worldwide, and their combined impact is expected to intensify under future climate scenarios. Quantitative trait locus (QTL) mapping and marker-assisted selection (MAS) have become indispensable tools for dissecting the complex, polygenic architecture of stress tolerance traits and for accelerating their introgression into elite breeding backgrounds. However, QTL identified for a given stress in one mapping population or environment often shows limited transferability across genetic backgrounds, developmental stages, and stress combinations, which complicates their direct deployment in breeding programs. This study adopts a comparative approach to synthesize and evaluate QTL associated with drought, heat, and salinity tolerance identified across multiple wheat mapping populations (including recombinant inbred lines, doubled-haploid populations, and diverse association panels), with the aim of identifying consensus genomic regions and candidate genes that confer tolerance across more than one stress type. Attention will be given to QTL clusters located on chromosomes such as 2A, 3B, 5A, and 7B, which have been repeatedly associated with root architecture, osmotic adjustment, stomatal regulation, and membrane stability traits linked to multiple stress responses. Linked SSR, SNP, and KASP markers validated across these studies will be compiled to propose a practical marker panel suitable for MAS-based introgression programs. Meta-QTL analysis will further be used to distinguish major, environmentally stable QTL from population-specific or minor-effect loci, providing breeders with a prioritized list of targets for pyramiding multiple stress-tolerance alleles into a single genetic background. The comparative synthesis presented here is expected to clarify which QTL/marker combinations offer the broadest applicability for multi-stress resilience breeding, thereby reducing the trial-and-error typically associated with QTL transfer between populations. By bridging classical QTL mapping outcomes with practical, marker-based breeding pipelines, this work aims to support the development of climate-resilient wheat cultivars adapted to the increasingly variable growing conditions of semi-arid and continental wheat-producing regions, including Central Asia.

Keywords: wheat, QTL mapping, marker-assisted selection, abiotic stress, drought tolerance, heat tolerance, meta-QTL, comparative genomics

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 462 Agricultural Technology

Genomic selection for yield and stress tolerance in wheat: integrating machine learning with molecular marker data

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Abstract. Wheat (Triticum aestivum L.) is one of the most important staple crops worldwide, and its productivity is increasingly threatened by drought, heat, and other abiotic stresses associated with climate change. Conventional phenotypic selection methods are often time-consuming, resource-intensive, and limited in their ability to capture the complex genetic architecture underlying yield and stress tolerance traits, which are typically governed by numerous small-effect loci and genotype-by-environment interactions. Genomic selection (GS), which uses genome-wide molecular marker data to predict breeding values, offers a powerful alternative for accelerating genetic gain in wheat improvement programs. However, the predictive accuracy of conventional GS models such as GBLUP and rrBLUP can be limited when dealing with non-additive genetic effects, epistasis, and complex marker-trait relationships. This study aims to evaluate and compare the performance of machine learning (ML) algorithms—including Random Forest, Extreme Gradient Boosting (XGBoost), Support Vector Regression (SVR), and Artificial Neural Networks (ANN)—against classical genomic prediction models for forecasting grain yield and drought/heat stress tolerance indices in a diverse panel of wheat genotypes. High-density SNP marker data will be integrated with multi-environment phenotypic datasets collected under well-watered and water-stressed conditions. Model performance will be assessed using cross-validation prediction accuracy, and SHAP (SHapley Additive exPlanations) analysis will be applied to identify and interpret the most influential markers and their contribution to trait prediction, providing biological insight beyond simple "black-box" predictions. Preliminary evidence from recent studies indicates that ensemble-based ML models, particularly Random Forest and XGBoost, can achieve competitive or superior prediction accuracy compared to ridge regression and GBLUP for complex traits such as grain yield and thousand-kernel weight, especially under contrasting water regimes. By combining the interpretability of SHAP with the predictive power of ML, this research seeks to develop a robust and transparent genomic selection framework that can be directly applied in practical wheat breeding programs to accelerate the development of high-yielding, stress-resilient cultivars.

Keywords: genomic selection, wheat, machine learning, molecular markers, drought tolerance, SHAP analysis, grain yield

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 463 Agricultural Technology

Heavy metal (Cr, Mn, Pb) removal performance of different substrate materials from wastewaters

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Abstract. Population growth and technological advancements are increasing the pollution pressure on limited freshwater resources day by day, making it imperative to effectively treat and reclaim wastewater. Constructed wetlands that are compatible with ecosystems and have low operational and installation costs—offer a sustainable alternative for wastewater management, particularly in rural areas. In this study, the performance of natural zeolite and pumice—materials emerging as alternative filter media in constructed wetlands—in removing the toxic heavy metals chromium (Cr), manganese (Mn), and lead (Pb) from wastewater was comprehensively investigated. The experiments were conducted using 100 cm³ of filter material in pilot-scale column tests. The study was completed using synthetic wastewater with pH of 5, various flow rates (2.5, 5.0, and 10 mL min-1), and different heavy metal concentrations (10, 25, and 50 mg L-1). Heavy metal analyses were performed using ICP-OES on samples collected periodically at 3rd, 6th, 12th, 24th, and 48th hours during the study. The results revealed that, under a flow rate of 2.5 mL min-1, pumice demonstrated up to 100% efficiency in the removal of Cr and Mn. In terms of Pb removal, it was found that both zeolite and pumice exhibited efficiency of up to 100% at full capacity. It was observed that high concentrations and hydraulic loads accelerated the saturation time of the materials, and it was determined that zeolite and pumice are highly efficient in natural treatment systems.

Keywords: Column Tests, Pumice, Treatment, Zeolite.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 467 Agricultural Technology

The effect of different drying methods and slicing shapes on the drying performance and some quality characteristics of apple varieties

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Abstract. This study investigated the effects of different drying methods (360 W microwave and 70 °C fan oven) and slicing shapes (circle, rectangle, cube) on the drying performance, mathematical modeling, energy consumption, and sensory quality of three different apple varieties (Pink Lady, Red Delicious, Granny Smith). According to the data obtained, the cutting geometry directly affected the drying kinetics, with faster moisture loss observed in rectangular and cube slices with a larger surface area and volume ratio. Among the models applied to mathematically explain the drying behavior of apple varieties, the Midilli-Küçük model (R^2=0.9985-0.9999) provided the highest fit to the experimental data in both drying methods. When energy performance indicators were examined, the specific moisture absorption ratio (SMER) of microwave drying was found to be significantly higher compared to oven drying. Furthermore, the specific energy consumption (SEC) was calculated to be 4-6 times lower in microwave drying compared to oven drying, proving that the microwave method is much more energy efficient. However, sensory analysis conducted with a panel of 10 people revealed that oven drying yielded superior results compared to microwave drying in terms of flavor, color, and overall liking. Specifically, oven-dried circular and rectangular cut Red Delicious samples received the highest overall liking scores from the panelists.

Keywords: Apple drying, energy consumption, sensory analysis.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 470 Agricultural Technology

Formation of an agricultural spatial data infrastructure in Kazakhstan

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Abstract. Kazakhstan has officially announced the completion of its National Spatial Data Infrastructure (NSDI), which has resulted in the creation of the QazTRF 2023 open geodetic system and basic spatial data, a significant achievement for the country. This path began in 2012 with the approval by the National Space Agency of the Republic of Kazakhstan (RK) of the "Concept for the creation and development of the national spatial data infrastructure of the Republic of Kazakhstan until 2020", proposed by O. Alipbeki et al. As global practice shows, after the creation of an open geodetic system and basic spatial data (NSDI), each sector of the economy whose activities involve spatial data must establish its own SDI. This served as the basis for research on the development of the Agricultural Spatial Data Infrastructure of the Republic of Kazakhstan (AgroSDI RK). The results of this work indicated that the country has the potential to develop operational spatial data for agricultural use. However, it was revealed that government organisations engaged in developing agricultural spatial data still do not show due interest in the principles governing the formation of both the NSDI RK and the AgroSDI RK. This delays the formation of a full-fledged, rapidly developing spatial data system for the agricultural sector, based on modern methodologies and digital technologies. In addition, it turned out that in the industry, despite the presence of qualified specialists, a system for the operational classification of Land Use and Land Cover (LULC) of rural areas (RA), including the agro-industrial complex (AIC), using Machine Learning and Deep Learning has not yet been established. The country has not yet begun a comprehensive assessment of the AIC, including the RA, using spatiotemporal, socioeconomic, and environmental data and leveraging Big Data and artificial intelligence. Taking the above into account, we have assessed the maturity level of the NSDI RK and proposed a methodology for the operational creation of spatial data, the classification of Remote Sensing data, and an integrated assessment of the AIC's activities using Big Data and Artificial Intelligence. The developed system of methodological approaches enables government agencies to effectively monitor AIC activities. The methodology enables agricultural enterprises to conduct their work using digital data, spanning all levels of the Digital Twin: spatial model, digital shadow, and digital twin.

Keywords: National Spatial Data Infrastructure (NSDI), Agricultural Spatial Data Infrastructure (AgroSDI), QazTRF 2023, Land Use and Land Cover (LULC), Remote sensing, Agro-industrial complex (AIC), Digital twin, Machine learning, Big Data, Precision agriculture.

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ID 477 Agricultural Technology

GIS-based indicators for sustainable land use in Almaty region

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Abstract. Land degradation, climate variability and growing anthropogenic pressure increase the need for spatially detailed land monitoring in Almaty Region, Kazakhstan. The study develops a regional framework for assessing sustainable land use by integrating GIS, remote sensing, cadastral and statistical data. The proposed methodology combines five groups of indicators: environmental condition, vegetation condition and productivity, agricultural-use efficiency, anthropogenic pressure, and spatial-territorial stability. Sentinel-2 and Landsat 8/9 data are considered as the main sources for calculating vegetation, moisture and land-surface indicators and for analysing multi-temporal changes. Indicators are normalized and aggregated through a two-level composite index; the Analytic Hierarchy Process is proposed for deriving weights and testing the consistency of expert judgments. The principal result is a reproducible methodological framework rather than completed empirical mapping, because the final calculations and field validation are outside the scope of the present version. The framework can support the identification of potentially vulnerable areas, prioritization of monitoring and evidence-based land-management decisions. Its practical implementation requires subsequent calculation of the indicators, sensitivity analysis, independent validation and interpretation by land-use category.

Keywords: sustainable land use; GIS; remote sensing; land degradation; Sentinel-2; Landsat; composite index.

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ID 479 Agricultural Technology

Innovative manufacturing methods and high value-added materials in agriculture: a current evaluation in terms of agricultural machinery and smart agriculture technologies

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Abstract. The agricultural sector is undergoing a significant technological transformation due to the increasing food demand, climate change, sustainable management of natural resources, and the impact of digitalization processes. This transformation encompasses not only agricultural production techniques but also the design and production processes of agricultural machines and equipment. In recent years, additive manufacturing, computer numerical control (CNC) production, laser processing, robotic welding, hybrid production systems, and Industry 4.0-based smart production technologies have enabled agricultural machines to be produced lighter, more durable, precise, and energy-efficient. However, high-value-added materials such as carbon fiber, glass fiber reinforced composites, high-strength steels, aluminum alloys, and bio-based composites offer significant advantages in terms of reducing machine weight, lowering fuel consumption, increasing corrosion resistance, and extending product lifespan. In this study, innovative manufacturing methods and high value-added materials used in the agricultural sector have been evaluated through a review approach in light of the current literature. In the study, modern manufacturing technologies used in the production of agricultural machinery were first examined, and then the mechanical, economic, and environmental contributions of advanced engineering materials were discussed. Ayrıca bu teknolojilerin hassas tarım uygulamaları, insansız hava araçları, tarımsal robotlar, sensör tabanlı sistemler ve akıllı tarım ekipmanlarının geliştirilmesindeki rolleri değerlendirilmiştir. In conclusion, the combined use of innovative manufacturing methods and advanced material technologies offers significant opportunities for improving performance in agricultural machinery, reducing energy consumption, lowering production costs, and supporting sustainable production goals. With the widespread adoption of digital production technologies in the agricultural machinery sector, it is anticipated that the use of artificial intelligence-supported production systems, digital twin applications, additive manufacturing, and biocomposite materials will further increase in the future. This study presents a comprehensive evaluation of the current state of innovative production technologies and high value-added materials in the field of agricultural machinery, providing insights for future research and industrial applications.

Keywords: Agricultural machinery, Innovative manufacturing, Layered manufacturing, Industry 4.0, Composite materials, Smart agriculture

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ID 480 Agricultural Technology

Intelligent rural territory as a model of spatial development of Kazakhstan under the digital transformation of the agro-industrial complex

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Abstract. Rural development remains a structural condition of food security and economic growth in Kazakhstan. Despite sustained public investment in digital infrastructure and agriculture, rural areas continue to show uneven territorial development, low labour productivity, limited diversification of the rural economy and persistent out-migration. Existing Smart Village and Digital Village frameworks address connectivity and individual services, but they do not explain how connectivity is converted into economic and social outcomes at the level of a single rural territory. This paper proposes the concept of the Intelligent Rural Territory (IRT), which treats a rural area not as an object of state support but as an integrated socio-economic production system in which digital technologies serve as instruments for raising the efficiency of the agro-industrial complex, expanding export potential and improving quality of life. A six-layer architecture is developed, linking digital infrastructure, data, intelligent analytics, platforms, new types of economic activity and sustainable development outcomes through an ascending data flow and a descending control loop. For quantitative assessment the study introduces the Intelligent Rural Territory Index (IRTI), a composite index covering six blocks: digital infrastructure, intelligent agriculture, economic performance, human capital, environmental sustainability and quality of governance. The index differs from the IDI family of digital development indices in three constructive decisions: a subnational unit of observation; measurement of the capacity of a territory to convert connectivity into economic and social results rather than of connectivity as such; and, most importantly, non-compensatory geometric aggregation, under which weak performance in any single block is not offset by strong performance in the others. The methodology is implemented as a modular information system with fixed normalisation bounds, logged winsorisation, an explicit missing-data policy and a reproducibility manifest for every run. Ranking is performed not at a single weight vector but over a Dirichlet distribution with 100,000 weight realisations, so that a median rank is published together with a 5-95% rank interval. The study is methodological: the numerical results were obtained on a synthetic panel of 17 observation units and verify the correctness of the software implementation of the protocol rather than assess real territories. The verification showed that the index is published for 14 units, that the ranks of six of them are unstable with respect to the choice of weights, and that non-compensatory aggregation penalises unbalanced profiles without reordering the balanced part of the sample. Computation on official statistics is planned in a subsequent publication. The results are applicable to the design of state policy on the digital transformation of rural areas of the Republic of Kazakhstan and to the formulation of a national programme, Intelligent Rural Territory of Kazakhstan 2035. The architecture is not country-specific and is transferable to other large, sparsely populated, agriculture-intensive economies.

Keywords: intelligent rural territory, digital transformation, agro-industrial complex, composite index, non-compensatory aggregation, sensitivity analysis, sustainable rural development, Kazakhstan

6th International Conference on Research of Agricultural and Food Technologies
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ID 374 Agronomy

A rewiew on determining the drought stress tolerance status of some berry species under in vitro conditions

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Abstract. As with all fruit varieties, significant problems are being experienced in the production of berry fruits such as raspberries, blackberries and goji berry due to global climate change and drought. Although Turkey has a significant advantage in terms of the production potential of berry fruits, it has not yet reached the desired level. When considering their biochemical composition and importance for human health, fruit types such as blackberries, raspberries and goji berries are among those most favoured by consumers. This study therefore aims to identify the tolerance levels of new varieties that are drought-tolerant thereby overcoming the adverse climatic conditions that hinder the realization of this potential and to propose new approaches in this regard. This will contribute to the identification of species and varieties with high tolerance to drought stress. Furthermore, as is evident from the literature, drought studies conducted under in vitro conditions, particularly for raspberry, blackberry and gooseberry species and varieties, are limited and insufficient. As such studies on berry fruits are limited in Turkey, this review aims not only to identify varieties with high tolerance but also to examine innovative methods and models regarding drought resistance, thereby serving as a guide for future research.

Keywords: Raspberry, blackberry, goji berry, drought stress, micropropagation

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 375 Agronomy

The status of walnut cultivation in Adıyaman province

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Abstract. Adıyaman province, thanks to its rich ecological diversity and geographical structure encompassing different microclimate zones, is an important agricultural city that allows for the cultivation of numerous fruit species on an economic scale. The rugged nature of the province's general topography and the limited availability of arable land direct producers towards production areas focused on obtaining high added value per unit area. In this context, the fruit farming sector plays a locomotive role in the Adıyaman economy with its high-income potential and contribution to employment. Especially in the last twenty years, with agricultural modernization, the widespread implementation of irrigation projects, and conscious farming practices, Adıyaman has achieved a significant development momentum in fruit production. In this dynamic transformation process, walnut (Juglans regia L.) cultivation has become one of the preferred investment areas by producers in districts with different altitudes and soil characteristics. The high adaptability of walnuts to the ecological conditions of the region, ease of storage, and high market value constitutes the main motivating factors for this trend. The research methodology primarily involves conducting a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis based on the acquired data, synthesizing existing literature findings, and performing comprehensive evaluations tailored to the region. Indeed, when current statistical data is analyzed; Walnut production areas in Adıyaman have shown a geometric increase over the last twenty years, with planting areas increasing 2.5 times in the last ten years alone. These data indicate that Adıyaman has made significant progress towards becoming a prominent province in Turkey's walnut production projections. This study details the changes in walnut cultivation in Adıyaman province in recent years and its current socio-economic situation, analyzing the critical potential of the sector for the provincial economy in light of scientific data. Furthermore, the study addresses fundamental structural problems encountered in the production process, risks such as frost and drought brought about by global climate change, and shortcomings in marketing networks, presenting a general future perspective. The aim of the study is to provide a technical vision for existing walnut producers in the region and to serve as a scientific guide for entrepreneurs planning new investments.

Keywords: Adıyaman, Walnut Cultivation (Juglans regia L.), Agricultural Economics, Rural Development, Fruit Growing.

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ID 376 Agronomy

Traditional viticulture in marginal areas of Adıyaman

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Abstract. Adıyaman is situated in the northern belt of the Southeastern Anatolia Project (SEAP) region; due to its climate and topography, it exhibits transitional climatic characteristics and possesses rich agricultural diversity. The province's northern sections are particularly mountainous and rugged, consisting of rocky, shallow, and sloped lands classified as "marginal," where prime agricultural land is scarce. Although these disadvantaged areas do not offer economic returns for field crop farming, they have supported traditional viticulture for centuries, thanks to the grapevine's (Vitis vinifera L.) drought tolerance and robust root system. Viticulture in Adıyaman's marginal areas relies largely on family labour and low-input practices, utilising local genetic resources adapted to the region's ecological conditions. Local varieties such as "Besni," "Kızlar Tahtası," "Mazrune," "Serpene Kıran," and "Tümbü" are able to retain their distinctive aroma and quality characteristics even when grown with the limited water and soil resources of this challenging terrain. Production in these areas employs traditional systems rather than modern trellising; these include the "goble" (bush/goblet) system, where the vine is kept close to the ground, and the "serpene" system, where the vine's crown is elevated slightly above the ground using pruning residues and stakes. Of these methods, the "goble" system protects grape clusters from the adverse effects of high temperatures and intense sunlight while enabling the vines to maximise their utilisation of water that has infiltrated the soil from spring rains. By contrast, the "serpene" system protects the grape clusters from the sun and ensures good aeration within the canopy, thereby reducing damage from fungal pathogens and enhancing the effectiveness of pesticide applications. In the post-harvest phase, viticulture in Adıyaman transitions into a culture centred on high-value-added raisins and grape-based products (Şire). Grapes harvested from marginal lands are preserved through traditional processing methods, yielding products such as fruit leather (Pestil), triangular fruit rolls (Muska), cut fruit sheets (Kesme), and, notably, raisins. These products serve not only the personal consumption needs of the local population but also constitute a significant source of income for the local economy. Traditional viticulture practices hold strategic importance for maintaining ecological balance and providing local employment for the rural population. Viticulture on Adıyaman's marginal lands represents a sustainable, traditional agricultural model in the face of threats such as climate change and desertification. Integrating this ancient heritage with modern viticulture techniques such as modern training systems, controlled irrigation, and selective breeding is essential for the sustainability of agricultural development in the region. This study analyses the existing potential of these areas and addresses strategies for future development.

Keywords: Adıyaman, Marginal Lands, Traditional Viticulture, Local Grape Varieties, Grape-Based Product Culture, Şire Culture.

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(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 380 Agronomy

The effect of nitrogen fertilization on yield and yield parameters of forageturnip (Brassica rapa L.) under Cukurova conditions

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Abstract. This research was conducted research and implementation area of University of Çukurova Faculty of Agriculture Department of Field Crops in order to investigate the effects of different nitrogen doses (0, 50, 100, 150 and 200 kg/ha) on the forage yield and yield parameters of the forage turnip in accordance with the randomized block trial design with 3 replications during the 2022 -2023 growing season. According to the data obtained from the research, the highest fresh leaf yield (53.37 t/ha), fresh tuber yield (52.83 t/ha), total fresh leaf and tuber yield (105.37 t/ha) and tuber dry matter yield (4143 kg/ha) values were obtained from 200 kg/ha nitrogen dose. In the study, nitrogen doses did not have a statistically significant effect on fresh tuber yield, tuber dry matter content, tuber dry matter yield and fresh leaf dry matter content. These results show that a nitrogen dose of 200 kg/ha is suitable for the sustainable forage production from forage turnip plants under Çukurova conditions.

Keywords: Forage Turnip, Forage, Nitrogen, Fertilization, Çukurova

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 390 Agronomy

Grain loss during harvesting

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Abstract. Grain losses occurring during the harvest pose a significant problem in terms of global food security, sustainable agricultural production, and farmer incomes. Throughout the process from pre-harvest through storage many factors, such as biotic stresses, mechanical deficiencies, inappropriate harvest timing, and storage conditions, contribute to increased crop losses. While the literature indicates that the acceptable total harvest loss for small-grained crops is approximately 3%, it has been demonstrated that increasing the combine harvester's forward speed significantly increases grain losses in wheat, whereas in rice, the optimal harvest time and the direct combine harvesting method reduce both quantitative and qualitative losses. From a mechanical perspective, synchronizing the combine harvester's forward speed with the harvesting chain, determining the appropriate cutting table height, and precisely optimizing the concave and counter-concave settings are among the fundamental practices that reduce grain shedding and mechanical damage. In recent years, the integration of optical, acoustic, capacitive, piezoelectric, and Internet of Things (IoT)-based smart sensors with artificial intelligence and machine learning algorithms has enabled real-time monitoring of grain losses and the automatic implementation of corrective decisions, leading to significant advancements in harvesting technologies. It has been demonstrated that specially optimized piezoelectric sensor systems can measure losses during the rice harvest with an error rate of less than 3.83%. Despite high investment costs and the need for technical expertise, the widespread adoption of smart agriculture technologies, the implementation of appropriate machine settings, advanced breeding efforts, and increased farmer training are critical to reducing harvest and post-harvest losses and supporting sustainable food production. .

Keywords: Grain Loss, Combine Harvester Optimization, Smart Agriculture, Harvest Monitoring.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 391 Agronomy

Grain losses during storage

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Abstract. In developing countries, post-harvest grain storage processes particularly in small-scale subsistence farming operations have a critical impact on food security and producer incomes. Inadequate storage infrastructure, along with factors such as rodents, moisture, mold, and insect infestations, can drive product losses in traditional storage systems to extreme levels ranging from 20% to 100%; empirical findings indicate that the average loss in Kenyan storage facilities is 17.6%, while in Uganda's bean production, it stands at 22%. These losses do not merely result in quantitative and economic depletion; they also cause significant degradation of the nutritional value of grains including carbohydrates, fats, proteins, iron, and zinc due to microbial and insect activity, thereby contributing to malnutrition. In this context, scientific storage methods offer a sustainable solution matrix capable of reducing product losses to 1–2%, or even below 1% with modern applications; Among these solutions, hermetic (airtight) storage systems stand out; by consuming oxygen and increasing carbon dioxide concentrations through biological respiration in a sealed environment, they suppress pest development without the need for chemical pesticides. Three-layer polyethylene bags (PICS) and galvanized steel silos (Postcosecha), stand out as low-cost, highly effective technologies for smallholder farmers; however, the success of these systems depends on prerequisites such as pre-storage cleaning, hygiene, and reducing grain moisture to the critical threshold of 12–14%, which prevents mold and aflatoxin formation. Consequently, the widespread adoption of hermetic solutions in vulnerable regions such as Sub-Saharan Africa and Asia optimizes food supply security at the macro level and economic resilience at the micro level by preserving grain quality for up to two years while enabling farmers to hold onto their crops in the face of price fluctuations.

Keywords: Post-Harvest Losses, Hermetic Storage, Food Security, Smallholder Farmers.

6th International Conference on Research of Agricultural and Food Technologies
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ID 392 Agronomy

Germination and early seedling growth of soybean (Glycine max (L.) Merr.) cultivars under salt stress

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Abstract. Salinity is one of the major abiotic stresses that limits seed germination and early seedling establishment in cultivated crops. This study evaluated the salt tolerance of seven soybean cultivars (Adel, Arısoy, Atlas 3616, Lena, Lider, Likya, and Superb) during germination and early seedling growth. Seeds were subjected to five sodium chloride (NaCl) concentrations (0, 50, 100, 150, and 200 mM), and the experiment was arranged in a two-factor completely randomized design with four replications. Germination rate, germination index, salt tolerance index, root length, shoot length, and fresh and dry seedling weights were measured. The results showed that increasing salinity significantly reduced germination and seedling growth. Mean germination rate declined from 88.8% under control conditions to 12.5% at 200 mM NaCl, while the germination index decreased from 12.2 to 0.8 over the same salinity range. Similarly, mean root and shoot lengths were reduced from 5.35 to 0.18 cm and from 2.58 to 0.31 cm, respectively. Fresh and dry seedling weights remained relatively stable up to 100–150 mM NaCl but decreased sharply at 200 mM. At this highest salt concentration, the cultivars Arısoy, Lena, and Lider failed to germinate. Among the tested cultivars, Atlas 3616 and Superb maintained better germination and seedling growth under salt stress and were therefore identified as the most salt-tolerant cultivars, whereas Lider showed highest sensitivity to salinity. These findings indicate that Atlas 3616 and Superb constitute promising candidates for cultivation under saline conditions.

Keywords: Soybean, Salt Tolerance, Abiotic Stress

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 398 Agronomy

Biological control of Xanthomonas euvesicatoria, bacterial leaf spot pathogen of tomato and pepper, by antagonist bacteria

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Abstract. Bacterial leaf spot disease symptoms, caused by different Xanthomonas species, are necrotic lesions on leaves, stems, and fruits of tomato and pepper. Thereby, it reduces economic yield and quality losses in globally. In the recent surveys, pathogenic bacterium identified as Xanthomonas euvesicatoria as the predominant pathogen in the Mediterranean Region (Adana, Mersin, Antalya) of Türkiye. In the control of the disease, chemical applications are widespread all over the world, also in Türkiye. The research has focused on biological control by antagonistic microorganisms as an environmentally friendly and sustainable disease management strategy. The objective of the study was to evaluate biocontrol activity of 107 antagonistic bacterial strains against Xanthomonas euvesicatoria YA- 611 strain (identified by Prof. Aysan) In vitro conditions. Antibiosis assays were performed using a three-point inoculation assay on Tyriptic Soy Agar (TSA) medium. Biocontrol efficacy was assessed by calculating an inhibition index based on inhibition zone diameter relative to colony growth. Data were analyzed using one-way ANOVA followed by LSD multiple comparison tests ($p \leq 0.05$). Among the tested strains, four strains (OAK5-2-6, OAK4-1-3, Y68, and OAK5-1- 4) significantly inhibited the pathogen growth and were grouped in the highest significance category. The highest inhibitory activity was observed in OAK5-2-6 strain with an index value of 3.04, followed by OAK4-1-3 strain with 2.95 value. These findings indicate that the selected strains are promising biocontrol candidates of Xanthomonas euvesicatoria and provide a solid foundation for future greenhouse and field-scale trials as well as formulation development. This study was supported by the TUBITAK 2209- A Program (Project No: 1919B012470538).

Keywords: Tomato, Pepper, Xanthomonas euvesicatoria, biological control, Antagonist bacteria, Antibiosis, Bacterial leaf spot disease.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 409 Agronomy

Studies on the phenotypic and genotypic characterization of total anthocyanin properties in strawberries

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Abstract. The strawberry belongs to the genus Fragaria within the Rosaceae family, and its cultivated varieties generally have an octoploid (2n = 8x = 56) chromosome number. Due to its distinctive aroma, economic importance, high nutritional value and health benefits, the strawberry is the best-known and most popular fruit among the berry group. In recent years, breeding programmes for strawberries have increasingly focused on research into fruit quality and health-promoting compounds. In particular, anthocyanins which give the fruit its characteristic red colour and possess strong antioxidant properties, are critical factors influencing consumer satisfaction and market success. Consequently, strawberry breeding programmes are focused on developing high-quality new fruit varieties that meet consumer expectations and stand out in terms of anthocyanin accumulation. In strawberry breeding, the identification of genes associated with anthocyanin biosynthesis and the early selection of superior individuals based on these traits through molecular analyses significantly accelerates the process. The use of phenotypic measurements in conjunction with genotypic methods, such as QTL and GWAS, to identify genetic regions controlling anthocyanin production provides significant advantages in breeding strategies. This review, prepared with this objective in view, aims to compile existing and current research on the characterization of total anthocyanin properties in strawberries at the phenotypic and genotypic levels and to shed light on future studies in this area.

Keywords: Strawberry, anthocyanin, quality parameters, strawberry breeding, GWAS, QTL

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 410 Agronomy

Studies on the phenotypic and genotypic characterization of color traits in strawberries

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Abstract. Strawberries are the most popular berry due to their distinctive aroma, high nutritional value, and health benefits. In the fresh fruit market, "fruit color" is one of the most important quality parameters that directly determine consumer preferences and market success. An ideal and uniform red color is a key indicator of the fruit's ripeness, freshness, and quality. For this reason, strawberry breeding efforts are focused on developing new varieties with bright, attractive colors that meet consumer expectations. In strawberries, color is a complex trait shaped by the interaction of genetic and environmental factors. For success in the breeding process, color parameters must be precisely phenotyped using colorimetric methods (L*, a*, b*, Chroma, Hue angle). The use of these phenotypic data in conjunction with genotypic methods such as QTL and GWAS to identify genetic regions that control color enables the early selection of superior individuals, thereby significantly facilitating breeding strategies. This review, prepared with this objective in mind, aims to compile existing and current research on the characterization of color traits in strawberries at the phenotypic and genotypic levels and to shed light on the future of marker-assisted breeding strategies.

Keywords: strawberry, phenotype, genotype, genetic diversity, color

6th International Conference on Research of Agricultural and Food Technologies
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ID 429 Agronomy

Regulatory irrigation practices for repeatedly planted sunflower and soybean crops and their effect on the physical and agrochemical properties of soil

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Abstract. This three-year field study (2020–2022) evaluated irrigation regimes for repeatedly planted sunflower and soybean and their effects on soil physical and agrochemical properties under the semi-arid soil conditions of Central Fergana, Uzbekistan. The experiment was conducted at the "Bobursho" farm in Ulugnor district on saline soils with groundwater at 1.5–2.0 m depth. Four varieties—sunflower "Jahongir" and "YangiZamon" and soybean "Orzu" and "Tomaris"—were tested under three pre-irrigation soil-moisture regimes: 70-70-60%, 70-75-65%, and 70-80-70% of field capacity. The experiment comprised 12 treatments arranged in four replications; each plot was 560 m², with a 280 m² accounting area. Irrigation water was measured with Chipoletti and Thompson water gauges, while soil bulk density, porosity, aggregate-size distribution, permeability, humus, total nitrogen, phosphorus, nitrate nitrogen, available phosphorus, and exchangeable potassium were determined using standard agro-physical and agrochemical methods. Experimental data were statistically processed according to the field-experiment methodology of B. A. Dospekhov, with treatment effects compared across the irrigation regimes. The results showed clear crop-specific responses. For sunflower, the 70-75-65% regime gave the highest three-year mean seed yield: 24.6 q/ha for "Jahongir" and 22.5 q/ha for "YangiZamon", compared with 20.7 and 18.0 q/ha, respectively, under 70-70-60%. For soybean, the highest yields were obtained at 70-80-70%: 20.1 q/ha for "Orzu" and 22.1 q/ha for "Tomaris". Under the recommended regimes, soil bulk density in the 0–30 cm layer increased by 0.051–0.061 g/cm³ for sunflower and 0.076–0.093 g/cm³ for soybean relative to the beginning of the season, while soil porosity decreased by 1.88% and 2.83%, respectively. For sunflower under 70-75-65%, six-hour soil permeability was 912.2 m³/ha, whereas soybean under 70-80-70% showed 889.9 m³/ha. Agrochemical results also indicated crop-specific nutrient dynamics: under 70-75-65%, the 0–30 cm soil layer after "Jahongir" contained 0.754% humus, 0.056% total nitrogen, and 0.130% phosphorus; under 70-80-70%, the corresponding values for "Orzu" were 0.776%, 0.062%, and 0.134%. The recommended irrigation practice was four irrigations for sunflower using a 1-2-1 system at 451–726 m³/ha per irrigation (2172–2204 m³/ha seasonally) and five irrigations for soybean using a 1-2-2 system at 382–473 m³/ha per irrigation (2069–2158 m³/ha seasonally). Overall, 70-75-65% field-capacity moisture was the most effective regime for repeated sunflower, while 70-80-70% was optimal for repeated soybean, providing the best balance among seed yield, soil condition, and irrigation requirements under the studied Central Fergana conditions.

Keywords: irrigation regime, repeated cropping, sunflower, soybean, soil properties, seed yield

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 446 Agronomy

Sustainable growing media in fruit production: potential use of agricultural wastes and biochar as substrate components

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Abstract. Growing media used in soilless cultivation systems are important for maintaining a balanced supply of water and nutrients in the root zone, ensuring adequate aeration, and supporting plant growth. Peat is often used as a substrate component because of its desirable physical and chemical properties, but the non-renewability of peat and the environmental impacts of its extraction greatly limit its sustainability. Therefore, there is increasing interest in alternative substrate components such as composts obtained from agricultural and agro-industrial waste, wood fiber, bark materials, and biochar, reduce or partially substitute peat usage. Studies suggest that when properly processed, these materials can improve the physical and chemical properties of growing media and contribute to the development of more circular production systems. Although materials from agricultural waste are advantageous in the sense of low cost, local availability, and waste recycling potential, the success of their application can be directly affected by the variability in source material, processing method, and physicochemical properties. Studies also indicated that the use of biochars derived from agricultural waste as substrate components does not always yield positive results. The growth of plants can be restricted by the accumulation of potentially toxic elements, salinity, high pH, and electrical conductivity depending on the raw material source and pyrolysis conditions. In fact, a recent study of biochars derived from shrimp shells and pineapple peels reported that plant growth was significantly limited by high salinity and alkalinity, and the safe application rate for high-salinity biochars was restricted to approximately 10% (v/v). Studies in fruit production also demonstrate the significant potential of alternative growing media. It has been reported that reduced-peat substrate mixtures containing wood fiber, green compost, and biochar can provide similar fruit yields to traditional peat-based media in strawberry cultivation. Similarly, in a study evaluating different substrates containing wood fiber, biochar, composted green waste, and bark over two production cycles, it was determined that marketable strawberry yields were comparable to control media in most alternative media. It has also been shown that the addition of biochar to soilless growing media can have positive effects on plant development and fruit quality, increasing root and shoot development, fruit number, soluble dry matter, and lycopene content in tomatoes. In conclusion, agricultural waste and biochar have a great potential to develop sustainable growing environments in fruit production. The efficiency and the safe usage rates of these materials, however, are different due to the raw material source, production conditions, physicochemical properties, and the cultivated species. Hence, substrate formulations should be optimized on a product and material basis.

Keywords: Sustainable Growing Media; Biochar; Agricultural Wastes; Peat Replacement; Soilless Cultivation.

6th International Conference on Research of Agricultural and Food Technologies
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ID 447 Agronomy

Genetic diversity and fruit quality in jujube (Ziziphus jujuba Mill.): breeding perspectives

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Abstract. Jujube (Ziziphus jujuba Mill.) is an important fruit species economically and nutritionally. It is characterized by wide ecological adaptation, drought and heat tolerance, and rich health-promoting compounds. Jujube populations, accessions, and cultivars have been reported to show significant morphological, genetic, and biochemical variation, providing valuable resources for germplasm conservation, selection, and cultivar improvement. Genetic resources showed wide variation in fruit quality traits, such as fruit size, soluble sugars, organic acids, phenolic and flavonoid compounds, anthocyanins, antioxidant activity, mineral composition, and ascorbic acid. This diversity allows the selection of superior accessions with desirable horticultural, nutritional, and functional properties. Beyond its nutritional value, jujube has a long history of use in traditional medicine. Its fruits contain diverse bioactive compounds, including polyphenols, flavonoids, terpenoids, anthocyanins, alkaloids, and carotenoids, and have been associated with antioxidant, antimicrobial, anti-inflammatory, neuroprotective, cardioprotective, hepatoprotective, and other pharmacological activities. Recent advances in molecular markers, genome resequencing, QTL mapping, transcriptomics, and metabolomics have substantially improved understanding of the genetic basis of important quality traits. Genomic regions and candidate genes associated with sugar and acid accumulation have been identified, while integrated transcriptomic and metabolomic studies have provided new insights into ascorbic acid metabolism and triterpenoid biosynthesis. Developmental and postharvest factors also affect biochemical quality. Recent studies have shown that processing conditions such as drying temperature can significantly impact sugars, organic acids, phenolic compounds, antioxidant activity, and color features of jujube fruits. Overall, integrating phenotypic, biochemical, and genomic information offers substantial opportunities for the identification of superior germplasm and the development of cultivars with improved fruit quality, enhanced functional value, and greater adaptation to changing environmental conditions. Although more than 800 jujube cultivars have been recorded in China, cultivar development and registration remain comparatively limited in other countries possessing rich jujube germplasm, including Türkiye and Iran. Therefore, further systematic characterization of local genetic resources, selection of superior genotypes, and integration of multi-level data are needed to accelerate cultivar development and strengthen future jujube breeding programs.

Keywords: Jujube; Genetic Diversity; Fruit Quality; Bioactive Compounds; Germplasm; Molecular Breeding.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 448 Agronomy

Effect of solid worm compost applications on yield and yield components of chickpea under Bursa conditions

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Abstract. Effect of Solid Worm Compost Applications on Yield and Yield Components of Chickpea under Bursa Conditions The research was conducted in the fields of the Bursa Uludağ University Faculty of Agriculture Application Farm during the 2020 plant growing season. In the study, the effects of solid worm compost at doses of 0, 100, 200, and 300 kg/da were examined on yield and yield components of the Azkan variety and the Local chickpea line, applied at planting. In the research results, no effect of worm compost was observed on all yield components examined except for protein content. The differences between the varieties were found to be statistically significant in all the characteristics examined. Plant height ranged from 39.5-47.7 cm, first pod height from 17.7-23.3 cm, number of branches per plant from 5.43-6.87, number of pods per plant from 8.7-12.7, number of seeds per plant from 8.6-12.6, 100-seed weight from 33.7-44.0 g, seed yield from 103.7-133.3 kg/da, and protein content from 21.2%-22.7%. No significant interaction was found between variety and fertilizer dose in the examined characteristics.

Keywords: Chickpeas, earthworm castings, grain yield, yield factors

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 449 Agronomy

From molecular markers to genomics in hawthorn (Crataegus spp.): advances in genetic diversity, taxonomy, trait mapping, and breeding

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Abstract. Hawthorn (Crataegus spp.) is a genus of the family Crataegaceae that exhibits high morphological, genetic and biochemical diversity and is also taxonomically complex. Interspecific hybridization, polyploidy, apomixis and the prevalence of morphological intermediate forms make classification based solely on phenotypic characteristics difficult and limit the accurate identification of genetic resources. Therefore, molecular markers have become increasingly important in hawthorn research. While early studies relied mainly on PCR-based dominant markers such as RAPD and ISSR, subsequent research has used systems with higher discriminatory power such as SSR, SCoT, IRAP and iPBS. SSR markers have become an important transferable technology due to their co-dominant structures, high polymorphism and suitability for determining genotype identity from population structure. The development of EST-SSR from RNA-seq data has directly transferred marker discovery to hawthorn sequencing data. Following the initial SRAP-based genetic maps, RAD-seq- and SNP-based high-density linkage maps have enabled the identification of QTLs associated with fruit traits. Recent genome-wide scanning studies have demonstrated a significant shift from classical marker characterization to genome-wide variation analysis. However, the current literature still largely focuses on genetic diversity, population structure and germplasm characterization; large-scale SNP genotyping, GWAS, validated marker-assisted selection and genomic selection applications remain limited. This review critically assesses the historical development of molecular marker technologies in Crataegus, their application in genetic diversity, taxonomy, germplasm conservation, DNA fingerprinting, linkage mapping and QTL studies, and discusses future research priorities for genome-assisted hawthorn breeding.

Keywords: Crataegus; hawthorn; molecular markers; RAPD; ISSR; SSR; SCoT; iPBS; SNP; QTL; genomics; breeding.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 450 Agronomy

Advances in molecular marker applications in almond (Prunus dulcis): genetic diversity, germplasm characterization, and breeding

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Abstract. Almond (Prunus dulcis [Mill.] D.A. Webb) is an important source for genetic resource conservation, variety development and new breeding material development due to wide genetic diversity. The accurate characterization of this diversity is particularly important as phenotypic traits can be strongly affected by environmental conditions and may not reflect the underlying genetic relationships. Thus, in the last decades, technologies based on molecular markers have become the basic tools in the research of almond genetics. Some of the early studies using randomly amplified polymorphic DNA (RAPD), inter-simple sequence repeats (ISSR) and amplified fragment length polymorphisms (AFLP) gave preliminary data on the genetic diversity and relationships among varieties, local genotypes and wild relatives. Simple sequence repeat (SSR) markers have since been widely applied due to their high polymorphism, codominant inheritance, reproducibility and use for variety fingerprinting, characterization of genetic resources, analysis of population structure and assessment of genetic relationships. Molecular characterization has recently gained in resolution and practical value through single nucleotide polymorphism (SNP)-based genotyping, high-throughput marker platforms and allele-specific approaches. Molecular markers for traits of economic importance such as nutty flavor and self-fertility are demonstrating their potential for early selection and marker assisted breeding. This review summarizes the advances in the applications of molecular markers in almond emphasizing their impact on the assessment of genetic diversity, characterization and conservation of genetic resources, identification of varieties, genetic relationships and their practical integration into breeding programs. Together, these advances represent a change in the use of molecular markers from early descriptive tools for diversity analysis to more precise tools for parental selection, utilization of genetic resources, and breeding decision-making in almond.

Keywords: Prunus dulcis DNA fingerprinting SSR markers SNP genotyping Population structure S alleles Functional markers Marker-assisted selection.

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ID 451 Agronomy

Investigation of fresh broad bean yield and yield components of some broad bean varieties and lines under Bursa ecological conditions

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Abstract. The research was conducted in the 2022-2023 growing season at the Bursa Uludağ University Faculty of Agriculture Application and Research fields. In the research, 1 local variety and 10 cultivar and lines were used as experimental material. Statistically significant differences were determined between the varieties in all the characteristics examined except for the number of branches, pod length, and pod width. According to the research results; It was determined that the plant height ranged from 126.0-142.0 cm, the number of branches per plant from 2.6-3.0, the number of pods per plant from 10.6-17.0, the biological yield of the plant from 231.6-348.6 g, the weight of the pod from 70.0-103.3 g, the pod length from 12.3-15.3 cm, the pod width from 1.4-1.7 cm, the yield of fresh plants with pods from 5388.6-7651.0 kg/da, and the fresh pod yield from 1336.0-1885.0 kg/da.

Keywords: Broad bean, fresh broad bean yield, fresh broad bean yield components

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 454 Agronomy

CRISPR/Cas9-based functional dissection of the GhCesA4/7/8 cellulose synthase supercomplex in upland cotton (Gossypium hirsutum L.): implications for fiber quality breeding

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Abstract. Cotton fiber is a single epidermal cell whose commercial value is largely decided during secondary cell wall (SCW) deposition, when cellulose accumulates to more than 90% of fiber dry weight and sets strength, micronaire and maturity. GhCesA4, GhCesA7 and GhCesA8 encode the catalytic subunits that drive this phase, and CRISPR/Cas9 has made it possible to test their function directly in allotetraploid cotton. This paper reviews that evidence and asks what it means for fiber quality breeding. Ten PubMed queries returned 60 records, of which 22 sources were retained. In fibers harvested during SCW synthesis, the three subunits assemble into a 36-mer-like cellulose synthase supercomplex (CSS) that is absent from cotton stem tissue and from Arabidopsis, and whose microfibrils appear to bundle 72 glucan chains. Knocking out any one of the three abolishes the CSS and yields fibers with no SCW thickening, and non-orthologous CesA genes fail to complement the loss, so each subunit is indispensable. Loss-of-function editing of GhCesA4/7/8 therefore validates gene function but is not a route to better fiber. The exploitable variation sits one level higher, among the regulators that set the timing and dosage of these genes: GhMYS1 represses GhCESA4/8 to postpone SCW onset and prolong elongation, while the GhIAA14–GhARF7 module releases the same genes at the elongation-to-SCW transition. Knockout of either shortens fibers and raises micronaire and wall thickness. Of eight edited targets compiled here, only two increased a fiber quality trait, and both act outside the cellulose machinery. We argue for dose- and timing-oriented editing, meaning promoter and cis-element targeting and base editing of regulatory alleles, coupled with KASP-based marker-assisted selection and speed breeding.

Keywords: Gossypium hirsutum; CRISPR/Cas9; GhCesA4/7/8; cellulose synthase supercomplex; secondary cell wall; fiber quality; molecular breeding

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 455 Agronomy

Seed nanopriming in cereals: mechanistic evidence, effect sizes and the reporting standards required before field deployment

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Abstract. Seed priming with nanoparticle suspensions has become one of the fastest-growing areas of agricultural nanotechnology; a bibliometric survey of 6302 Scopus records reports exponential growth since 2013, with rice and wheat as the dominant crops. This review asks a narrower question than the field usually poses: what does the published evidence actually support, and what would have to be reported before a cereal seed or breeding programme could adopt the technique. Ten PubMed queries returned 63 records, from which 22 sources were retained, including 11 primary nanopriming studies. Mechanistically the results converge: particles adsorbed on or entering the seed coat trigger a controlled reactive oxygen species burst and redox signalling, followed by activation of antioxidant enzymes and faster mobilisation of stored reserves. Amorphous SiO_2 priming of rice at 20 mg L^{-1} acted through silanol and siloxane surface chemistry and enriched 18 amino acids and 6 sugars relative to hydropriming, while iron oxide priming of pepper produced more than 2200 differentially expressed genes although an equivalent iron dose supplied as $FeCl_3$ did not, which places the effect on the particle rather than on the released ion. Reported effect sizes decline sharply with developmental stage: 25 to 40% at germination and early seedling growth, 12.6 to 13.9% for composite stress indices, and 6.5 to 7.8% for field grain yield, the latter at p values of 0.051 and 0.066. Of the 11 compiled studies, 8 reported germination, 2 reported field yield and none reported food-chain endpoints. Concentration, particle size and zeta potential were the dominant predictors of response in a screen of 56 treatments in maize, and dose responses are biphasic, so single-concentration experiments cannot support a recommendation. We propose a minimum reporting set covering phase identity, dispersion state, ionic-equivalent controls and multi-environment validation.

Keywords: nanopriming; seed priming; cereals; reactive oxygen species; hormesis; reporting standards; food safety

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 475 Agronomy

Effect of some organic fertilizer resources on the yield and yield components of winter chickpea (Cicer arientinum L.) in Mediterranean climate conditions

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Abstract. Chickpea that is rich for protein, mineral matter, carbohydrate and vitamins and it is important for human food. It also fixed nitrogen throughout rhizobia bacteria in the nodules in the root. This study was conducted to investigate the effect of different organic fertilzer resources and their combinations on the yield and yield componenets of winter chickpea in Mediterreanean climate conditions. This experiment was conducted for two years in the research area of Çukurova University, Faculty of Agriculture, Department of Field Crops, based on rainfall in 2021/2022 and 2022/2023 growing seasons. The experiment were set up in autumn in both years according to the randomized blocks experiment design with 3 replications. Hasanbey registered chickpea cultivar was used as a research material. Treatments were: control (no fertilizer), microbial fertilizer, vermicompost fertilizer, K-humate fertilizer, chemical fertilizer + vermicompost fertilizer, microbial fertilizer +humate, humate + vermicompost fertilizer, vermicompost fertilizer+ chemical fertilizer, humate + chemical fertilizer. Basal chemical fertilizer was application of 27 N ha-1 and 69 kg N ha-1 (diammonium phosphate) before sowing. Grain yield was varied beween 2178 and 3870 kg ha-1. according to mean of the years. The grain yield in the control plot was the lowest while the highest grain yield was obtained from application of humate + vermicompost fertilizer in to the soil before sowing.

Keywords: Chickpea, Organic Fertilizer, Yield, Yield Components

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 418 Fisheries

Sustainable solutions for Caspian Sea ecology and oil extraction

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Abstract. The Caspian Sea is home to fragile marine species found nowhere else on Earth, such as the Caspian seal and sturgeon. At the same time, it serves as a massive oil and gas base for Azerbaijan, Kazakhstan, Turkmenistan, Russia, and Iran. Because these countries rely heavily on energy exports to support their economies, stopping offshore drilling is simply not realistic. However, routine industrial waste and accidental oil spills continue to put heavy pressure on marine life, conflicting directly with UN SDG 14 (Life Below Water) and SDG 13 (Climate Action). This paper explores a practical middle ground to protect the Caspian without damaging regional economies. We outline a combined approach centered on two main steps: deploying low-cost AI sensor networks for early spill detection, and building a shared environmental fund financed by local energy companies. By uniting modern technology with joint diplomatic action, Caspian states can build a workable system to protect marine life alongside ongoing energy operations.

Keywords: Caspian Sea, Oil Extraction, Marine Ecology, SDG 14, Environmental Protection

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 367 Soil Science

Assessing the operational applicability of GLDAS-2 Noah soil moisture estimates in an irrigated agricultural district of the Lower Seyhan Plain, Türkiye

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Abstract. Soil moisture products derived from global land-surface models are increasingly used in agricultural drought monitoring and water-resources assessment; however, their operational applicability at the field scale remains uncertain in intensively irrigated areas, where local irrigation events, heterogeneous soils, and root-zone conditions may not be adequately represented. This study addresses this gap by evaluating the operational usefulness of the GLDAS-2.1 Noah soil moisture product (Spatial resolution of 0.25°) in the 9,495-ha Akarsu Irrigation District of the Lower Seyhan Plain, Türkiye. Monthly GLDAS-2.1 Noah estimates for August 2024-May 2025 were compared with in-situ soil moisture observations from five multi-depth sensor locations representing the dominant İncirlik, Yenice, and Arıklı soil series. Performance was assessed using the coefficient of determination (R^2), mean bias error (MBE), and root mean square error (RMSE). GLDAS-2.1 Noah systematically underestimated field-measured soil moisture at all monitoring locations, with MBE values ranging from −26.19 to −14.85 %v/v and RMSE values from 15.63 to 26.42 %v/v. Nevertheless, the product captured seasonal wetting-drying behavior at selected locations, particularly TNS3 ($R^2 = 0.80$) and TNS1 ($R^2 = 0.75$). The discrepancies were mainly attributed to grid-to-point scale mismatch, local soil hydraulic variability, irrigation effects, and differences between model-layer and monitored profile depths. These findings indicate that GLDAS-2.1 Noah can support regional soil-moisture anomaly detection, seasonal trend monitoring, and preliminary agricultural drought assessment. However, local bias correction and calibration with in-situ observations are required before using the product for field-scale irrigation scheduling, root-zone water-deficit estimation, or operational threshold-based decisions. Integrating GLDAS outputs with ground-based sensor networks can therefore improve irrigation management and regional water-resources assessment in Mediterranean irrigated agricultural systems.

Keywords: GLDAS-2 Noah, soil moisture monitoring, irrigated agriculture, calibration, Lower Seyhan Plain

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 368 Soil Science

Suspended sediment export as an indicator of soil loss in Mediterranean irrigated agricultural drainage systems: evidence from the Lower Seyhan Plain, Türkiye

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Abstract. Suspended sediment export from irrigated agricultural drainage systems is a critical but often under-monitored component of soil loss and particle-associated pollutant transport, particularly in Mediterranean environments where rainfall events and irrigation return flows generate contrasting hydrological conditions. However, net suspended sediment export remains poorly quantified in intensively irrigated Mediterranean drainage systems, particularly through simultaneous monitoring of drainage inflows and the final outlet. This study addresses this gap by applying an inflow-outflow mass balance to quantify the magnitude and seasonal distribution of net suspended sediment export. This study quantified suspended sediment export in the Akarsu Irrigation District, Lower Seyhan Plain, Türkiye, during the 2025 hydrological year (1 October 2024-30 September 2025). Total suspended solids (TSS) were monitored at two drainage inflow points (L2 and L11) and at the drainage outlet (L4). Daily suspended sediment loads were estimated by combining measured TSS concentrations with daily discharge data, while net sediment export was calculated using a mass-balance approach: $S\_net = S\_L4 - (S\_L2 + S\_L11)$. The mean TSS concentration at the outlet was 702.7 mg L^{-1}, markedly higher than those observed at L2 and L11, which were 111.6 and 105.1 mg L^{-1}, respectively. Annual net suspended sediment export reached 56,065 Mg, equivalent to 5.905 Mg ha^{-1} yr^{-1} when normalized by area. Most of the annual net export occurred during the irrigation season, accounting for 98.6% of the total load. The highest monthly sediment exports were observed in July and October, indicating strong seasonal variability that may reflect irrigation return flows, in-channel sediment remobilization, and rainfall-related sediment mobilization during seasonal transitions. These findings demonstrate that agricultural drainage networks can act as active pathways of sediment export and highlight the need for integrated drainage-channel maintenance and irrigation return-flow management to reduce off-site sediment transport in intensively irrigated Mediterranean catchments.

Keywords: Suspended sediment, total suspended solids, irrigation return flow, agricultural drainage, Lower Seyhan Plain

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 457 Soil Science

Soil-plant-microorganism interactions: implications for soil biology and plant health

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Abstract. The dynamics of the soil ecosystem, plant growth, and plant well-being depends on the interaction of soil, plants, and microorganism. The interaction is crucial in the rhizosphere, affecting the development of roots, nutrient availability, degradation of organic matter, and biological activities of soils. Different types of organic materials produced by plant roots affect the diversity and functional properties of microorganism in soils, whereas the microbial metabolism affects the regulation of nutrient intake, growth, and response to the environment in plants. Besides, the soil microorganism affect the development of soil pathogens, resulting in plant diseases. In this research, the key aspects of the interactions between soil, plants, and microorganism and the impact of these interactions on soil biological activities and plant well-being have been investigated. Rhizophospheric bacteria have been studied in their effect on soil biological properties, plant vitality, and plant growth and diseases. Preservation of soil biological properties and improvement of plant well-being require understanding the interaction of microorganism, plants, and soil.

Keywords: Soil biology, rhizosphere, soil microbiota, plant health, interactions

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 355 Animal Science

Effect of storage position on egg weight loss in hatching eggs

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Abstract. This study investigated the effect of egg storage position on egg weight loss in hatching eggs. A total of 90 hatching eggs obtained from 33-week-old broiler breeders were used. The eggs were stored for 7 days in a room maintained at 20 °C and 70% relative humidity. Half of the eggs were stored with the broad end up (normal position), whereas the remaining eggs were stored with the narrow end up (opposite position). As a result, egg weight loss was higher in eggs incubated with the narrow end up. However, the difference in egg weight loss according to storage position was not statistically significant ($p > 0.05$).

Keywords: Egg Weight Loss, Storage Position, Hatching Eggs, Narrow and Broad End Up.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 358 Animal Science

Evaluation of crop residues as silage (silo feeds)

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Abstract. The increasing global population and the resulting growth of the livestock sector are driving a growing need for high-quality and economical roughage. Feed costs, accounting for a significant portion (approximately 70%) of total operating expenses, are leading producers to seek alternative and economical feed sources. In this context, agricultural residues (corn stalks, sunflower heads, cereal straw, sugar beet leaves, etc.) that are left in the field or burned, causing environmental pollution, are potential sources of roughage. However, their fibrous structure, low digestibility, and lack of crude protein limit their direct consumption, and the high moisture content of some makes storage difficult. This study investigates the possibilities of increasing and preserving the nutritional value of these harvest residues through silage (silo feed) technology. The silage process is optimized by using various additives (molasses, urea, lactic acid bacteria, and enzymes) that accelerate fermentation and improve its quality. In conclusion, utilizing plant harvest residues by making silage offers a strategic approach that not only reduces input costs in livestock farming but also prevents environmental pollution through the recovery of agricultural residues and contributes to a sustainable agricultural cycle.

Keywords: Crop residues, silage, silo feed, animal nutrition, recycling, sustainability.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 359 Animal Science

The importance of minerals in calf feeding and their effects on development

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Abstract. The sustainability and profitability of livestock farms are directly dependent on healthy calf-rearing strategies. The calf period is the most critical stage in an animal's development, shaping its future productivity potential and rapidly developing its immune system and skeletal structure. During this process, macro (calcium, phosphorus, magnesium, etc.) and micro (copper, zinc, selenium, iodine, etc.) minerals play a role in vital biochemical and physiological functions. Calcium and phosphorus ensure the strong formation of the skeletal system, while trace elements such as zinc, selenium, and copper support antioxidant defense mechanisms and immune responses, providing resistance against diarrhea and respiratory infections, which are the leading causes of calf mortality. Milk and replacer feeds, the primary feed for young calves, are often deficient in some trace minerals (especially iron and copper) necessary for growth. Mineral deficiencies lead to serious economic losses such as stunted growth, poor feed utilization, anemia, and increased susceptibility to disease. This study investigated the critical functions of minerals in calf feeding, the clinical manifestations of their deficiencies, and strategies for using the correct mineral combinations and highly bioavailable organic mineral sources in early-stage rations. It was shown that a balanced mineral feeding plan is a fundamental element in increasing calf survival rates and achieving herd renewal success.

Keywords: Calf nutrition, macro minerals, trace elements, immune system, growth performance.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 364 Animal Science

Deep learning-based image processing for early detection of mastitis in dairy cattle: a review and future directions

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Abstract. Mastitis is one of the most widespread and economically significant diseases in dairy cattle, negatively affecting milk yield, quality, and overall farm profitability. Early detection is essential for effective treatment and improved animal welfare; however, conventional methods such as somatic cell count and visual inspection often fail to provide timely and reliable results. Recent advances in artificial intelligence, particularly deep learning-based image processing, offer promising alternatives for automated and early mastitis detection. This study reviews current approaches that utilize computer vision techniques, including Convolutional Neural Networks (CNNs) and transfer learning models, to identify mastitis-related abnormalities from udder images, thermal data, and visual indicators. The review examines key stages of these systems, including data collection, preprocessing, model development, and performance evaluation. It also highlights major challenges such as limited datasets, class imbalance, and variability in farm conditions, which may affect model performance in real-world applications. Furthermore, emerging trends such as multimodal data integration, edge computing, and explainable artificial intelligence (XAI) are discussed as potential solutions to improve system reliability and usability. Overall, deep learning-based image processing provides a non-invasive and scalable approach for early mastitis detection, supporting sustainable dairy production and improved herd health management.

Keywords: Mastitis, Deep learning, Image processing, Dairy cattle, Precision livestock farming

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 365 Animal Science

Adjusting the dietary energy/protein ratio can positively affect growth performance and carcass characteristics in ANADOLU-T broiler chickens!

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Abstract. In this study, the effects of diets with varying energy-to-protein (E/P) ratios on performance, carcass characteristics, selected organ weights, and body defects were investigated in ANADOLU-T broiler chickens across different growth stages. A 42-day trial was conducted using six experimental groups with differing E/P ratios. Soybean meal was included in the diet during various periods (D1: 4th period, days 31–42; D2: 3rd–4th periods, days 21–42; D3: 2nd–4th periods, days 11–42; D4: 1st–4th periods, days 0–42), while fish meal was added to the diet for group D5 (1st–4th periods, days 0–42). No differences in feed consumption were observed among the treatment groups during the trial. Regarding the feed conversion ratio (FCR) in the 3rd week, the highest value was recorded in group D1 (1.40) and the lowest in group D5 (1.32) ($P<0.05$). FCR was significantly affected in the 3rd and 6th weeks ($P<0.05$). In the 3rd week, groups D4 and D5 showed higher values compared to D1 and D3, whereas in the 6th week, groups D5 and D2 exhibited better feed conversion than the control group. Overall, the dietary treatments did not significantly affect carcass weight, carcass yield, or carcass part weights. While no differences were observed in live weight or the breast meat-to-live weight ratio, abdominal fat and digestive system weights were found to be higher in females. Digestive system weight was higher in group D3 compared to the control group. Abdominal fat decreased by 24.6% in the D5 group compared to the control group ($P < 0.05$). While footpad dermatitis scores were higher in the D2 group, and toe curvature deformity and elbow burn scores were higher in the D5 group, no significant differences were observed in meat quality traits—including pH, color, woody breast, and white striping. In conclusion, lowering dietary energy/protein (E/P) ratios improved certain carcass characteristics of ANADOLU-T broilers. Furthermore, supplementing ANADOLU-T rations with fish meal positively influenced performance by improving feed conversion and reducing abdominal fat accumulation.

Keywords: broiler, ANADOLU-T, energy/protein ratio, performance, abdominal fat, meat quality, fish meal, soybean meal

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 366 Animal Science

Can branched-chain amino acids and L-glutamine improve growth performance and carcass characteristics in ANADOLU-T broiler chickens?

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Abstract. Growth performance and carcass characteristics in broiler chickens are directly influenced by the amino acid profile of the diet, in addition to genetic potential. Branched-chain amino acids (BCAAs)—specifically leucine, isoleucine, and valine—play a critical role in regulating muscle protein synthesis, whereas L-glutamine is considered an important amino acid for intestinal epithelial integrity and cellular metabolic processes. This study aimed to determine the effects of supplementing Anadolu-T broiler diets with BCAAs and L-glutamine on growth performance and carcass characteristics. A total of 560 day-old Anadolu-T broiler chickens were used in the study. The experiment involved 8 treatment groups with 7 replicates each, with 10 birds (5 female, 5 male) per replicate. Treatments consisted of a control group and groups receiving varying levels of BCAAs (20%, 35%, 50%), 1% L-glutamine, and combinations thereof. The trial lasted 42 days, during which weekly live weight, feed intake, feed conversion ratio, carcass parts, and certain internal organ parameters were evaluated. Live weight gain was generally highest in the 20% BCAA + 1% L-glutamine group ($P<0.05$). The best feed conversion ratio was observed in the 50% BCAA + 1% L-glutamine group during the first week and in the 1% L-glutamine group during the sixth week, while the poorest value was recorded in the control group. All groups supplemented with glutamine achieved better feed conversion ratios than the control group, whereas no difference was found between the BCAA-supplemented groups and the control group. No differences were observed among the groups regarding carcass weight; the weights of the liver, gizzard, spleen, abdominal fat, bursa of Fabricius, and digestive system; or the length of the digestive system. The breast meat percentage was found to be higher in the group receiving 35% BCAA + 1% L-glutamine compared to the 35% BCAA, 50% BCAA, 50% BCAA + 1% L-glutamine, and control groups.

Keywords: Anadolu-T, BCAA, L-glutamine, growth performance, feed utilization

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 412 Animal Science

Nanotechnology applications for sustainable livestock production

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Abstract. Nanotechnology offers ways to modify mineral delivery, protect bioactive feed ingredients and develop veterinary treatments, but its contribution to sustainable livestock production requires evidence beyond a favorable biological response. This narrative review examines a purposively selected, full-text literature set comprising original animal experiments, application reviews and a food-and-feed risk-assessment guidance document. The synthesis compares material characterization, experimental design, comparators, nutritional and health outcomes, and the limits of environmental interpretation. Studies in piglets and chickens report formulation-dependent responses to selenium, zinc and copper nanoparticles. A dairy-goat experiment links nanozeolite supplementation with changes in rumen fermentation and milk production, while a chicken nanoemulsion trial provides a direct example of bioactive delivery. An experimental bovine mastitis study extends the discussion to veterinary applications but remains preliminary. Across these studies, responses depend on the material, dose, animal model and endpoint; improved performance does not establish universal superiority over conventional supplements. Evidence for long-term exposure, residues, environmental fate and economic feasibility remains insufficient within the selected corpus. Nanotechnology can therefore be considered a set of application-specific approaches whose nutritional and veterinary value must be assessed alongside safety and resource use. The review identifies practical comparison requirements without proposing universal supplementation rates or estimating an overall treatment effect.

Keywords: Nanotechnology; sustainable livestock production; nanominerals; animal nutrition; animal health.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 413 Animal Science

The role of nanotechnology in animal welfare and production efficiency

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Abstract. Nanotechnology is being investigated as a means of improving nutrient delivery, animal health and production efficiency, but the strength of evidence differs among applications. This narrative review synthesises 25 publications from 2017 to 2026 for which a DOI and an accessible online full text were verified. Experimental feeding studies are considered separately from reviews, diagnostic development and therapeutic proof-of-concept studies. Selenium, zinc and copper formulations produced favourable responses in selected growth, intestinal, antioxidant or mineral-status measures, although improved nutrient status did not consistently increase production. In dairy cows, lysine-coated copper oxide nanoparticles increased hepatic copper retention without increasing milk yield. Nanoemulsions containing curcumin and capsaicin improved feed conversion under high stocking density in Korat chickens, while a selenium formulation modified selected meat-quality and antioxidant measures under heat stress. These findings are specific to the formulations and experimental conditions tested. Selenium-tellurium nanoparticles produced a transient bacteriological response in an experimental bovine mastitis model without a significant clinical-score advantage. A graphene-based calcium sensor provides an analytical example relevant to milk-fever screening, but its farm-level diagnostic and welfare benefits remain unestablished. Interpretation requires attention to comparator diets, dose units, particle characterisation, statistical significance and the distinction between health indicators and direct welfare outcomes. Priorities include longer-term safety, tissue and product residues, reproducible manufacturing, clinical validation and farm-level economic and environmental assessment. Nanotechnology may support animal production and health management when evaluated for a defined purpose; a favourable biomarker or production response alone does not establish an overall welfare benefit.

Keywords: Nanotechnology, animal welfare, nanominerals, nanoencapsulation, feed efficiency, biosensors.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 435 Animal Science

The chicken embryo model in biotechnology and translational research: applications, advantages, and future perspectives

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Abstract. The chicken embryo (Gallus gallus domesticus) is a widely used experimental model in biological and translational research due to its external development, short 21-day incubation period, low maintenance cost, and ease of experimental manipulation. These characteristics make it suitable for diverse research areas, including developmental biology, toxicology, angiogenesis, oncology, tissue engineering, and genetic studies. In particular, the highly vascularized chorioallantoic membrane (CAM) provides a practical in vivo-like system for evaluating tumor development, vascular responses, and biomaterial interactions. CAM assays can therefore support rapid preclinical screening while reducing the need for more costly and complex mammalian experiments. The model also offers ethical advantages through its compatibility with the 3Rs principles. Furthermore, developments in genome editing, advanced imaging, and single-cell technologies have increased its value for mechanistic and functional studies. Despite limitations associated with species-specific physiology and the investigation of long-term processes, the chicken embryo remains a scalable, economical, and versatile platform that effectively bridges in vitro studies and mammalian in vivo models.

Keywords: Chicken embryo, biotechnology, CAM model, developmental biology

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 469 Animal Science

Relationship of estimated dry matter intake and pasture sward nutritive value with individual milk yield and milk quality parameters in cows

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Abstract. The aim of the study was to assess the relationship of estimated dry matter intake (estimated DMI) and pasture sward nutritive value parameters with individual milk yield and milk composition under rotational grazing. The study was conducted in lactating cows (commercial herd) at APC "Bastau-2019". The association between estimated DMI and milk yield was analyzed for paddocks 3–6 (30.05–25.07.2026) using HerdMonitor data. Feed intake was calculated using the formula: eating time × 0.03 kg DM/min. The Pearson correlation between estimated DMI and individual milk yield was weakly negative and statistically non-significant ($r = -0.153$; $p = 0.191$). Changes in milk quality were evaluated based on fat, protein, solids-not-fat (SNF), density, and somatic cell count (SCC). During monitoring, 13 sward samples were analyzed; the results were interpreted taking into account the animals' daily supplementation (4 kg of ground barley and 0.5 kg of linseed meal).

Keywords: dry matter, milk yield, commercial dairy cattle, rotational grazing, pastures, fat, protein.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 377 Other

Bell pepper yield and chlorophyll response to deficit irrigation strategies under Mediterranean field conditions

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Abstract. Water limitation is a major constraint for bell pepper production under Mediterranean field conditions, where high evaporative demand may reduce chlorophyll status and yield formation. This study evaluated the effects of surface and subsurface drip irrigation combined with different irrigation strategies on yield, soil water status, actual crop evapotranspiration and chlorophyll response of bell pepper. Field experiments were conducted during the 2016 and 2017 growing seasons using a split-plot design with four replications. Surface drip irrigation and subsurface drip irrigation were assigned as main plots, while full irrigation, 75% and 50% deficit irrigation, partial root drying and regulated deficit irrigation were tested as irrigation strategies. Leaf chlorophyll status was monitored using a portable chlorophyll meter before irrigation events. Irrigation strategy significantly affected yield in both years, whereas irrigation method had no significant effect. Full irrigation produced the highest yields, reaching 74.9 t ha–1 in 2016 and 71.1 t ha–1 in 2017, while partial root drying resulted in the lowest values, with 49.8 and 45.9 t ha–1, respectively. Chlorophyll readings declined with increasing water restriction, ranging from 49.8 to 67.5 across treatments and years. Strong curvilinear relationships were obtained between chlorophyll readings and soil water content, actual crop evapotranspiration and yield. The results indicate that deficit severity was more decisive than drip lateral placement in determining bell pepper performance, and that chlorophyll readings may support irrigation monitoring when interpreted together with soil water status and yield response.

Keywords: Capsicum annuum; water stress; SPAD index; soil moisture; partial root drying; crop performance

6th International Conference on Research of Agricultural and Food Technologies
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ID 383 Other

The impacts of pesticides on sustainable agriculture: an evaluation of herbicides and fungicides

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Abstract. The intensification of agricultural production has substantially increased global reliance on pesticides, particularly herbicides and fungicides, to enhance crop productivity and ensure food security. While these agrochemicals play a crucial role in controlling weeds and fungal diseases, their intensive and indiscriminate application has raised serious concerns regarding environmental sustainability, biodiversity conservation, and human health. Reports published by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) indicate that the environmental and societal impacts associated with pesticide exposure continue to increase worldwide. Accordingly, this study investigates the environmental and social risks posed by intensive herbicide and fungicide use and examines how these risks should be incorporated into sustainable agricultural planning and policy development. The primary objective is to comprehensively assess the environmental, ecological, and social implications of pesticide use while identifying current trends and policy directions that support sustainable agricultural systems. This study evaluates the impacts of herbicides and fungicides on soil, water, and air quality, pesticide residues in agricultural products, biodiversity, ecosystem services, and human health. A qualitative research framework based on systematic content analysis was employed using national and international scientific publications, official reports published by the FAO and WHO, institutional databases, and relevant academic literature. The collected data were analyzed using the MAXQDA qualitative data analysis software through thematic coding and categorization under key dimensions, including environmental impacts, human health risks, food safety, biodiversity loss, sustainable agricultural planning, and alternative pest management strategies. The findings demonstrate that intensive pesticide use extends beyond agricultural productivity and generates significant environmental, ecological, and public health challenges. Water contamination, soil degradation, declining populations of beneficial organisms, disruption of ecosystem services, and pesticide residues in food products were identified as major threats to sustainability. The results further indicate that conventional pesticide-dependent agricultural practices require critical reconsideration within the framework of sustainable agriculture. The study concludes that achieving sustainable agricultural systems requires the integration of precision agriculture technologies, biological control strategies, and Integrated Pest Management (IPM) into agricultural and spatial planning processes, thereby reducing environmental impacts while maintaining agricultural productivity.

Keywords: Pesticide, herbicide, fungicide, sustainable agriculture, MAXQDA, spatial planning, environmental sustainability, biodiversity

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 401 Other

Assessing the economic sustainability of regional floriculture agribusiness: development and application of the floriculture economic sustainability index (FESI) in Namangan region, Uzbekistan

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Abstract. Sustainable floriculture agribusiness has become an increasingly important component of regional agricultural development due to its high value-added production, employment generation, and export potential. This study aims to evaluate the sustainable development of floriculture agribusiness in Namangan Region, Uzbekistan, by developing and applying a Floriculture Economic Sustainability Index (FESI). The proposed composite index integrates five key dimensions of sustainability, namely territorial development, production performance, financial performance, resource efficiency, and diversification, providing a comprehensive framework for assessing regional floriculture development. The empirical analysis is based on official statistical data covering the period 2016–2025 and focuses on the three leading floriculture clusters of the region: Namangan city–Davlatabad agglomeration, Namangan district, and Uchqo'rg'on district. The results indicate that the FESI increased from 100.0 in 2016 to 1131.7 in 2025, reflecting substantial improvements in production capacity, financial performance, and territorial specialization. Comparative analysis further reveals significant spatial differences among the three clusters, with the Namangan city–Davlatabad agglomeration demonstrating the highest level of economic performance and production concentration. The findings suggest that future sustainable development should prioritize technological modernization, efficient resource utilization, greenhouse expansion, and market diversification. The proposed FESI provides a practical analytical tool for evaluating regional floriculture development and may support evidence-based policymaking aimed at strengthening the competitiveness and long-term sustainability of high-value agricultural sectors in Uzbekistan.

Keywords: Floriculture agribusiness, Economic sustainability, Floriculture Economic Sustainability Index (FESI), Regional development, Agricultural clusters, High-value agriculture, Uzbekistan, Namangan Region, Production performance, Resource efficiency.

ID 408 Other

Determination of the complete sequence data for the CLAVATA, FASCIATA, STAMINA PISTILLOIDA and WUSCHEL genes in the plant Vuralia turcica, endemic to Turkey

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Abstract. Multicarpellate gynoecia are uncommon in legumes. Although the Caesalpinioideae subfamily exhibits multicarpellary ovaries, multilocular ovaries have not been documented within this group. While legumes typically feature a gynoecium with just one carpel, on rare occasions a multicarpellate gynoecium may emerge, triggered by mutations, environmental shocks, or other mysterious causes. Meristem size is typically shaped by a dynamic interplay between the gene WUSCHEL (WUS) and its negative regulators, including CLAVATA (CLV) and FASCIATA (FAS). Vuralia turcica stands out for its remarkable carpel multiplication within the Papilionoideae subfamily; however, a literature review reveals that no research has yet explored the mechanism behind its multicarpellary trait. The enduring Eber population of V. turcica, still thriving in the Nezahat Gökyigit Botanical Garden (NGBG), served as the primary plant material for this research. Complete sequence data for the CLV, FAS, STAMINA PISTILLOIDA (STP), and WUS genes, for which partial sequences were previously known, have been obtained and visualized using Tablet. BLASTn analysis of the sequence data showed that V. turcica was most similar to Glycine max for the CLV gene and to Lupinus angustifolius for the FAS and WUS genes. The partial FAS gene sequence identified in the researcher's previous studies matched the CDS in the 12th exon with 99.01 percent accuracy. Furthermore, the protein sequence data for the relevant genes were also determined.

Keywords: Clavata, Fasciata, multicarpellate gynoecia, Vuralia turcica, Wuschel

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 420 Other

Cluster-based development of agritourism entrepreneurship: an integrated tourism attractiveness and econometric assessment of the Namangan region, Uzbekistan

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Abstract. Agritourism has become an important instrument for promoting sustainable rural development by integrating agriculture, tourism, entrepreneurship, and environmental management. However, despite its considerable resource potential, the development of agritourism in many transition economies remains constrained by insufficient institutional coordination, uneven territorial competitiveness, and limited analytical tools for regional planning. This study aims to develop an integrated framework for assessing agritourism entrepreneurship using the Namangan region of Uzbekistan as an empirical case. The research applies a mixed-methods approach combining standardized tourism attractiveness indicators, an Integrated Tourism Attractiveness Index (ITAI), cluster-based institutional analysis, multiple regression modelling, and forecasting techniques. Tourism attractiveness was assessed using four standardized indicators: protected natural areas, tourism infrastructure, unique natural attractions, and environmental quality. The findings reveal significant spatial disparities among districts, with Kosonsoy, Pop, Chortoq, Chust, and Yangiqo'rg'on demonstrating the highest agritourism competitiveness. The econometric results indicate that average real income per capita, diversification of agritourism services, and urban population positively influence visitor arrivals, while the estimated regression model explains approximately 91.4% of the observed variation in agritourism demand. Forecasting results suggest that the number of agritourism visitors may increase from 4,463 in 2024 to approximately 4,670 by 2029, representing an overall growth of about 4.6% under the baseline development scenario. The study contributes to the literature by integrating destination competitiveness, institutional governance, cluster-based regional development, and econometric forecasting within a unified analytical framework. The proposed approach provides practical policy recommendations for strengthening agritourism entrepreneurship and sustainable regional development in Uzbekistan and other transition economies.

Keywords: Agritourism entrepreneurship; Tourism attractiveness; Integrated Tourism Attractiveness Index (ITAI); Cluster-based development; Regional competitiveness; Econometric modeling; Sustainable rural development; Tourism forecasting; Namangan region; Uzbekistan.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 421 Other

Development of the floriculture economic sustainability index (FESI): a composite framework for assessing regional floriculture agribusiness in Uzbekistan

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Abstract. Sustainable floriculture agribusiness has become an increasingly important component of regional agricultural development because of its high value-added production, employment generation, and export potential. This study evaluates the economic sustainability of floriculture agribusiness in Namangan Region, Uzbekistan, by developing and applying a Floriculture Economic Sustainability Index (FESI). The composite index integrates four economic dimensions: territorial development, production and financial performance, resource efficiency, and diversification. The empirical analysis uses official statistical data for 2016–2025 and focuses on three leading floriculture clusters: the Namangan city–Davlatabad agglomeration, Namangan district, and Uchqo'rg'on district. Each underlying indicator is converted into a base-year index (2016 = 100); benefit indicators are expressed as the ratio of the current value to the 2016 value, while cost indicators are inversely indexed. Indicators receive equal weights within each dimension, and the four sub-indices receive equal weights of 0.25 in the FESI. On this scale, the FESI rose from 100.0 in 2016 to 1131.7 in 2025. The value 1131.7 therefore denotes an index level 11.317 times the baseline, or 1031.7% above it, rather than a percentage score bounded between 0 and 100. The increase was driven mainly by territorial expansion and production–financial performance, while resource efficiency improved much more slowly. Spatial comparison shows that the Namangan city–Davlatabad agglomeration had the highest production concentration and economic performance. The FESI is intended as a longitudinal measure of economic sustainability; it does not constitute a comprehensive assessment of social or environmental sustainability.

Keywords: Floriculture agribusiness, Economic sustainability, Floriculture Economic Sustainability Index (FESI), Composite indicator, Regional agricultural development, Agricultural clusters, High-value agriculture, Uzbekistan, Namangan Region, Longitudinal analysis.

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ID 423 Other

Innovation-driven development of agritourism entrepreneurship: evidence from the Namangan region of Uzbekistan

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Abstract. Agritourism is increasingly used to diversify rural entrepreneurship, create additional farm income, preserve local culture, and strengthen multifunctional rural development. This study examines innovation-driven agritourism entrepreneurship in the Namangan region of Uzbekistan. It uses the dissertation's conceptual framework and a 2022 survey of 71 landowners in Kosonsoy, Pop, Chortoq, and Yangiqo'rg'on. Seven innovation dimensions were assessed on a ten-point scale. Product innovation received the highest assessment (8.1 points), followed by marketing and social innovation (7.4 points each). Ecological innovation was evaluated at 5.3 points, information innovation at 4.7 points, and organizational innovation at 4.5 points, while technological innovation remained among the weakest dimensions. The paper systematizes a three-stage innovation management framework: generation and search for ideas; development and selection of ideas; and implementation supported by legal, organizational, financial, human-resource, technical, and information mechanisms. The findings indicate that agritourism competitiveness depends on the capacity of entrepreneurs to transform agricultural, natural, and cultural resources into differentiated visitor experiences.

Keywords: agritourism; entrepreneurship; innovation; rural development; tourism services; Namangan region; Uzbekistan.

ID 424 Other

Agritourism as a vertical diversification strategy for rural entrepreneurship: employment, income and institutional implications for the Namangan region

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Abstract. This article examines agritourism as a vertical diversification strategy for rural entrepreneurship in the Namangan region of Uzbekistan. The empirical component uses four benchmark-year observations (2010, 2015, 2020, and 2021) on economically active and inactive populations, transcribed from official regional labour-resource statistics reproduced in the underlying dissertation materials. The economically active population increased from 866.0 thousand in 2010 to 1,224.0 thousand in 2021, while the active rural population rose from 295.8 thousand to 415.9 thousand. These figures describe the regional labour context; they do not measure an agritourism effect. The conceptual component defines vertical diversification as the movement of a farm or rural household toward downstream processing, direct sale, hospitality, and experience provision while retaining a functional link to agriculture. On this basis, agritourism is interpreted as a potential mechanism for converting agricultural products, household assets, landscapes, and local knowledge into higher-value services. Claims concerning employment, income, local multipliers, and institutional development are presented as theoretically and externally supported propositions requiring enterprise-level verification in Namangan.

Keywords: agritourism; vertical diversification; rural entrepreneurship; employment; farm income; rural development; Namangan; Uzbekistan.

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ID 434 Other

The climate change and possible effects on the capital city of Turkiye

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Abstract. Climate change, a major environmental challenge, has caused droughts in many regions worldwide. This study aims to examine climate change and its potential impacts in Turkey's capital city by analyzing key climate factors such as temperature (average, maximum, and minimum), precipitation, humidity, rainy days, and sunny hours. To do this, linear regression and standard deviation are used. The minimum temperature data range from -4.2°C to 16.1°C; the maximum temperature varies from 29.9°C to 3.7°C, and the average temperature ranges from 23.3°C to -0.6°C. Precipitation peaks in March, November, and December, and is lower in January, July, and August, indicating seasonal shifts. Humidity (%) reaches its highest in January (75%) and December (72%), then drops to its lowest in July and August (38%). Rainy days fluctuate, with peaks of 7 days in March and December and lows of 1 day in July. Summer (July–September) experiences 1–2 rainy days, showing continental influence. Winter and early spring see more rainfall, suggesting increased water availability and greater drought risk in summer. July has the most sunny hours (12.9), while January has the fewest (5.3). The study concludes that climate change is likely to worsen current issues, threatening water resources, agriculture, infrastructure, and health. Implementing effective adaptation strategies such as water management, green infrastructure, and sustainable urban planning is critical for Ankara's future resilience.

Keywords: Global warming, Climate change, Capital city, Ankara province, Turkiye

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 441 Other

Animal welfare and sustainable agriculture in Kazakhstan: bridging national law and international standards

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Abstract. The main aims of this article are to demonstrate that the welfare of agricultural animals is an integral part of sustainable development, to compare Kazakhstan's legislation with international animal welfare standards, and to develop legislative and policy recommendations in this regard. The author will highlight the interconnection between animal welfare and animal health, human health, and environmental sustainability. The article will examine the One Health and One Welfare perspectives, which are international approaches aimed at connecting the welfare of farm animals with food security, human health and well-being, sustainable agricultural production, and environmental protection. The necessity of protecting the welfare of farm animals is evident. Healthy animals kept in conditions that minimize pain, fear, and stress contribute to healthier and safer food production. At the same time, intensive factory farming and mass production of animals create serious animal welfare concerns and have a significant impact on the environment, human health, and the health of agricultural workers and local populations. Large-scale intensive production contributes to environmental degradation, including through greenhouse gas emissions, waste, pressure on natural resources, and loss of biodiversity. The apparent short-term economic benefit of lower market prices for animal products is outweighed by the long-term costs to nature, human health, and the sustainability of agricultural production. These issues are increasingly recognized within international approaches to sustainable animal farming. Kazakhstan's legislation concerning animals includes the Law on Veterinary Medicine, which primarily regulates animal health, veterinary activities, animal disease prevention and control, and veterinary and sanitary safety. The Law on Responsible Treatment of Animals, adopted in 2021, represents an important step towards recognizing animal welfare in Kazakhstan's legal framework. It expressly recognizes that animals are capable of experiencing pain and physical suffering and establishes, among its principles, the responsibility of animal owners for the life, health, and welfare of animals. However, the law does not yet provide a comprehensive framework for the welfare of farm animals, particularly in relation to the conditions in which animals are bred, kept, transported, and slaughtered. Regional integration legislation in the form of EAEU agreements is also of limited assistance in establishing comprehensive animal welfare requirements. Kazakhstan's legislation therefore remains to be further harmonized with internationally recognized animal welfare standards, including those developed by the World Organisation for Animal Health (WOAH). Currently, a significant share of Kazakhstan's red meat and milk production comes from small family farms, where animals may receive more individualized treatment. This provides some hope that animals may be treated better in these settings, although the actual level of welfare depends on farming practices and conditions. At the same time, most poultry is produced in intensive production systems, and the number of large-scale mass-production establishments for the red meat and milk is constantly increasing. This increase is driven primarily by profit- generation considerations. However, this is a direction that Kazakhstan should reconsider in light of the long-term survival and sustainability of the agricultural industry, its impact on nature, and its consequences for human health and animal welfare. The article will propose legislative and policy measures aimed at strengthening the protection of farm animals and bringing Kazakhstan's legal framework closer to international standards. It will argue that integrating animal welfare into agricultural and sustainable development policies is necessary for achieving a more sustainable agricultural sector and addressing the interconnected challenges of food security, environmental protection, and human health in long perspective.

Keywords: Animal welfare, Sustainable agriculture, Kazakhstan legislation, One Health, One Welfare, Farm animals, Veterinary law, Intensive farming, WOAH standards, Food security.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 453 Other

Carbon-free heat supply of rural health and sport facilities based on a low-enthalpy artesian well: a case study from Pavlodar Region, Kazakhstan

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Abstract. Rural heat supply in Kazakhstan relies almost entirely on small coal-fired boiler houses, a poorly decarbonised segment of the energy system. This study assesses the technical, environmental and economic feasibility of a carbon-free heat supply for a rural swimming pool building in Konstantinovka village, Pavlodar region, using an existing artesian mineral well (No. 24: wellhead temperature 36 °C, permitted yield 5.0 l/s). Because the source is warmer than the pool water (27 °C), a two-stage cascade is proposed: direct heat exchange covers the pool load, and the residual flow at 34.2 °C feeds a 200 kW water-to-water heat pump for space heating and domestic hot water. Heat load, thermodynamic, emission and economic models were applied against a coal-fired baseline. The design heat load of the refurbished building is 199.6 kW, 37.6 kW of it directly; direct use supplies 30 % of the 660 MWh annual demand. The heat pump coefficient of performance is 6.38 at a 45 °C supply temperature and 4.57 at 55 °C (seasonal value 5.85), and the system-level heat-to-electricity ratio is 7.6. The scheme avoids 203 t of coal and 285 t of carbon dioxide per year (81.0 %) and pays back in 5.6 years on the incremental investment. The effluent at 27.8 °C retains about 330 kW of recoverable heat for a cascade extension to greenhouse heating or produce drying. Existing mineral wells can thus serve as ready heat sources for rural decarbonisation; the results are design estimates pending field monitoring.

Keywords: artesian well, low-enthalpy geothermal energy, direct use, water-to-water heat pump, decarbonisation, rural heat supply, swimming pool heating, green economy, Kazakhstan.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 458 Other

Effect of drying method and particle size on the phenolic composition and biological activity of pomegranate peel

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Abstract. Various extraction methods have been reported to influence the chemical composition of plant extracts. The advantages and limitations of the extraction methods depend on the plant material preparation and extraction conditions. Drying is an important processing step that can affect the stability, extractability and biological properties of phenolic compounds. In addition, in solid–liquid extraction the particle size of the sample significantly affects the bioactive components. The aim of this study was to evaluate the effect of two drying methods and particle size on the phenolic composition and biological activity of pomegranate peel. Pomegranate peels were freeze-dried (lyophilisation) and oven-drying at 60 °C. Dried samples were fractionated to particle size: >500 µm and <500 µm. Extracts were prepared using ultrasound-assisted extraction in 50% ethanol. Total phenolic content (TPC) was determined using the Folin–Ciocalteu method, while phenolic composition was characterised chromatographically. Antioxidant activity was evaluated by the FRAP assay, and antimicrobial activity was determined by the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) against selected food-borne and spoilage microorganisms. The results demonstrated differences in TPC, individual phenolic compounds and biological activity depending on the drying treatment and particle size. The highest TPC was observed in the <500 µm fraction of oven-dried peel (85.00 mg GAE/g), followed by the <500 µm fraction of freeze-dried peel (83.85 mg GAE/g). The highest FRAP value was obtained for the <500 µm oven-dried fraction (86.00 mM TE). Differences in antimicrobial activity were also observed among the tested extracts indicating more effectiveness against the Gram-positive bacterial strains, with MIC and MBC concentrations <0.31 g/L. The punicalagin was identified as a dominant phenolic compound, reaching concentrations of 7.4 g/L in the <500 µm oven-dried fraction. Differences among drying treatments and particle-size fractions were also observed for the remaining individual phenolic compounds, particularly gallic acid and epicatechin, which were dominant in oven-dried samples. Both drying method and particle size showed to be important factors affecting the phenolic composition and biological activity of pomegranate peel. The high abundance of punicalagins, together with the pronounced antioxidant and antimicrobial activity of the extracts, confirms the potential of pomegranate peel as a valuable source of natural bioactive compounds.

Keywords: agri-food by-product, pomegranate peel, phenolic compounds, antioxidant and antimicrobial activity

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(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 459 Other

AI-enabled lifelong learning for green transformation: reskilling agribusiness, SMEs and extension professionals in CAREC countries

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Abstract. The rapid adoption of artificial intelligence (AI) is reshaping professional learning and creating new opportunities for workforce development, including in agriculture. This study examines how AI-enabled lifelong learning can support reskilling and upskilling among agribusiness employees and managers, small and medium-sized enterprises (SMEs), entrepreneurs, and agricultural extension professionals across Central Asia Regional Economic Cooperation (CAREC) countries. Building on capacity-building and lifelong-learning perspectives, the study explores how AI-supported training, digital learning platforms, and microlearning can strengthen digital competencies, green skills, and the capacity to adopt climate-smart and sustainable practices. A mixed-methods approach combines policy and literature analysis and questionnaire-based survey study with stakeholder evidence from CAREC countries to examine learning needs, emerging training models, barriers to adoption, and opportunities for institutional cooperation. The study proposes an integrated pathway linking AI-enabled professional learning, continuous professional development, reskilling and upskilling, green and digital competencies, and organizational capacity for sustainable transformation. Particular attention is given to the potential role of universities, extension centres, agribusinesses, and development partners in building accessible lifelong-learning ecosystems. The study contributes to emerging debates on AI, workforce transformation, and sustainable agriculture by positioning lifelong learning as a critical mechanism connecting digital transformation with green transition across CAREC economies.

Keywords: artificial intelligence; lifelong learning; green skills; reskilling and upskilling; agribusiness; agricultural extension; CAREC; digital transformation

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 465 Other

A general assessment of meadow and pasture areas in Ereğli (Konya, Türkiye)

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Abstract. The district of Ereğli in Konya, situated between the Central Anatolian steppes and the Taurus Mountains, is an important transitional area for meadow and pasture livestock farming. The district has a semi-arid climate, receiving approximately 300–330 mm of annual rainfall. In terms of rainfall effectiveness, Ereğli is classified as semi-arid, with a climate characterized by significant water scarcity. The hot and extremely dry summers, combined with cold and snowy winters, limit natural forage production, particularly during the summer months. Consequently, pasture productivity is largely dependent on spring rainfall and the moisture stored in the soil over the winter and spring. In terms of vegetation, Ereğli is situated within the Iran-Turan phytogeographical region; its natural vegetation is primarily composed of steppe and anthropogenic steppe formations. As one moves into mountainous areas and the lower slopes of the Taurus Mountains, communities of mountain pine, oak and juniper become evident. Around the Ereğli Marshes, there is a wetland-type flora. For this reason, the district's pastures are not classified as a single type, but are categorized as dry steppe, mountain slope, plain and wetland pastures. Within the livestock sector, horse breeding and racehorse stud farms hold particular economic and ecological significance for Ereğli. The Ereğli-İvriz (Halkapınar) area stands out for horse breeding due to its extensive pastures, water sources, low humidity and summer conditions. The district is home to a significant proportion of Turkey's private stud farms, where a large number of English and Arabian horses are bred. However, as the increase in horse farms could lead to greater grazing pressure and soil compaction if pasture areas are used uncontrollably, this issue must be addressed in conjunction with pasture management. Thorny leguminous species such as Astragalus microcephalus, A. gummifer and A. condensatus, which form cushion-like semi-shrub forms, play an important role both in soil conservation and in providing shelter for other plants. To protect the soil and improve the pasture, it is essential to prioritise the use of perennial, drought-tolerant grasses and legumes that are adapted to the local ecology. Cynodon dactylon is one of the prominent natural forage plants in horse breeding in Ereğli. In addition, in suitable areas, species such as Festuca, Agropyron/Elymus, Bromus and Poa, as well as legumes such as Medicago, Trifolium and Onobrychis, should be utilized; however, it is important that species selection is based on soil salinity, pH, altitude and water regime.

Keywords: Astragalus, grazing, flora, pasture, steppe.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 468 Other

Integrating cadastral and satellite indicators for forest-land use assessment: an open-data framework for Almaty Region, Kazakhstan

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Abstract. Forest-fund land is a legal category, whereas satellite tree cover is a biophysical observation; neither alone establishes efficient land use. This study proposes a cadastral and Earth-observation workflow and demonstrates its satellite screening component for the historical Almaty unit retained in GADM 4.1, Kazakhstan. No cadastral parcel overlay or field validation was performed. A source snapshot downloaded on 12 October 2026 records 3,739.16 ha of gross tree-cover loss during 2001–2025 against 836,193.54 ha of baseline tree cover in 2000. These mapped aggregates yield approximately 0.45% cumulative disturbance, a 99.55% gross retention complement and a 0.018% annualized disturbance ratio. Fire-associated loss was 1,970.11 ha, or approximately 52.7% of the unrounded loss total. Independently rounded fire and other-loss components are 2.0 and 1.8 thousand ha, while the separately rounded total is 3.7 thousand ha. Proposed management classes cover conservation monitoring, fire prevention and restoration, and review of permitted use. Gross retention does not measure net forest change, ecosystem condition or legal compliance. Operational application to present Almaty and Zhetysu regions requires current authoritative boundaries, parcel integration and independent validation.

Keywords: forest land; land management; cadastre; remote sensing; GIS; tree-cover loss; wildfire; Kazakhstan.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 472 Other

Integrating Sentinel and Landsat satellite data with artificial intelligence algorithms for monitoring land-use change

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Abstract. Reliable monitoring of land-use and land-cover change requires observations that are spatially detailed, temporally dense, radiometrically comparable, and suitable for reproducible analysis. This analytical review develops an integrated framework in which Sentinel-2 multispectral imagery, Landsat 8/9 optical and thermal observations, and Harmonized Landsat and Sentinel-2 products are combined with machine-learning and deep-learning methods. The framework connects surface-reflectance preprocessing, cloud and shadow masking, geometric and spectral harmonization, temporal compositing, feature engineering, classification, direct change detection, and statistically defensible validation. Particular attention is given to Random Forest, temporal convolutional networks, U-Net-type segmentation, and Transformer architectures. The review shows that model sophistication alone does not guarantee reliable results: data comparability, reference-sample design, class balance, spatial independence, and explicit treatment of uncertainty frequently determine the quality of the final change map. Post-classification comparison remains interpretable and operationally convenient, whereas direct spatio-temporal models can reduce error propagation when representative change labels are available. The proposed workflow is applicable to agricultural monitoring, urban expansion assessment, forest-disturbance detection, and other long-term land-management tasks.

Keywords: Sentinel-2, Landsat 8/9, Harmonized Landsat and Sentinel-2, artificial intelligence, land-use and land-cover change, change detection, remote sensing.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 382 Food

Geographical indication fermented dairy products in Turkiye: a review of the nutritional properties and functional potential of yoghurt, ayran and dried fermented dairy products

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Abstract. Türkiye ranks among the countries with significant diversity in traditional food products thanks to its geographical location and rich cultural heritage. Traditional foods are registered and protected to ensure that their unique characteristics are preserved and passed on to future generations. In this context, the European Union has established three types of quality labels under its food quality policies: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Specialty Guaranteed (TSG). In Turkey, registration is carried out by the Turkish Patent and Trademark Office. Fermented dairy products are preferred by consumers due to their high nutritional content, desirable sensory characteristics, and positive functional effects on human health. Some of the fermented dairy products traditionally produced in Türkiye have been protected through the granting of geographical indications. This ensures the preservation of the quality of fermented dairy products, their production according to specified methods, the protection afforded to producers by the registration, the prevention of counterfeit products, and the sustainability of cultural heritage. In this study, using data from the Turkish Patent and Trademark Office, Türkiye's geographically indicated fermented dairy products such as yogurt, ayran, and keş were evaluated in terms of their geographical origins, production techniques, sensory characteristics, consumption patterns, and functional and nutritional properties. It is believed that presenting these products in a more comprehensive manner will contribute to the preservation of the traditional food heritage, the enhancement of their added value, and the strengthening of their recognition at both the national and international levels.

Keywords: Fermented Dairy Product, Geographical Indication, Functional Foods.

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 411 Food

Computational perspectives on novel bioactive peptides from camel milk proteins associated with glucose homeostasis

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Abstract. Camel milk exerts positive effects on glucose metabolism, however, the key bioactive constituents responsible for this activity remain to be fully characterized. This study investigated the glucose metabolism-regulating potential of camel milk proteins and their hydrolysates, computationally screened novel bioactive peptides, and validated them in vitro. Camel milk proteins and their hydrolysates, particularly whey protein hydrolysate, attenuated weight gain and insulin resistance, and restored triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), alanine aminotransferase (ALT), and albumin (ALB) levels in glucose-intolerant rats ($P<0.05$). From 15,420 identified peptides, 37 peptides were selected through activity ranking and PepSite 2 for molecular docking and dynamics simulations. IPLPLL exhibited the strongest DPP-IV inhibition (IC_{50}=0.43mg/mL), while LPPLF showed the highest α-amylase inhibition (IC_{50}=9.62mg/mL). Both peptides bound stably to active sites of metabolic enzymes via hydrogen bonds and hydrophobic interactions. ADMET analysis indicated favorable stability and low toxicity. This study enriches the catalog of candidate hypoglycemic peptide,and provides guidance for mechanistic research and functional food applications.

Keywords: Camel milk, bioactive peptides, glucose homeostasis, molecular docking, molecular dynamics simulation

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 417 Food

Processing methods reshape the compositional landscape of camel milk: integrative evidence from oligosaccharidomics, metabolomics, proteomics and lipidomics

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Abstract. Background: The effects of different processing methods on the compositional landscape of camel milk remain insufficiently investigated. Method: Raw camel milk was obtained from Bactrian camels in Aksu, Xinjiang Autonomous regions and samples subjected to pasteurization, UHT sterilization, microbial fermentation, and low-temperature spray drying were systematically collected. Oligosaccharide (OS) profiling, non-targeted metabolomics, label-free quantitative proteomics, and lipidomics analyses were performed using high-resolution mass spectrometry platforms. Differential components were identified through multivariate statistical analysis, and multi-omics network co-occurrence models were employed to systematically dissect the effects of different processing methods on the camel milk composition. Results: Pasteurization effectively preserved the compositional profile of raw milk. For OS profiles, UHT sterilization and spray drying significantly reduced the contents of total OSs and fucosylated OSs, while fermentation markedly increased the levels of total OSs, acidic OSs, and neutral non-fucosylated OSs. For metabolomics, fermented camel milk exhibited increased abundances of indoles and derivatives, organonitrogen compounds, and fatty acyls; the levels of steroids and steroid derivatives elevated in UHT sterilizated camel milk, and metabolites related to glycerophospholipids elevated in spray-drying camel milk. For proteomics, fermentation induced the most substantial alteration in camel milk protein composition, with differential proteins uniquely enriched in the neuroactive ligand-receptor interaction, AMPK signaling, and PI3K-Akt signaling pathways. As for lipidomics, fermented camel milk showed significantly elevated levels of glycerophospholipids and fatty acyls, with enrichment of negatively curved lipids (PE, CL, DG, Cer); UHT sterilization and spray drying led to a marked reduction in glycerophospholipid content. The multi-omics network co-occurrence analysis showed that pasteurized and UHT sterilized milk exhibited coordinated suppression of fatty acid metabolism and steroid biosynthesis pathways; fermented camel milk demonstrated enhanced oxidative stress defense capacity. Conclusions: From the perspective of compositional integrity and bioactive compound retention, fermentation represents the optimal processing method. This study provides evidence-based support for the scientific selection of camel milk processing techniques.

Keywords: Camel Milk; Processing methods; Compositional landscape; Multiomics

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 426 Food

Future molecular hydrogen applications in the food industry

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Abstract. Molecular hydrogen (H2) has attracted increasing attention recently because of its unique properties. Its eco-friendly and sustainable features have led many research teams to investigate its applications in the food industry. Besides the well-known hydrogenation of fats, recent reports, especially from our H2Team in Turkey, highlight new uses of hydrogen. Our H2Team has shown that applying these hydrogen-based techniques across various processes and formulations can significantly benefit the product, producer, and consumer. Advantages include maintaining quality, improving safety, and extending shelf life. Hydrogen can also reduce heavy metal levels, limit biogenic amine formation, and preserve phenolics, flavonoids, antioxidants, pigments, and vitamins in foods. The main hydrogen application methods in food processing are fumigation and the use of hydrogen-rich water. Additionally, hydrogen-producing magnesium is a novel method developed by our team for food applications. When integrated into edible coatings and films, hydrogen-producing magnesium helps protect the quality and safety of foods, such as meat and fruit products. Using a hydrogen-rich solvent method to efficiently extract phytochemicals and nutrients, like proteins, from agri-food wastes is another emerging area of hydrogen application. Numerous areas and processes offer potential for H2 applications, creating opportunities for further research. Our H2Team continues exploring other promising uses in collaboration with international partners.

Keywords: Molecular hydrogen; Foods; Quality; Safety; Extraction

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 442 Food

Comparative LC-HRMS characterization and in vitro biological activities of two agro-industrial fruit wastes: pomegranate and coconut pomaces

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Abstract. Agro-industrial food waste represents an underutilized source of value-added bioactive compounds. This study comparatively evaluated the phytochemical composition, antioxidant activity, and antidiabetic potential of pomegranate (Punica granatum L.) and coconut (Cocos nucifera L.) pomaces. Both pomaces were extracted with ethanol using Soxhlet extraction. Phenolic compounds were characterized by LC-HRMS, total phenolic content was determined using the Folin–Ciocalteu method, antioxidant activity was assessed by the DPPH radical scavenging assay, and antidiabetic potential was evaluated by in vitro α-glucosidase inhibition. Pomegranate pomace exhibited a substantially higher total phenolic content (168.012 mg GAE/g extract) than coconut pomace (27.971 ± 2.525 mg GAE/g extract). LC-HRMS analysis detected ellagic acid and caffeic acid in pomegranate pomace, with ellagic acid as the predominant identified compound, whereas none of the selected phenolic compounds were detected in coconut pomace under the applied analytical conditions. Pomegranate pomace also showed strong antioxidant activity and 71.04% α-glucosidase inhibition at 0.5 mg/mL. In contrast, coconut pomace showed no detectable DPPH radical scavenging activity and no significant α-glucosidase inhibition. These findings demonstrate marked differences between the two agro-industrial by-products under comparable experimental conditions and identify pomegranate pomace as a promising source of bioactive compounds for sustainable valorization. The absence of detectable target phenolics and biological activity in coconut pomace suggests that alternative extraction approaches and broader phytochemical profiling are required to more comprehensively assess its potential for value-added applications. Overall, the results support selective valorization strategies based on the phytochemical characteristics of individual food-processing wastes rather than assuming equivalent bioactivity among diverse by-products.

Keywords: Punica granatum, Cocos nucifera, Agro-industrial Waste, LC-HRMS, Phenolic Compounds, Antioxidant Activity, α-glucosidase Inhibition

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 456 Food

Occurrence and exposure assessment of tetracycline residues in milk marketed in Tirana, Albania

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Abstract. Veterinary drug residues pose a significant food safety concern because they can promote antimicrobial resistance and cause direct toxic effects, particularly in children. This study evaluated the prevalence of tetracycline residues in milk using a competitive enzyme-linked immunosorbent assay (ELISA) across three supply channels: domestic processed, imported, and milk sold by ambulant farmers. Tetracycline residues were detected in 11 samples (36.7%), with a mean concentration of 62.40 µg/L (range: 1.32–159.45 µg/L). Two samples (6.7%) exceeded the European Union maximum residue limit (100 µg/kg). Stratified analysis indicated that the informal, direct farm-sale channel had a substantially higher contamination rate (66.7% incidence; mean 118.44 µg/L) than domestic processed milk (35.3%; 32.65 µg/L) and imported milk (30.0%; 84.54 µg/L), despite accounting for only 10.0% of the samples analyzed. Estimated Daily Intake (EDI) and Hazard Quotient (HQ) were calculated for adults based on a milk intake of 0.441 L/day. Exposure levels remained well below the Acceptable Daily Intake (ADI) according to both JECFA (0–30 µg/kg bw/day) and FDA (25 µg/kg bw/day) reference standards. The results suggest that, although the overall population risk remains low, informally sourced milk contributes disproportionately to tetracycline exposure risk, indicating that consumers with frequent or high milk intake may experience an elevated risk of dietary exposure to tetracycline residues. These findings emphasize the importance of targeted monitoring and enhanced veterinary oversight of antibiotic withdrawal periods. Further quantitative risk assessment is warranted.

Keywords: Tetracycline residues; Milk; Risk assessment; Albania

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 460 Food

Modernization of the agricultural sector and food security: strategic priorities in the case of Azerbaijan

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Abstract. This article examines the relationship between agricultural modernization and food security in Azerbaijan. It analyzes changes in agricultural production and structure during 2005–2024, self-sufficiency in major food products, import and export patterns, resource use, and storage, processing, and logistics capacities. Data for 2025 are used to assess recent foreign-trade changes. The descriptive results show uneven changes in production, self-sufficiency, and trade patterns across product groups during the modernization period. Domestic production and export potential are relatively strong for fruit and vegetables, whereas import dependence remains significant for wheat, poultry meat, and dairy products. Food-system resilience is also affected by trade concentration, water losses, soil and drainage conditions, and storage and logistics constraints. The study argues that modernization priorities should focus on productivity growth, efficient resource use, effective state support, livestock development, trade diversification, and sustainable farm incomes.

Keywords: Azerbaijan agricultural sector, food security, modernization, self-sufficiency, diversification, water resources, state support

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 473 Food

Utilization of biopolymer films in meat products

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Abstract. Meat and meat products are high in nutrients and quickly deteriorate due to perishable nature, thus the meat industry suffers significant financial losses. The reduced shelf life of meat products is directly caused by their exposure to the environment. Food packaging's major objective is to preserve the product's quality and safety so that it may be eaten without endangering human's health. High-nutrient meat products can be spoiled by microbial development and airborne oxygen reactions if they are not packaged properly. The purpose of using packing materials to preserve meat products is to stop the microbial growth, block oxidative processes, cover up unappealing characteristics, and preserve the nutritional value of the meat. The use of biopolymers as food packaging materials has received a lot of interest recently because of its significant qualities include non-toxicity, accessibility, biocompatibility, and biodegradability. It indicates their potential as a substitute for traditional plastic packaging, which has long been the subject of environmental contamination concerns. The creation and application of biodegradable polymers, could save the human health and environment. These developments include the use of natural biopolymers, the creation of nanocomposite films to increase film stability, and the mixing of several biopolymers to improve mechanical properties while maintaining biodegradability. Biobased polymers, derived from renewable resources like natural biopolymers (polysaccharides, proteins, and lipids), synthetic biopolymers (polylactic acid and polybutylene succinate), or microbial biopolymers (polyhydroxy alkanoates and bacterial cellulose), are used to make biodegradable films. Biopolymers often show less mechanical and chemical resilience as compared to traditional plastics. Using polymer blends, which can lessen the repulsive forces in the biopolymer chain, is one possible way to enhance the characteristics of biopolymers. In this sense, hydrophobic materials including vegetable oils, essential oils, waxes, and fatty acids can be included into the biopolymer film matrix to improve the poor water barrier capacity. Generally, the application of biopolymer films signifies a promising approach for sustainable meat packaging, in terms of both environmental concerns and consumer demand for high-quality safer food products.

Keywords: Biopolymer, Perishable meat, Food packaging, Biocompatibility, Biodegradable

6th International Conference on Research of Agricultural and Food Technologies
(I-CRAFT'2026, ALMATY/KAZAKHSTAN)

ID 474 Food

Lactic acid bacteria–yeast consortia as sourdough starter cultures: bacterial community, aroma formation and dough rheology

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Abstract. Sourdough starter cultures are among the most promising natural alternatives to synthetic bread improvers, yet multicomponent consortia assembled from autochthonous strains of the Central Asian region remain poorly characterised. Two three-strain consortia of lactic acid bacteria (LAB) and yeast were assembled from strains isolated from Kazakhstani raw materials — wheat flour, kumis and spontaneous sourdoughs — whose components had been selected for biocompatibility during co-cultivation: consortium 1 (Lacticaseibacillus paracasei LB-27 + L. paracasei LB-319 + Saccharomyces cerevisiae LVg) and consortium 2 (L. rhamnosus RH-5 + L. paracasei LB-319 + S. cerevisiae A-28g). The consortia were characterised within a single experimental framework covering antagonistic activity, profiling of volatile organic compounds (VOCs) by HS-SPME–GC-MS, the structure of the bacterial community (16S rRNA gene amplicon sequencing) and dough rheology. Cell-free supernatants of both consortia inhibited the principal agents of bread spoilage, the growth-inhibition zones reaching 27.0–30.3 mm against Penicillium notatum and 18.3–19.0 mm against Aspergillus flavus. The VOC profile of the consortia combined the organic acids and C4 carbonyl compounds of the LAB with the higher alcohols and esters of the yeast. In the inoculated sourdoughs the introduced genus Lacticaseibacillus prevailed in the bacterial community from as early as 18 h of fermentation (68–82%), whereas the spontaneously fermented sourdough remained dominated by Enterobacteriaceae (Pantoea, up to 91%). Added at 10% of the flour mass, the sourdoughs softened the dough, reducing the deformation energy W of wheat dough by 38–39% and shifting the configuration ratio P/L from 1.38 to 0.88–0.89.

Keywords: Sourdough, Lactic Acid Bacteria–Yeast Consortium, 16S rRNA Amplicon Sequencing, Dough Rheology.

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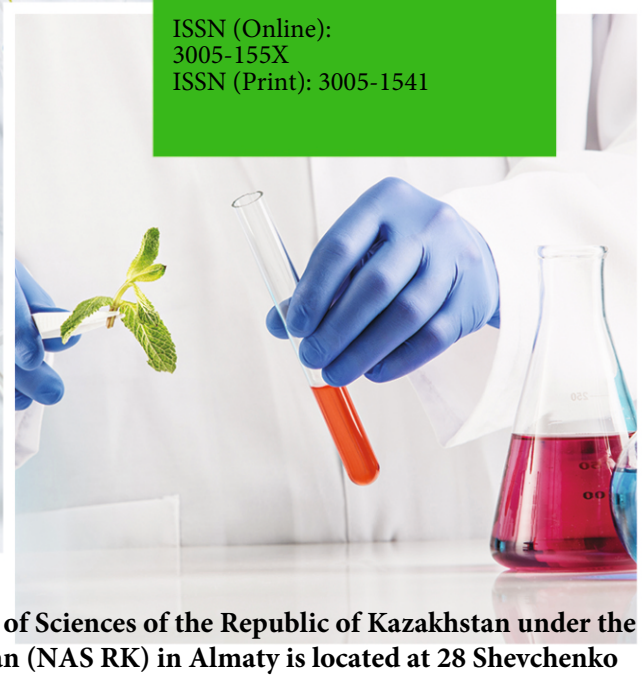
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ISSN (Online): 3005-155X
ISSN (Print): 3005-1541



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