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CLOSING THE AGRI-FOOD LOOP

RESOURCES, POLICY AND PRODUCTIVITY

BOOK OF ABSTRACTS

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PLANT PRODUCTION

CLIMATE TRENDS AND WATER BALANCE AS INDICATORS OF AGRICULTURAL VULNERABILITY AND ADAPTATION NEEDS IN THE SUS-SOIL LIVING LAB CENTRAL BOSNIA

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Abstract

Agriculture in Bosnia and Herzegovina is increasingly exposed to climate variability and climate change, while adaptation capacities at the local level remain constrained by fragmented production structures, limited infrastructure, weak monitoring systems, and insufficient integration of climate information into land and water management. This study analyses the climatic context and water-balance dynamics of three SUS-SOIL Living Lab Central Bosnia locations, with the aim of assessing their relevance for agricultural vulnerability and adaptation planning. Long-term meteorological data from the nearest representative stations were used to compare the reference period 1961–1990 with the recent period 1991–2023/2024, focusing on air temperature, precipitation and selected agroclimatic indicators. The results show clear warming at all three locations, with annual mean temperature increases of 1.16°C in Sarajevo, 1.39°C in Bugojno and 1.16°C in Tuzla. The strongest changes were observed during summer, indicating increased thermal pressure during the main vegetation period. Annual precipitation changed only slightly, but seasonal redistribution was evident, particularly through reduced summer precipitation in Sarajevo (-23 mm) and Tuzla (-16 mm), while Bugojno showed a slight summer increase. These patterns suggest increasing evaporative demand and higher risk of seasonal water stress, especially in lowland and peri-urban agricultural areas. By linking climatic evidence with local agricultural constraints, the paper identifies priority needs for climate-smart soil and water management, improved monitoring and farmer-oriented adaptation measures within the SUS-SOIL framework.

Keywords: *climate change, water balance, agricultural adaptation, soil management, SUS-SOIL*

THE USE OF ENDOPHYTIC BACTERIA IN APPLE ORCHARD

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Abstract

We aim to produce apples sustainably and in an environmentally friendly way, which can be achieved through targeted and goal-oriented application of plant treatment preparations. In addition to yield quantity, fruit quality is also very important, both internally and externally. Appropriate appearance, firmness, sufficient soluble solids content, and organic acids are essential characteristics of high-quality fruit that will satisfy even the most demanding customers. Therefore, we designed an experiment using a biostimulant containing the endophytic symbiotic bacterium *Paenibacillus polymyxa* (the preparation Bactim® Endofix) on 'Idared' apple trees to determine whether the use of endophytic bacteria can increase both the quantity and quality of apples. The experiment included three treatments: 1) a biostimulant based on endophytic bacteria, with trees treated with Bactim® Endofix; 2) a biostimulant based on endophytic bacteria with the addition of an organic mineral fertilizer, with trees treated with Bactim® Endofix and Soya Gold; and 3) a control, with trees not treated with either preparation. We found that the endophytic bacterium *Paenibacillus polymyxa* increased the number of fruits per tree and the yield per tree of first quality class, as well as the total yield per tree and per hectare. When the mineral fertilizer Soya Gold was added to the endophytic bacteria, the yield per tree of first quality class, the total yield per tree, and the yield per hectare were even higher than with endophytic bacteria alone. The chlorophyll content in the leaves was significantly higher where endophytic bacteria were applied. When food for the bacteria was added alongside the endophytic bacteria, the chlorophyll content remained higher until harvest.

Keywords: *fruit growing, apple, Malus domestica, endophytic bacteria, yield, biostimulants*

IDENTIFICATION AND SYMPTOMATIC EVALUATION OF STRAWBERRY LEAF DISEASES CAUSED BY PLANT PATHOGENIC FUNGI

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Abstract

Strawberry is an economically important fruit crop, but its expanding cultivation increases the risk of fungal leaf diseases that reduce plant vitality and yield. This study aimed to identify the most common strawberry leaf mycoses in the municipalities of Fojnica and Kiseljak (Bosnia and Herzegovina, BiH) and assess infection intensity at selected production sites. Research was conducted on strawberry plantations of different ages and cultivation systems at six locations (3 per municipality). Fields were regulary monitored from april to august for disease occurrence. The most common symptoms observed were small red-purple leaf lesions, sometimes with a white center. Laboratory analyses of 180 symptomatic samples identified fungi and mould from the genera *Mycosphaerella, Aspergillus*, *Penicillium*, *Fusarium*, and *Mucor*. Symptoms observed in the field were linked to common strawberry leaf spot caused by *Mycosphaerella fragariae*, and disease development was modeled using climatic and biological factors. The intensity of infection ranged from 9% to 32%, with significant differences among locations. Variations in disease incidence were associated with plantation age, production system, altitude, and specific agroclimatic characteristics of the studied area. The results improve understanding of strawberry leaf disease occurrence and support more effective monitoring and management practices.

Keywords: *fungi isolation, disease severity, IPM, plant disease forecasts*

EFFECTS OF 6-BENZYLADENINE AND 1-NAPHTHALENEACETIC ACID ON FRUIT QUALITY AND BIOCHEMICAL PROFILE OF 'GOLDEN DELICIOUS' APPLE

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Abstract

Plant growth regulators are widely used in modern apple production to regulate crop load and improve fruit quality. This study investigated the effects of 6-benzyladenine (6-BA; cytokinin) and 1-naphthaleneacetic acid (1-NAA; auxin) on the fruit quality and biochemical profile of 'Golden Delicious' apple. The experiment was conducted over two growing seasons in a commercial apple orchard in the Municipality of Gradačac, Bosnia and Herzegovina. Fruit quality was evaluated based on fruit weight, firmness, peel colour, soluble solids content, titratable acidity, HPLC-determined sugars and organic acids, and the Perlim and Thiault quality indices. Application of 6-BA, alone or in combination with 1-NAA, significantly increased fruit weight compared with the control. The highest average fruit weight was recorded in the 6-BA treatment (171.27 g), followed by the 6-BA + 1-NAA treatment (150.80 g), compared with 113.18 g in the control. Bioregulator application was associated with reduced fruit firmness relative to the control. The 6-BA + 1-NAA treatment resulted in the highest average contents of total sugars and total organic acids, indicating a pronounced effect on the fruit biochemical profile. Compared with the control (7.61), fruits treated with 6-BA (10.16) and 6-BA + 1-NAA (9.99) achieved higher Perlim quality index values, reflecting superior overall fruit quality. ANOVA, PCA and heatmap analyses indicated that treatment responses were strongly influenced by growing season conditions.

Keywords: *6-benzyladenine, 1-naphthaleneacetic acid, fruit thinning, fruit quality, biochemical profile*

UVOMETRIC PROPERTIES OF SOME TABLE GRAPE VARIETIES GROWN IN THE ŽEPČE AREA, BOSNIA AND HERZEGOVINA

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Abstract

This study aimed to compare the mechanical composition of three table grape varieties (Moldova, Lasta and Italia) grown in the Žepče area, Bosnia and Herzegovina. The research evaluated cluster parameters (weight, rachis weight, berry weight, length, width) and berry parameters (length, width, weight of 100 berries, skin weight, seed weight, flesh weight, number of seeds in 100 berries). The Italia variety exhibited the highest cluster weight (354.51 g), berry weight per cluster (346.5 g), weight of 100 berries (514.3 g), skin weight (56.0 g) and flesh weight (446.7 g) in 100 berries. The Lasta variety recorded the highest rachis weight (8.2 g) and number of seeds (200). In contrast, the Moldova variety showed the lowest values for most of the uvological cluster and berry parameters. However, regarding chemical composition, the highest sugar content was determined in Moldova and the lowest in Italia, while an opposite trend was observed for total acidity content. All three varieties exhibited satisfactory yield characteristics under the agro-ecological conditions of Žepče, indicating that this region is suitable for their cultivation.

Keywords: *Moldova, Lasta, Italia, uvology, Žepče*

CHITOSAN/ALGINATE CO-HYDROGELS AS ECO-FRIENDLY CARRIERS OF *ARTHEMISIA ABSINTHIUM* ESSENTIAL OIL

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Abstract

Artemisia absinthium essential oil (EO) is a valuable source of phenolics and terpenoids; however, its volatility and limited physicochemical stability restrict its direct application. This study evaluated chitosan/sodium alginate co-hydrogels as carriers of *A. absinthium* EO and examined how differences in hydrogel composition and EO concentration affected the incorporation/preservation of its bioactive constituents. Four formulations (H1–H4), consisted of different mass ratios of chitosan, sodium alginate and $CaCO_3$, were immersed in EO aqueous suspensions ranging from 0.025 to 1% obtained from starting 2% EO. Total phenolic content (TPC) was determined by the Folin–Ciocalteu assay and expressed as mg/mL of gallic acid equivalents (GAE), whereas total terpenoid content (TTC) was determined colorimetrically and expressed as mg/mL of linalool equivalents (LE). After 24h of hydrogel imersion in EOs TPC and TTC assays confirmed succesfull incorporation of EO bioactive consitituents into hydrogels. However, for EO preparation at lower concentration (0.4-0.025%) TPC/TTC values after hydrogel treatment were below LOQ. H3 and H1 triggered the highest TPC depletion at 1% i.e. 0.4%, respectively, while H2 exhibited the highest ability to absorb terpenoids at 1% EO concentration. These findings demonstrate that both EO concentration and hydrogel composition controled the apparent incorporation of phenolic and terpenoid constituents, supporting the development of biodegradable co-hydrogels as controlled-delivery matrices for volatile plant bioactives. Further studies should evaluate ability of the prepared co-hydrogels to be aplied as carriers of phytochemicals intended for application in plant protection based on eco-friendly chemical control.

Keywords: *Artemisia absinthium; chitosan/alginate co-hydrogels; phenolic compounds; terpenoids; controlled delivery*

CHANGES IN THE CROPPING STRUCTURE OF FIELD CROPS UNDER THE INFLUENCE OF CLIMATIC FACTORS: THE CASE OF THE MUNICIPALITY OF RUMA

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Abstract

Agriculture is the economic sector most exposed to the negative impacts of climate change, with consequences directly reflected in production stability and yield levels. Although farmers traditionally adopt radical changes more slowly, the drastic decline in yields of once leading spring crops, such as maize and soybean, has forced them to change their strategies. This paper analyzes the ten-year period from 2016 to 2025 in the territory of the municipality of Ruma. Significant yield reductions of spring crops were observed in years such as 2022, 2023, and 2024. A record was set in 2025, when the average temperature during the critical period for spring crops (June, July, August) was 2.37°C higher than the multi-year average, resulting in a dramatic yield decline, particularly in maize and soybean. Data analysis shows a turning point from 2020, when areas under wheat increased by 38% and reached their maximum in 2025, while sunflower areas nearly tripled, whereas maize and soybean recorded a sharp decrease. The aim of this paper is to highlight, through the analysis of cultivated areas and ecological conditions in the municipality of Ruma, the broader context of the inevitability of adapting cropping structures across the entire Western Balkans. Since irrigation possibilities in the region are economically and infrastructurally limited, the current shifts in the balance of traditional crops represent only the first phase of adaptation. The paper points out that further directions of adjustment will inevitably require, first, changes in varieties (maturity periods and drought tolerance), and ultimately, the introduction of entirely new plant species more resistant to altered agroclimatic conditions.

Keywords: *climate change, cropping structure, drought*

BACTERIAL PATHOGENS OF *Cannabis sativa* L.: A CRITICAL REVIEW OF DIAGNOSIS, EPIDEMIOLOGY, AND DISEASE MANAGEMENT

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Abstract

Despite renewed agricultural, medicinal, and commercial interest in *Cannabis sativa* L., records of bacterial diseases affecting this crop remain scattered, diagnostically heterogeneous, and epidemiologically limited. This review synthesizes published records of bacterial pathogens reported on *Cannabis* and evaluates them in terms of taxonomy, symptomatology, epidemiology, diagnosis, and disease management. The records examined include *Serratia marcescens*, *Pseudomonas syringae* pv. *mori*, *Xanthomonas cannabis pv. cannabis*, the *Agrobacterium tumefaciens* species-complex, and *Pseudomonas cannabina* pv. *cannabina*, all of which have been reported to cause disease in *Cannabis*. Across these records, bacterial diseases have mainly been associated with distinct symptom types, including leaf spots, stem lesions, and gall formation. When historical and recent studies are considered together, the available diagnostic and epidemiological evidence differs substantially among pathogens. Epidemiological information is also uneven across reports; some studies identify possible sources of inoculum, whereas others provide only limited observational or experimental data. This situation reveals two major knowledge gaps: disease prevalence, crop losses, transmission pathways, and host susceptibility have rarely been quantitatively evaluated; moreover, rapid diagnostic methods and standardized disease management approaches remain insufficiently developed. Therefore, this review emphasizes the need to combine modern diagnostic methods, standardized epidemiological studies, and preventive disease management strategies to enable more reliable assessment and management of bacterial diseases in cannabis.

Keywords: *Cannabis sativa*, *bacterial diseases, phytopathogenic bacteria, pathogen diagnosis, epidemiology*

DISTRIBUTION OF THE INVASIVE SPECIES *Solidago canadensis* AND *Solidago gigantea* IN BOSNIA AND HERZEGOVINA

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Abstract

Canadian goldenrod (*Solidago canadensis* L.) and Giant goldenrod (*Solidago gigantea* L.) native to North America, are among the most invasive plant species in Europe. In Bosnia and Herzegovina (B&H), both species are considered as Invasive Alien Species (IAS). *S. gigantea* was first recorded in 1926 in B&H and *S. canadensis* in 1983 (Sarajevo). The species is now reported in numerous cities across (B&H), with the highest abundance in the Posavina region, indicating a progressive spread under diverse ecological conditions and increasing invasive potential. Solidago spp. poses a moderate risk to high-conservation-value habitats but a high risk of reducing local biodiversity due to strong interspecific competition mediated by allelopathic chemicals present in its roots. Although its abundant flowering attracts pollinators, including bees, its long-term dominance suppresses floral diversity and threatens ecosystem stability. Given the clear trend of spread across (B&H), integrated management strategies and continuous monitoring are crucial to mitigate its invasive potential and safeguard local biodiversity.

Keywords: *Solidago canadensis, Solidago gigantea, invasive species, biodiversity, allelopathy, ecological impact*

THE EFFECT OF ORGANIC MANURE ON THE PRODUCTIVITY AND BOTANICAL COMPOSITION OF SEMI-NATURAL GRASSLANDS

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Abstract

Semi-natural grasslands represent an important component of livestock production in Bosnia and Herzegovina, and their productivity largely depends on management practices. The aim of this study was to evaluate the effect of cattle manure application on productivity and botanical composition of a semi-natural grassland under temperate continental climate conditions. The research was conducted in the Butmir experimental field over a two-year period (2022-2023). Four treatments were tested: a control without fertilization and three manure application rates of 15, 20, and 30 t ha^{-1}. The results showed that organic manure application had a positive effect on grassland productivity. Dry matter yield increased with increasing manure rates, with the highest total yield recorded in the 30 t ha^{-1} treatment (5.3 t ha^{-1} in 2022 and 10.7 t ha^{-1} in 2023). A similar trend was observed for crude protein yield, which reached 478.8 kg ha^{-1} in 2022 and 1625.8 kg ha^{-1} in 2023 under the same treatment. Fertilization also influenced the botanical composition by increasing the proportion of grasses and reducing forbs, while the proportion of legumes varied depending on fertilization rate and climatic conditions between years. These findings confirm that cattle manure application can significantly improve both productivity and botanical structure of semi-natural grasslands, contributing to more sustainable forage production systems.

Keywords: *grasslands, fertilization, dry matter, crude protein, botanical composition*

APPLICATION OF UAV MULTISPECTRAL IMAGING AND VEGETATION INDICES FOR COMPARATIVE ASSESSMENT OF FOOTBALL PITCH QUALITY: A CASE STUDY OF GRBAVICA AND BILINO POLJE STADIUMS

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Abstract

The application of unmanned aerial vehicles (UAVs) equipped with multispectral sensors represents an increasingly valuable tool for monitoring turfgrass quality and supporting data-driven decision-making in sports turf management. The aim of this study is to evaluate the applicability of the Phantom 4 Multispectral UAV and Pix4Dfields software for assessing the condition of natural grass football pitches at Grbavica Stadium and Bilino Polje Stadium. High-resolution multispectral imagery is processed to generate orthomosaics and vegetation index maps, including NDVI, GNDVI, NDRE, BNDVI, LCI, MCARI, SIPI2 and TGI. These vegetation indices are used to compare turfgrass health, spatial variability and areas affected by physiological stress. In addition, the Magic Tool is applied to estimate the proportion of high-quality turf and to identify areas potentially associated with occurrence of *Poa annua* and other weeds. The study also describes the construction characteristics of both football pitches, with particular emphasis on the root zone material with sand-based system, including its origin, composition and particle size distribution, and discusses its importance for turfgrass establishment and maintenance. The results obtained are compared with NDVI assessments provided by ProPitch to evaluate the consistency of different turf monitoring approaches. The findings indicate that the integration of multispectral UAV imaging, vegetation index analysis and root zone characterization provides a reliable decision-support tool for sports turf managers, enabling more efficient planning of irrigation, fertilization, topdressing, renovation and overall pitch maintenance.

Keywords: *multispectral UAV, Pix4Dfields, vegetation indices, sports turf management, decision support*

SYNERGISTIC AND ANTAGONISTIC FUNGAL INTERACTIONS INFLUENCING MYCOTOXIN OCCURRENCE IN MAIZE

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Abstract

Maize is the most widely produced crop globally and ranks highly in both human and animal nutrition. It is highly susceptible to fungal contamination, with the most common moulds belonging to *Fusarium*, *Alternaria*, *Aspergillus*, *Cladosporium*, *Penicillium*, *Rhizopus*, and *Mucor* genera, several of which are mycotoxicogenic. A total of 133 maize samples were collected immediately post-harvest across two successive years (2024–2025) and analyzed for fungal contamination and mycotoxin content. Mould species were identified through morphological characterization and species-specific gene sequencing, while mycotoxins were quantified by liquid chromatography-tandem mass spectrometry (LC-MS/MS). Thirty-nine mould species were identified, with *Fusarium verticillioides* showing the highest frequency (67.1% in 2024; 30.3% in 2025). The most prevalent mycotoxin was fumonisin B1, reaching a maximum concentration of 6,644.65 µg/kg. *Penicillium oxalicum* was associated with higher 15-acetyl-deoxynivalenol ($\chi^2 = 4.89$, $p = 0.03$) and lower aflatoxin B1 concentrations ($\chi^2 = 5.12$, $p = 0.02$). *Cladosporium cladosporioides* was associated with deoxynivalenol concentrations ($\chi^2 = 5.47$, $p = 0.02$). As expected, *Aspergillus flavus* was associated with aflatoxin B1 ($\chi^2 = 16.89$, $p \leq 0.01$), but also showed an unexpected association with fumonisin B1 ($\chi^2 = 5.54$, $p = 0.02$). Chi-square analysis revealed significant associations between

mycotoxin concentrations and three mould species not recognized as primary producers of the detected mycotoxins. These findings suggest synergistic or antagonistic inter-species interactions influencing mycotoxin co-occurrence, with implications for targeted contamination prevention strategies.

Keywords: *grains, toxicogenic moulds, mycotoxins, fungal interactions*

ENERGY EFFICIENCY OF A GROUND-SOURCE HEAT PUMP SYSTEM FOR WINTER GREENHOUSE LETTUCE PRODUCTION

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Abstract

Greenhouse vegetable production during the winter season requires supplementary heating to maintain optimal microclimatic conditions for plant growth and development, while energy costs remain one of the main factors affecting production sustainability. Ground-source heat pumps provide an energy-efficient heating solution by utilizing renewable thermal energy stored in the soil. This study evaluated the application of a ground-source heat pump system for heating a greenhouse used for winter lettuce (*Lactuca sativa* L.) production, variety *Neil F1*. The experiment was conducted over a three-year period in two identical 100 m² greenhouses located at the Experimental Field of the Faculty of Agriculture and Food Science, University of Sarajevo. One greenhouse was equipped with a ground-source heat pump heating system, while the second greenhouse served as an unheated control. The heating system was primarily designed to warm the soil within the root zone, while providing supplementary low-intensity heating of the greenhouse air to maintain favorable growing conditions. Continuous monitoring included microclimatic conditions using high-precision environmental sensors, electricity consumption, crop growth duration, yield, and energy balance parameters. The heated greenhouse recorded a specific energy input (SEI) of 60.09-101.27 MJ/kg, an energy ratio (ER) of 0.0069-0.0116, and an energy productivity (EP) of 0.0099-0.0166 kg/MJ. In comparison, the unheated greenhouse achieved an SEI of 1.03-2.92 MJ/kg, an ER of 0.24-0.68, and an EP of 0.34-0.97 kg/MJ. Although the heated greenhouse required substantially higher energy inputs, it maintained favorable growing conditions throughout the winter season, shortened the lettuce production cycle (production cycle

duration: heated 67-85 days, unheated 112-134 days), decreased yield per production cycle (yield: heated 3.26-5.47 kg/m^2, unheated 3.34-6.88 kg/m^2), and enabled a greater number of production cycles compared with the unheated greenhouse. The average electricity consumption per operating hour of the heat pump ranged from 1.22 kWh in February to 1.67 kWh in November. Despite higher initial installation costs, the results demonstrate that ground-source heat pump technology represents a sustainable and efficient solution for winter greenhouse vegetable production.

Keywords: *geothermal heat pump, energy efficiency, lettuce, greenhouse*

POWER OF AGRICULTURAL MACHINERY PER UNIT AREA AS AN INDICATOR OF AGRARIAN POLICY EFFECTS IN THE FEDERATION OF BOSNIA AND HERZEGOVINA

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Abstract

Agricultural machinery power per unit area (kW/ha) represents a significant quantitative indicator of the level of mechanization, technological endowment, and effectiveness of agricultural policy. This paper analyzes the dynamics of this indicator in the Federation of Bosnia and Herzegovina over the period 2022-2024, based on data on the number, age structure, and installed power of registered tractors, sown areas, and estimated diesel fuel consumption, while also accounting for the impact of subsidies for the purchase of agricultural machinery. The results show that the total number of registered tractors increased by 57.01% (from 4357 to 6841), while sown areas decreased by 9.9% (from 199135 to 179447 ha). Total installed tractor power rose from 119793 kW to 185871 kW, and the mechanization indicator (kW/ha) increased from 0.60 to 1.04 kW/ha. The share of tractors up to five years of age more than doubled (from 942 to 2166), while estimated diesel fuel consumption per tractor decreased by 39% (from 5786 l to 3530 l), indicating improved average energy efficiency of the fleet. However, pronounced regional disparities were observed, with kW/ha values across cantons ranging from 0.26 to 3.23. Despite the observed growth dynamics, the mechanization level in the Federation of BiH (1.04 kW/ha) remains considerably below the average values recorded in agriculturally developed EU countries, pointing to the need for further intensification of investment incentives. The research confirms that the kW/ha indicator is

useful for evaluating subsidy policies; however, its interpretation requires supplementary indicators such as age structure, energy efficiency, and regional distribution. The obtained results provide a foundation for the formulation of targeted agricultural policy measures aimed at achieving sustainable and competitive agricultural production in the Federation of Bosnia and Herzegovina.

Keywords: *agricultural mechanization, power per unit area (kW/ha), agricultural policy, Federation of BiH, energy efficiency*

RENOVATION MODELS OF THE CULTURAL-HISTORICAL BUILDING AND THE GARDEN OF VILLA ŠANTIĆ IN BORCI

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Abstract

Bosnia and Herzegovina is distinguished by it's rich heritage- whether you look at it's cultural, traditional, material, or nonmaterial values. An example of this heritage is the Šantić villa, located in the village Borci, just above the city of Konjic. The Villa was comissioned and built in 1902, as a residence for the then ruler in the Austro-Hungarian regime in Bosnia and Herzegovina, Barun Benko. During the years, it was a residence of the poet Aleksa Šantić, whose name it proudly bears and is now protected as a National Monument. At one point in time, it was residence to the painter and artist, Lazar Drljača. Unfortunately, during wartime in the 1990s, the villa was completely burned down, with only the stone walls remaining. It's courtyard is totally neglected, but still shows vague signs of planned landscaping. The aim of this paper is to provide a renovation model for this important cultural-heritage site by combining architecutural and landscape designing. To achieve this, we used on-site measuring combined with historical photographs to reconstruct the mansion. For the surrounding park, due to a lack of available data, it was decided that a completely new landscape concept will be made to fit the character of this national monument and it's further use. The plan consisted of a number of plant species already located on site, with an addition of new species and, architectural elements which aim to enhance the courtyard's infrastructure and make it more aesthetically pleasing while being more functional.

Keywords: *renovation, National monument, architecture, landscape design*

ELECTROCUTION-INDUCED MORPHOMETRIC RESPONSES IN JAPANESE KNOTWEED (*Reynoutria japonica* HOUTT.)

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Abstract

Invasive weeds pose a significant threat to biodiversity and ecosystem functioning worldwide, prompting the exploration of novel, non-chemical management strategies, such as electrocution. Accurate characterisation of morphometric responses to electrocution is essential for understanding treatment-induced effects in highly invasive weeds, particularly the Japanese knotweed (*Reynoutria japonica* Houtt.). This study evaluated the morphometric responses of *R. japonica* rhizome sprouts subjected to controlled electrocution treatments for 60 seconds at 0 V, 20 V, 40 V, 60 V, 80 V, 100 V, 120 V, 140 V, 160 V, and 180 V. Each treatment comprised 3 sprouts (n = 3). Following exposure, sprouts were grown under controlled conditions for 7 days and assessed for length and diameter. The one-way ANOVA revealed a significant effect of electrocution on sprout length ($p < 0.05$), accounting for 53.80% of the observed variation ($\eta^2 = 0.538$), whereas sprout diameter remained largely unaffected ($p > 0.05$). The subsequent Tukey's HSD post-hoc test revealed significantly reduced sprout length at 60 V (21.00 ± 2.00 cm) and the greatest sprout length at 180 V (43.00 ± 5.00 cm). Overall, these findings demonstrate that electrocution can induce measurable alterations in sprout morphology, with sprout length emerging as a more sensitive indicator of

electrocution-induced changes than sprout diameter. The observed morphometric response patterns provide a quantitative framework for further optimisation of electrocution as a non-chemical management strategy to mitigate the spread of *R. japonica*.

Keywords: *invasive weeds, non-chemical management, rhizome sprouts, morphometric traits*

CHITOSAN-BASED ALTERNATIVES FOR PLANT PROTECTION IN SUSTAINABLE AGRICULTURE

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Abstract

The growing global population increases demand for quantities of high-quality food, presenting one of the biggest challenges for modern agriculture. At the same time, climate change, plant diseases and pests contribute to economic losses in crop production. As a response to these challenges, intensive and often irrational use of chemical pesticides has become common practice, resulting in environmental pollution, pesticide resistance, and negative effects on human and animal health. Therefore, the development of sustainable and environmentally friendly plant protection strategies has become a major priority. Among promising alternatives, chitosan has attracted attention due to its biodegradability, biocompatibility, low toxicity, and biological activity against numerous plant pests and pathogens. It can be applied alone or in combination with other active compounds, including conventional pesticides and biopesticides. This study aimed to highlight the potential of chitosan in sustainable plant protection. Recent studies of chitosan focused on nanoparticles loaded with different insecticides. Even at low concentrations, spinosad and permethrin showed enhanced activity against *Drosophila spp.*, indicating the potential of nanopesticides for targeted and prolonged action. Furthermore, chitosan has shown synergistic antifungal effects when combined with copper, allowing a reduction of copper concentration by up to 50% while maintaining antifungal efficacy. Such combinations represent an important step toward reducing the negative impact of conventional agriculture. Overall, chitosan-based formulations and their combinations with other active substances have significant potential for improving crop protection, preserving ecosystems, and supporting the transition toward more sustainable agriculture.

Keywords: *chitosan, biopesticides, spinosad*, *copper*, *sustainable agriculture*

STILBENE-ASSOCIATED DEFENSE RESPONSES IN ORGANIC VITICULTURE

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Abstract

Stilbenes are key grapevine phytoalexins involved in plant defense against biotic and abiotic stress. Their accumulation intensity depends on infection risk, phenological development, and genotype. This study aimed to evaluate the biosynthesis dynamics of the main stilbenes in grapevine (trans-resveratrol and trans-polydatin) in organically grown grapes.

The experiment was conducted in 2024 in an organic vineyard located in Čortanovci, Serbia. Grapevine varieties Gamay, Moldova, Muscat Hamburg, Muscat Italia, Lasta, and Sauvignon Blanc were sampled at four phenological stages according to the BBCH scale, from pea-size berries to technological maturity. Climatic conditions during this season were characterized by high temperatures, drought periods followed by supercell storms, creating favorable conditions for physiological stress and disease pressure.

The content of stilbenes was determined using a previously validated SPE-HPLC/DAD analytical method. Trans-polydatin increased around veraison (BBCH 83-85), a stage recognized as highly sensitive to phytopathogenic infection due to rapid berry softening and metabolic changes. Trans-resveratrol showed lower and more variable concentrations with variety-dependent patterns, generally higher in technological maturity.

The observed dynamics suggest that stilbene biosynthesis is closely associated with higher infection risk when the grapevine defense responses are most active. Environmental stress further enhanced these responses, indicating the combined effect of biotic and abiotic factors. The predominance of trans-polydatin supports its role in the storage of grapevine defense, whereas trans-resveratrol is actively responsive to specific triggers.

Overall, the results emphasize the importance of organic viticulture in enhancing and revealing the natural defense potential of grapevine through stilbene metabolism under stress conditions.

Keywords: *stilbenes, grapevine, stress response*, *resveratrol, polydatin*

THE EFFECT OF HARVESTING ON THE YIELD AND ESSENTIAL OIL CONTENT OF THE LEAVES AND FLOWERS OF *Hysopus officinalis* L.

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Abstract

The effects of successive harvesting on plant yield, yield components, and essential oil content of the leaves and flowers of *Hyssopus officinalis* L. cultivated under the ecological conditions of Eskisehir, Türkiye, in 2025 were investigated. The experiment was conducted using a randomized block design with three replications. Plant height, fresh herb yield per plant, dry herb yield, dry leaf yield, dry flower yield, leaf SPAD value and essential oil contents of the leaves, and flowers were eveluated following three successive harvests conducted in early summer, late summer and autumn. The highest plant height (51.97 cm) and leaf SPAD value (56.95) were obtained at the late-summer harvest. The highest fresh herb yield (207.58 g), dry herb yield (63.37 g) were obtined at the early-summer harvest. Whereas the highest dry leaf yield was obtained at the autumn harvest. The essential oil contents of the flowers and leaves were 1.12% and 0.82%, respectively. These results indicate that harvest time significantly affects the yield characteristics and essential oil content of *H. officinalis* and that the optimal harvest period may vary depending on the desired plant component and production objective.

Keywords: *Hyssopus officinalis*, *Harvesting, Yield, Essential Oil, leaves, flowers*

EFFECT OF CORM DIMENSION AND PLANTING TIME ON FLOWER AND STIGMA YIELD OF SAFFRON (*Crocus sativus* L.) IN A SEMI-ARID ENVIRONMENT

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Abstract

A field experiment was conducted in 2025 at the Faculty of Agriculture of Eskisehir Osmangazi University, Türkiye. A single population of *Crocus sativus* L. was used as the plant material. Each plant was considered as a replicate. Five different planting dates (12 September, 22 September, 2 October, 12 October, and 22 October) and five different corm sizes (>6 cm, 8 cm, 9 cm, 10 cm, and <11 cm) were evaluated. The results showed that the highest flower and stigma yields were obtained from corms larger than 11 cm and from the earliest planting date (12 September). Delayed planting resulted in lower flower and stigma yields under mild winter conditions. Corms larger than 9 cm are recommended for efficient flower production.

Keywords: *corm dimension. planting time, flower yield, stigma yield, Crocus sativus L.*

BACTERIAL DISEASES OF *Foeniculum vulgare*: A CRITICAL REVIEW OF PATHOGEN RECORDS, DIAGNOSIS, EPIDEMIOLOGY, AND DISEASE MANAGEMENT

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Abstract

Although *Foeniculum vulgare* Mill. is an economically and medicinally important aromatic plant; published records of bacterial diseases affecting fennel remain scattered, taxonomically heterogeneous, and variable in diagnostic evidence. In this review, published records of bacterial diseases of fennel were critically evaluated in terms of pathogen taxonomy, symptom type, diagnostic approach, epidemiological information, and disease management. The records examined include *Pseudomonas* and *Erwinia species*. Reported symptoms mainly consist of leaf blight, leaf spot, and streak-type lesions associated with *Pseudomonas* species, as well as bulb or leaf-stalk base soft rot associated with pectolytic bacteria. The level of diagnostic evidence differs markedly among reports; some studies include isolation, phenotypic characterization, pathogenicity testing, re-isolation, and rep-PCR-based confirmation, whereas older reports rely primarily on classical bacteriology. Epidemiological information is limited; soil, wounds, high humidity, irrigation, and mechanical injury have been mentioned as possible factors, but they have rarely been tested quantitatively. Reliable assessment of bacterial diseases of fennel requires modern molecular diagnostics, standardized pathogenicity assays, systematic surveys, and evidence-based integrated management strategies.

Keywords: *Foeniculum vulgare*, *bacterial diseases*, *Pseudomonas syringae*, *soft rot*, *pathogen diagnosis*

EFFECT OF MANUAL AND MECHANICAL SUMMER PRUNING ON FRUIT QUALITY OF PLUM (*Prunus domestica* L.)

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Abstract

Plum (*Prunus domestica* L.) is a nutritionally valuable fruit with significant commercial importance, with pruning being an essential practice that directly influences yield and the attainment of consistent fruit quality. This study investigated the effects of cultivar, summer pruning treatment, and study year on the chemical composition of plum fruit, focusing on total phenols, flavonoids, and antioxidant capacity. The research was conducted over two growing seasons in an intensive orchard at the Bakinci location with the cultivars 'Čačanska lepotica' and 'Stenli', grafted on *Prunus cerasifera* Ehr. seedlings, trained in a spindle system, and planted at a distance of 4.0 × 1.80 m. The experiment included three treatments: manual pruning, mechanical pruning, and control trees without summer pruning. The results showed that both the cultivar and the applied pruning treatments significantly influenced changes in the chemical composition. Mechanical pruning had the most pronounced positive effect on increasing the content of phenols, flavonoids, and antioxidant activity, which was particularly noticeable in 'Čačanska lepotica', while different and less uniform effects were recorded in 'Stenli' depending on the year. The application of mechanical summer pruning contributes to a significant advancement and improvement of the overall quality of plum fruits, especially in the cultivar 'Čačanska lepotica'.

Keywords: *plum, summer pruning, cultivar, polyphenols*

EFFECTS OF PLANT GROWTH REGULATORS ON VEGETATIVE DEVELOPMENT AND YIELD OF DUKE HIGHBUSH BLUEBERRY

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Abstract

Application of plant growth regulators (PGRs) plays a key role in modern northern highbush blueberry (*Vaccinium corymbosum* L.) production by influencing vegetative development, increasing yield, and improving fruit quality. The aim of this study was to examine the effect of foliar application of PGRs on shoot growth and yield of blueberry cultivar *Duke*. The research was conducted during 2024 in a commercial blueberry plantation established in 2019 in Romanovci, Gradiška (45°08′43″ N, 17°15′04″ E). The PGR treatments were applied once during full bloom (BBCH 54–59) using a hand sprayer with a water volume of 500 L ha^{-1}. The experiment included individual and combined applications of Globaryll (0.5 L ha^{-1} and 1 L ha^{-1}), Obsthormon (0.13 L ha^{-1} and 0.26 L ha^{-1}), Orogib (3.125 L ha^{-1}) and an untreated control. Morphometric measurements were carried out at the end of the growing season. Results showed that the applied treatments increased the length of one-year shoots and the number of leaves per shoot compared to the control, with the combination of Globaryll 1 L ha^{-1} + Obsthormon 0.26 L ha^{-1} and Orogib 3.125 L ha^{-1} being the most effective. Additionally, the individual leaf surface area reached its highest values under Obsthormon 0.13 L ha^{-1} and Orogib 3.125 L ha^{-1} treatments. Due to the strong promotion of shoot elongation and leaf development, the treatment with Orogib successfully resulted in a 2.6 times higher yield compared to the untreated control.

Keywords: *6-benzyladenine, naphthylacetic acid, gibberellins, shoot length, leaf area*

MULTIVARIATE ASSESSMENT OF PHENOTYPIC DIVERSITY IN AN F_2 POPULATION DERIVED FROM TRITICUM COMPACTUM × TRITICUM TURANICUM

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Abstract

Understanding phenotypic variation in segregating populations is essential for identifying promising breeding materials and characterizing genetic diversity. This study aimed to evaluate the phenotypic diversity of 36 F_2-derived individuals obtained from a cross between Triticum compactum and Triticum turanicum using multivariate statistical methods. Fourteen morphophysiological and yield-related traits, including flag leaf area, chlorophyll content, canopy temperature, relative water content, plant height, spike characteristics, grain number, grain weight, harvest index, and thousand-kernel weight were assessed. Principal component analysis (PCA) revealed substantial variation among F_2 individuals, with the first two principal components explaining 56.7% of the total variance in the data. The first principal component was mainly associated with grain weight, thousand-kernel weight, spike weight, and spike number, whereas the second component was largely influenced by the harvest index, plant height, grain number, and flag leaf area. Hierarchical cluster analysis based on Ward's method grouped the populations into three distinct phenotypic clusters. Cluster I was characterized by higher grain number, grain weight, and harvest index; Cluster II by greater flag leaf area and relative water content; and Cluster III by higher chlorophyll content and lower canopy temperature. The large distances observed among the cluster centroids indicated substantial phenotypic divergence within the population. The results demonstrated extensive segregation and diversity in the F_2 population and highlighted several individuals with favorable trait combinations for future selection. The identified phenotypic groups also provide a useful framework for future cytogenetic investigations and chromosome characterization studies to segregate wheat populations.

Keywords: *F_2 population, Phenotypic diversity, Principal component analysis, Cluster analysis, Wheat breeding*

INFLUENCE OF HARVEST TIME ON THE YIELD AND QUALITY OF POT MARIGOLD FLOWERS (*Calendula officinalis* L.)

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Abstract

Pot marigold (*Calendula officinalis* L.) is an annual medicinal plant from the Asteraceae family. It is a popular medicinal plant species on the global market due to its wide application in the pharmaceutical and cosmetic industries. In Bosnia and Herzegovina (B&H), it is grown on smaller plantations and in gardens as an ornamental plant. Pot marigold is characterised by the successive development and maturation of flowers; that is, in cultivation, it has a greater number of harvests. Often, the development of individual flowers occurs in different weather conditions, which affects the quality and yield. Given the previous fact, the aim of this research was to determine the yield and quality of pot marigolds in different harvests in the environmental conditions of central B&H. Field experiments were carried out in the 2022 growing season at a private farm ″Gavrić″ in Kakanj. The traits tested were the number of harvests, flower yield, total phenolic content, total flavonoid content, antioxidant capacity, and constituent content in the essential oil. The results showed that the yield and quality of pot marigold inflorescences vary with harvest time. For example, as average daily air temperature increased, yield decreased. A total of 23 constituents were identified in the essential oil. The largest share was: α-cadinol, tau-cadinol, cadina, α-muurolene and α-thujene.

Keywords: *Pot marigold , quality, yield, antioxidant capacity, essential oil*

OCCURRENCE OF GRAPEVINE VIRUSES AND PHYTOPLASMAS IN DIFFERENT VARIETIES IN LEVAČ WINE REGION IN SERBIA

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Abstract

Over the last decade, viticulture and winemaking in Serbia have experienced a dynamic revival. However, managing plant health remains a critical challenge, as grapevine (*Vitis vinifera* L.) can host more than 100 viruses and several phytoplasmas.

To evaluate the prevalence of viruses and phytoplasmas, leaf samples from 13 grapevine varieties were collected across 10 vineyards in the vicinity of Rekovac in Levač wine region. During visual inspections of the vineyards, which ranged in age from 2 to 40 years, the vast majority of the vines appeared asymptomatic. In total, 29 samples were collected, comprising both asymptomatic leaves and those displaying distinct visual symptoms indicative of viral or phytoplasma infections.

A multiplex reverse transcription-polymerase chain reaction (mRT-PCR) assay was utilized for the simultaneous detection of nine viruses: grapevine fan leaf virus (GFLV), grapevine leafroll virus 1, 2, and 3 (GLRaV-1, GLRaV-2, and GLRaV-3), grapevine rupestris stem pitting-associated virus (GRSPaV), grapevine virus A (GVA), grapevine virus B (GVB), grapevine fleck virus (GFkV), arabis mosaic virus (ArMV). A nested-PCR protocol was employed for phytoplasma identification.

The analysis revealed high incidence of viral infections in Levač wine region, alongside a high rate of mixed infections. The presence of GFLV was confirmed in all analysed samples. The most common viruses were GLRaV-1 (20 samples), GFkV (18 samples), and ArMV (16 samples). GLRaV-2, GVA, and GVB were confirmed in nine samples, and GRSPaV in three samples. '*Candidatus* phytoplasma vitis' (FD) was confirmed in three samples.

These results indicate the need to strengthen the control of virus and phytoplasma diseases of grapevine.

Keywords: *grapevine, viruses, phytoplasmas, mRT-PCR, nested-PCR*

PHYTOCHEMICAL PROFILE AND ANTIOXIDANT CAPACITY OF WILD AND CULTIVATED THYME (*Thymus vulgaris* L.) INFUSIONS

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Abstract

This study aimed to compare the phytochemical composition and antioxidant capacity of wild growing and cultivated thyme (*Thymus vulgaris* L.) obtained from the Rtanj mountain region and nearby Sokobanja (Serbia), respectively. Plant material was provided by *Adonis d.o.o.,* and aqueous extracts were prepared as infusions in order to simulate traditional tea consumption, whilst analyses were performed using spectrophotometric methods. The obtained results revealed notable differences in phytochemical composition between these groups. The cultivated sample showed higher levels of total phenolic content (TPC), while the wild growing thyme was characterized by higher contents of total flavonoids (TFC), hydroxycinnamic acids (HCAs), and tannins. Regarding antioxidant capacity, the results varied depending on the applied assay. The wild growing thyme exhibited higher ferric reducing power (FRP), whereas the cultivated sample demonstrated stronger antioxidant activity in total antioxidant capacity (TAC) and cupric reducing antioxidant capacity (CUPRAC) assays. No statistically significant differences were observed between the samples in $DPPH^{\bullet}$ and $ABTS^{\bullet+}$ assays. The results indicate that the differences between wild and cultivated thyme are more pronounced in phytochemical composition than in antioxidant assays, suggesting that antioxidant potential is method dependent and not solely determined by phenolic content. Therefore, both wild and cultivated thyme can be recommended for consumption as functional herbal infusions, offering complementary phytochemical and antioxidant properties.

Keywords: *wild thyme, cultivated thyme, infusion, phenolic compounds, antioxidant capacity*

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INFLUENCE OF IRRIGATION METHOD ON YIELD, WATER STRESS PARAMETERS, AND WATER USE EFFICIENCY OF LETTUCE (*Lactuca sativa* L.)

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Abstract

The introduction of efficient irrigation methods and the establishment of optimal cultivation conditions have become key objectives of modern agriculture to ensure the sustainable and rational use of water resources. This study examined the effects of regulated deficit irrigation (RDI) on the yield, water use efficiency (WUE), and crop water stress index (CWSI) of lettuce (*Lactuca sativa* L.). The experiment was conducted in a greenhouse from March 2025 to May 2025. Lettuce of the Carmesi variety (Meridiem Seeds) was planted at a spacing of 25 cm (16 plants per m²) in gutters measuring 0.4 m wide, 0.4 m deep, and 10 m long, filled with substrate containing Danube sand and 15–20% perlite, with known water-physical and chemical properties. Two irrigation methods were used: Responsive Drip Irrigation (RDI), which delivers water according to plant needs, and Standard Drip Irrigation (SDI), which served as the control. Plant growth and the amount of water applied with each irrigation method were continuously monitored throughout the experiment. Every 7 to 10 days, the temperature of the lettuce canopy was measured using remote sensing techniques and a thermal imaging camera (FLIR T335). The thermal images were processed with FLIR Tools software, and the resulting data were used to calculate the Crop Water Stress Index (CWSI) according to the method described by Idso *et al*. (1981). At the end of the experiment, yield was measured (fresh and dry weight in $g \cdot m^{-2}$), and water use efficiency (WUE) was calculated as the ratio of yield to the total amount of irrigation water applied. The results showed that the RDI method significantly reduced water consumption while achieving higher yields, greater WUE, and lower CWSI values compared with the SDI method.

Keywords: *regulated deficit irrigation, standard drip irrigation, crop water stress index, water use efficiency*

MODELING FUTURE CLIMATE CHANGE EFFECTS ON MAIZE YIELD AND SOIL NITROGEN DYNAMICS IN MEDITERRANEAN CROPPING SYSTEMS

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Abstract

After being calibrated and validated, the DSSAT model (System for Agrotechnology Transfer) was used to assess the effects of future climate change on maize yield, cover crop residue nitrogen mineralization, and nitrogen leaching under combinations of cover crop residues (common vetch and common vetch oat mixture) and tillage systems (conventional tillage, CT, and no tillage, NT) in a sprinkler-irrigated field in Zaragoza, Spain. Climate projections untill 2100 were obtained from CMIP6 using four different global climate models (CNRM-CM6-1, CNRM-ESM2-0, EC-Earth3-Veg-LR, and EC-Earth-CC), under the SSP2-4.5 and SSP5-8.5 scenarios. Maize yield decreased significantly across all treatments and scenarios. However, the highest yield was obtained with common vetch residues under CT with averages of 8601 kg DM ha^{-1} and 8003 kg DM ha^{-1} for SSP2-4.5 and SSP5-8.5, respectively. Under common vetch residues and NT the maize system showed similar yield preformance and the greatest nitrogen mineralization potential (average of 198 kg N ha^{-1}), but also the highest nitrogen losses through leaching. Overall, the simulation outputs indicate that common vetch residues under CT provided the best balance between maize production and reduced environmental nitrogen losses.

Keywords: *DSSAT, N mineralization, climate change, maize production*

GIS ANALYSIS OF SUITABILITY OF APPLE GROWING IN THE AREA OF TOPLICA AND KOLUBARA DISTRICTS

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Abstract

Due to climate change, limited arable land, and growing global demand for food production, agroecological zoning is becoming a crucial approach for planning sustainable agricultural production. It enables the adequate and sustainable planning of agricultural production in a specific area and can play an important role in the formulation and implementation of agricultural policies. The aim of this research was to analyze the suitability of selected areas for apple cultivation using Geographic Information Systems (GIS) and multi-criteria spatial analysis. The study utilized spatial data on land use, slope, elevation, solar radiation, and pedology for the Toplica and Kolubara districts. Relevant factors will be standardized and integrated using GIS tools to create suitability maps for cultivation in these two districts within the Republic of Serbia. The applied approach will allow for the integration of various spatial and environmental data into a single model for assessing land suitability for each of the analyzed districts. The results obtained will be compared to identify similarities and differences in cultivation suitability between the researched areas, providing a basis for improving spatial planning and decision-making in agricultural production.

Keywords: *GIS, agroecological zoning, spatial planning, apple*

SEASONAL DYNAMICS OF MACRONUTRIENTS IN *Arundo donax* L. CULTIVATED ON A FLY ASH DISPOSAL SITE

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Abstract

Power plant fly ash disposal sites are characterized by unfavorable physicochemical properties and low nutrient availability, which limit vegetation establishment. Evaluating macronutrient dynamics in plants provides important insights into adaptation to such environments and their suitability for phytomanagement. Due to its high adaptability, *Arundo donax* is considered a promising species for cultivation on marginal and degraded lands. This study examined the seasonal dynamics of nitrogen (N), phosphorus (P), and potassium (K) in *Arundo donax* grown on a coal ash disposal site. The experiment was established in May 2023 at the ash disposal site of the "TENT B" thermal power plant near Obrenovac, Serbia, using a randomized block design with three replicates. Three fertilization treatments were applied: control without fertilization (C), T1, and T2 (310 and 620 kg NPK ha^{-1}, respectively). Macronutrient concentrations were determined in roots, rhizomes, stems, and leaves during the vegetative, reproductive, and harvest stages. Results revealed pronounced nutrient remobilization during plant development. Leaf N concentrations decreased by 27–41% from the vegetative stage to harvest, while rhizome N increased by 59–78%, depending on fertilization treatment. Similar trends were observed for P and K, with decreasing concentrations in aboveground organs and greater accumulation in belowground tissues. Nutrient redistribution occurred even in unfertilized plants. The ability of *Arundo donax* to efficiently remobilize and conserve essential nutrients indicates that this species can successfully establish and grow under nutrient-limited conditions. Which enables the formation of a sustainable biocover and highlights its potential for phytomanagement and ecological restoration of degraded areas.

Keywords: *Arundo donax, phytomanagement, macronutrients, coal ash*

HEAVY METAL TRANSLOCATION IN PERENNIAL GRASSES USED FOR FLOTATION TAILINGS RECLAMATION

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Abstract

One of the fastest ways to establish vegetation cover on flotation tailings is by planting perennial grasses. Previous studies have shown significant potential for the survival and persistence of fescue species, particularly red fescue and tall fescue. However, when grasses are grown on substrates with elevated concentrations of potentially toxic elements (PTEs), there is a risk of element uptake and translocation from roots to aboveground plant organs.

A field experiment was conducted on the flotation tailings of a lead-zinc mine in central Serbia on April 1, 2021, using three replications (experimental plot size 10 m^2) with pure stands of red fescue and tall fescue sown at a rate of 60 kg ha^{-1}. In addition to substrate fertility parameters (pH in water and KCl, humus content, organic carbon, and the macronutrients N, P, and K), the concentrations of Cd, Co, Cu, Ni, Fe, Mn, Pb, and Zn were determined, as well as their contents in the roots and aboveground biomass of each grass species. The aim of the study was to evaluate the sustainability of grass cover on a PTE-rich substrate and to assess the translocation of absorbed elements to the aboveground plant parts. Flotation tailings are a substrate with very poor nutrient status and elevated concentrations of PTEs. The investigated elements were predominantly retained in the root systems of both grass species. The translocation factor for all analyzed elements was below 1, indicating limited transfer of

absorbed metals to the aboveground biomass and classifying both grass species as heavy-metal excluders.

Keywords: *flotation tailings, potentially toxic elements, red fescue, tall fescue, translocation factor*.

AN IMPORTANT PLANT PATHOGENIC FUNGUS: *STEMPHYLIUM*

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Abstract

Stemphylium is a genus of fungi within the phylum Ascomycota, consisting of important plant pathogenic species that infect a variety of hosts, particularly economically significant crops. *Stemphylium* species are necrotrophic fungal pathogens that affect a wide range of hosts, targeting many economically significant crop species globally. These fungi have been identified as causing diseases in over 150 plant genera across more than 30 plant families, including onions, tomatoes, lentils, alfalfa, spinach, sugar beets, asparagus, and various ornamental plants. The most substantial economic losses are linked to crops in the Amaryllidaceae, Fabaceae, Solanaceae, and Amaranthaceae families. These fungi can cause diseases such as leaf blight, leaf spot, and infections of stems and fruits, resulting in considerable losses in both yield and quality. Species of *Stemphylium* demonstrate broad ecological adaptability and can be found in diverse climatic and geographical regions. Morphologically, they are characterized by darkly pigmented hyphae, septate conidia, and distinctive conidial structures. However, due to the high morphological similarity among species, identification based solely on these traits is often inadequate. Therefore, molecular methods, especially DNA sequence analyses, have become essential for the accurate and reliable identification of *Stemphylium* species.

Keywords: *Stemphylium spp., plant pathogens, Stemphylium ecology*

CHARACTERISTICS OF OLD AUTOCHTONIC PLUM CULTIVARS

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Abstract

Plum is one of the most important and traditionally cultivated fruit species in the Balkan region. In the past, old autochthonic plum cultivars predominated in this area. In recent years, interest in their cultivation has increased once again. This paper presents the characteristics of three old indigenous plum cultivars (*Crvena ranka*, *Okruglica*, and *Drenovka*). The cultivar *Čačanska lepotica*, one of the most widely grown plum cultivars in Serbia, was used as the control. The results obtained over two years of investigation (2023 and 2024) showed that the old cultivars flowered, on average, four days earlier than *Čačanska lepotica*. Fruit ripening occurred simultaneously with *Čačanska lepotica* in *Crvena ranka*, while it was delayed by 7 days in *Okruglica* and by 17 days in *Drenovka*. All autochthonic cultivars were characterized by poor stone separation (clingstone fruits) and relatively small fruit size (*Drenovka* – 14.88 g, *Okruglica* – 15.14 g, *Crvena ranka* – 17.36 g). In contrast, *Čačanska lepotica* produced fruits that were more than twice as large (35.21 g). On the other hand, the autochthonic cultivars had significantly higher soluble solids content, ranging from 22.69 °Brix in *Drenovka* to 24.09 °Brix in *Okruglica*, whereas the fruits of *Čačanska lepotica* contained 18.34 °Brix. Although the cultivation of autochthonic cultivars has recently expanded, they should not replace the currently grown commercial plum cultivars. Instead, they should complement the existing cultivar assortment, primarily to produce high-quality plum brandy. In addition, these cultivars should be preserved because of their adaptability and resilience to local environmental conditions, as well as their importance for conserving plum genetic resources.

Keywords: *plum, autochthonic cultivars, genetic resources*

SELECTION OF SPECIES AND VARIETIES AS A KEY SUSTAINABILITY FACTOR IN FRUIT GROWING AND VITICULTURE PRODUCTION

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Abstract

Sustainability in fruit growing and viticulture implies the application of environmental responsible, economically profitable and socially beneficial practices. Ecological factors include: soil health and biodiversity, water management, integrated pest management, energy reduction. Economic factors implies: profitability, waste valorization, diversification. Social factors include: gene banks and safe working conditions. The primary foundation of sustainability in fruit growing and viticulture is the choice of species, varieties and rootstocks. In this work, for plum, apple, pear, sweet cherry, sour cherry, peach, walnut, raspberry, strawberry and grapevine, as the most cultivated species in Serbia and the region, from the key pillars of sustainability are shown: genetic resistance and tolerance of varieties, adaptation to climatic conditions, compatibility with the rootstock and soil, pollination and structure of plantations. The special attention of many producers is focused on autochthonous varieties for cultivation. In addition to them, newly recognized varieties of fruit trees and grapevine from different breeding programs in the world are increasingly being introduced into production. Breeding objectives in those programs are primarily focused on creating resistant varieties to biotic and abiotic stresses (diseases, pests, drought, frost), with high quality fruits. To achieve the goals, hybridization and clonal selection are mostly used. Among the new techniques in breeding stand out marker-assisted selection, genetic modifications, genomic selection, and genome editing, which shortens the process of creating new varieties. The optimal selection of species and varieties and all measures can therefore directly affect the economic profitability, longevity of fruit and viticulture production, enabling easier adaptation to climate changes and reduction of growing costs.

Keywords: *fruit species, grapevine, selection, variety, sustainability*

EVALUATION OF SHEEP WOOL FERTILIZER AS A SUSTAINABLE NUTRIENT SOURCE FOR RED LETTUCE PRODUCTION

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Abstract

The transition towards sustainable horticulture requires innovative fertilizers that improve crop production while supporting circular resource use. Sheep wool, an underutilized livestock by-product, can be processed into an organic fertilizer with slow nutrient release. This study evaluated the performance of pelleted sheep wool fertilizer in red lettuce (*Lactuca sativa* L.) cultivation compared with commercially available organic fertilizers. The experiment was conducted at the experimental field of the Faculty of Agriculture and Food Science, University of Sarajevo, located in Butmir (43°49′34.42″ N, 18°19′18.48″ E; 505 m a.s.l.), using a randomized block design with three replications. Plant growth, yield, total phenolic content, flavonoid content, and antioxidant capacity were assessed. Sheep wool fertilizer achieved performance comparable to standard organic fertilizers, indicating its potential as a sustainable alternative for red lettuce production while contributing to the valorization of agricultural by-products and circular economy principles.

Keywords: *lettuce, organic fertilizer, circular economy, sheep wool fertilizer*

BIOLOGICAL MANAGEMENT OF APHIDS IN APPLE ORCHARDS: A ONE HEALTH APPROACH TO SUSTAINABLE CROP PROTECTION IN AZERBAIJAN

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Abstract

The adoption of environmentally sustainable pest management strategies is essential for improving plant health, protecting biodiversity, and enhancing the resilience of agrifood systems within the One Health framework. This study investigated aphid species diversity and evaluated the efficacy of biological control agents as a low-impact alternative to conventional pesticides in apple orchards located in the Goygol and Samukh districts of the Ganja-Dashkasan Economic Region of Azerbaijan. Field surveys conducted across ten locations identified six aphid species based on key diagnostic morphological characteristics under stereomicroscopy: *Aphis pomi*, *Hyalopterus pruni*, *Eriosoma lanigerum*, *Aphis fabae*, *Myzus persicae*, and *Dysaphis pyri*, with *Aphis pomi* and *Eriosoma lanigerum* identified as the dominant species. The efficacy of biological and chemical control methods against *Aphis pomi* was assessed under actual field conditions over a seven-day treatment period with four replications per treatment. Treatments were applied using calibrated backpack sprayers at the following field concentrations: Nimbecidine (azadirachtin 0.03% EC at 5 mL/L), Kormicarb 50 WP (pirimicarb 500 g/kg at 1 g/L), and Nimboterm (3 mL/L). By the seventh day of field observations, the mean aphid population declined from 8.7 individuals per shoot in the untreated control to 1.5 following Nimboterm application, 1.0 after Kormicarb 50 WP treatment, and 0.9 following the neem-based biopesticide Nimbecidine-corresponding to approximately 90% population suppression. Notably, Nimbecidine achieved this level of control while preserving populations of beneficial parasitoids and predatory insects, indicating a favourable selectivity profile compared with conventional chemical treatments. As a plant-derived, bio-based input, azadirachtin also aligns with circular bioeconomy principles, offering a renewable alternative to synthetic pesticide inputs. These findings demonstrate that neem-based biological products can effectively replace or substantially reduce conventional

pesticide use in integrated pest management (IPM) programmes for apple orchards. We recommend the integration of azadirachtin-based biopesticides into national IPM guidelines for apple production in Azerbaijan, as a practical step toward reducing chemical inputs, conserving orchard biodiversity, and strengthening the resilience and sustainability of agrifood systems under the One Health approach.

Keywords: *One Health, Integrated Pest Management, Biological Control, Apple Orchards, Aphis pomi, Azadirachtin, Circular Bioeconomy, Sustainable Agriculture*

LIVING LAB CENTRAL BOSNIA SOILS-SUSTAINABLE MANAGEMENT OF THE SUBSURFACE SOIL LAYER

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Abstract

"Caring for Soil is Caring for Life" is the guiding motto of the EU Soil Mission under the Horizon Europe programme, aiming for at least 75% of EU soils to be healthy by 2030, ensuring food security, biodiversity, climate resilience, and human well-being. Since soil degradation also affects subsoil, reducing its ecological functions, the SUS-SOIL project focuses on improving subsoil knowledge and management. SUS-SOIL is a four-year project establishing a network of 15 Living Labs across Europe. Its activities include: (i) subsoil inventory and characterization through soil coring to 1 m depth, analyses of physical, chemical, biological, and ecotoxicological properties, and development of a database interoperable with the LUCAS soil database; and (ii) assessment of long-term Agroecological Subsoil Management (ASM) practices through experimental field trials in conventional and organic farming systems using organic and mineral fertilizers, biochar, and compost. Within the Central Bosnia Soils Living Lab, field investigations will be conducted at three representative locations: Bugojno, Ilidža, and Živinice. The Bugojno Basin is characterized by Mesozoic limestone along its margins and Neogene–Quaternary deposits in the basin floor. Dominant soil types include Fluvisols and meadow soils in the lowlands, with brown valley soils developed on limestone and colluvial deposits in the surrounding terrain. The Ilidža Living Lab is bordered by the limestone mountains of Igman and Bjelašnica and includes the Sarajevo Plain, formed by Neogene and Quaternary sediments. Its dominant soils are Fluvisols, Gleysols (Semigleys) in low-lying areas, and Cambisols on elevated terrain, providing representative conditions for evaluating sustainable subsoil management practices.

Keywords: *subsoil, soil health, Living Labs, soil characterization, Agroecological Subsoil Management (ASM)*

ASSESSMENT OF HEAVY METAL CONTAMINATION IN PUBLIC GREEN SPACES AND PARKS OF SARAJEVO CANTON

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Abstract

Heavy metals are a natural component of soil; however, their presence at elevated concentrations can have harmful effects on human health and the environment. This is particularly problematic in urban areas, where emissions from traffic and industry significantly contribute to increased levels of heavy metals in the environment, including soils. As cities become increasingly populated and polluted, industrial activities and intensive traffic contribute to the contamination of air, water, and soil with various hazardous substances. As a direct consequence, a wide range of health problems may occur in both humans and animals. The soils of Sarajevo Canton are continuously exposed to anthropogenic pressures. However, the soil monitoring system is insufficiently developed, and there is a lack of reliable data on the potential pollution or contamination of soils, particularly non-agricultural soils in urban environments such as parks, children's playgrounds, schoolyards, and similar public spaces. The legal framework in the Federation of Bosnia and Herzegovina concerning soil quality and monitoring applies only to agricultural land and does not cover other soil types. At present, neither the Federation of Bosnia and Herzegovina nor Sarajevo Canton has legislation regulating the permissible concentrations of hazardous substances in non-agricultural soils.

The primary objective of this study was to determine the concentrations of heavy metals in park soils within the urban area of Sarajevo. Soil samples were collected from thirteen locations in Sarajevo. The research included soil sampling at the selected locations, laboratory analysis of the collected samples, and interpretation of the results. None of the analyzed soil samples contained concentrations of the investigated heavy metals - lead (Pb), copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), cadmium (Cd), chromium (Cr), nickel (Ni), and cobalt (Co) - that exceeded the prescribed limit values.

Keywords: *urban environment, parks, heavy metals, soil pollution*

THE EFFECT OF CORN (*Zea mays*) FLAKE ADDITION ON ALFALFA (*Medicago sativa*) SILAGE QUALITY

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Abstract

The study was carried out to determine the effects of corn (*Zea mays*) flakes on the chemical composition, digestibility, and fermentation properties of alfalfa (*Medicago sativa*) silages ensiled with different levels of corn flakes addition. Within the scope of the study, alfalfa chopped to 1-2 cm sizes were ensiled by vacuuming in anaerobic plastic bags by adding 5%, 10% and 15% flaked corn to the treatment groups. Silage samples were kept 45 days for fermentation in a dark ambient condition. Some characteristics were measured such as silage pH, concentrations of lactic and acetic acid, content of crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) of silage. Results illustrated that pH value of silage, rate of acetic acid and CP decreased significantly in the treatment groups compared to the control group ($P<0.01$). In contrast, those values of dry matter content, rate of lactic acid, NDF and ADF increased in the study. pH value of silage decreased in the treatment groups compared to the control, and the highest mean was determined in the group to which 15% corn flakes were added. Content of CP was also found to be similar in the 5% corn flakes added group and the control group but decreased significantly at the 10-or 15% corn flakes level. NDF and ADF increased considerably with 10-15% corn flakes. Rate of lactic acid significantly increased with the addition of corn flakes. Additionally, acetic acid was significantly higher in the control group than in the treatment groups. It was concluded that corn flake rate of 10% could be used to increase fermentation properties and nutritional value of alfalfa silage.

Keywords: *alfalfa*, *corn flake*, *silage*, *fermentation*, *digestibility*

HUMIC AND FULVIC ACIDS ENHANCE FLOODING TOLERANCE IN LETTUCE BY IMPROVING GROWTH, PHOTOSYNTHETIC PIGMENTS, MINERAL NUTRITION AND OXIDATIVE STRESS REGULATION

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Abstract

The increasing incidence of extreme rainfall events associated with climate change poses a mounting threat, as flooding stresses limit vegetable production. Lettuce (*Lactuca sativa* L.) is among the most economically important leafy vegetables globally and is especially sensitive to root-zone hypoxia, which quickly compromises water and nutrient uptake, photosynthetic performance, and oxidative balance, ultimately reducing plant productivity. This research assessed the protective effects of HA and FA on growth, physiological traits, oxidative metabolism, antioxidant defense, and mineral nutrition in lettuce plants under flooding stress. Flooding significantly reduced plant height, stem diameter, leaf area, and biomass accumulation compared with control plants, and it also decreased chlorophyll content and macro- and micro-element accumulation. These negative effects were significantly mitigated in the presence of humic substances. Overall, humic acid provided the greatest improvements in shoot growth, biomass production, chlorophyll content, and nutrient accumulation, whereas fulvic acid was superior at promoting root growth and improving sulfur, boron, and sodium accumulation. Principal component analysis showed segregation of treatment groups, with the first three principal components explaining 78.05% of the total variation. Biomass production, chlorophyll content, and mineral nutrition were significantly positively correlated, whereas all oxidative stress indicators were negatively correlated with growth traits, based on Pearson correlation analysis. We carried out hierarchical clustering to confirm that humic substances

regulate the morphological, physiological, biochemical, and nutritional responses of the plants in a coordinated manner. In conclusion, these results indicate that humic substances regulate lettuce tolerance to flooding stress through coordinated mechanisms that control plant growth, photosynthetic efficiency, antioxidant metabolism, and nutrient acquisition. As determined in our tests, humic acid was the most powerful biostimulant tested for reversing flooding-induced damage, emphasizing its high potential as a sustainable management strategy for vegetable production in regions faced with progressively wetter growing conditions.
Keywords: *waterlogging, lettuce, humic acid, fulvic acid*

EFFECTS OF DOPAMINE ON REDUCING SALT STRESS DAMAGE IN PEPPER (*Capsicum annuum* L.) AT MORPHOLOGICAL, PHYSIOLOGICAL, BIOCHEMICAL AND MOLECULAR LEVELS

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Abstract

Salt stress is a major environmental challenge that significantly reduces agricultural productivity, particularly in arid and semi-arid regions. Excessive sodium chloride (NaCl) accumulation in soil negatively affects plant growth, physiological functions, and biological processes. Dopamine, a catecholamine neurotransmitter, has emerged as a potential regulator of plant stress responses. This study investigated the effects of exogenous dopamine on salt stress tolerance in pepper (*Capsicum annuum* L.) by examining morphological, physiological, biochemical, and molecular responses. Pepper seedlings were subjected to 100 mM NaCl stress and treated with dopamine at concentrations of 50, 100, and 200 µM. Dopamine application, particularly at 100 µM and 200 µM concentrations, significantly improved plant growth parameters, including height, stem diameter, leaf area, and biomass accumulation. It enhanced photosynthetic efficiency by increasing chlorophyll content, stomatal conductance, and transpiration rate, while reducing oxidative stress markers such as H_2O_2 and MDA. Dopamine also regulated antioxidant enzyme activity (SOD, CAT, POD) and maintained ion homeostasis by reducing sodium (Na^+) and chloride (Cl^-) accumulation and promoting potassium (K^+) and calcium (Ca^{2+}) uptake. At the molecular level, dopamine influenced the expression of genes involved in ion transport (AKT1, HKT1, HKT2;2) and photosynthesis (psb). This study demonstrates that dopamine is a promising plant growth regulator that

enhances salt tolerance in pepper plants. It achieves this by improving growth, photosynthetic efficiency, antioxidant defense, and ion homeostasis, while modulating key molecular pathways. These findings suggest that dopamine could be utilized as a sustainable strategy to mitigate salt stress and improve crop productivity in saline-affected agricultural regions. Further research is needed to explore its application in other crops and under field conditions.
Keywords: *Pepper, salt stress, dopamine, physiological and biochemical responses, gene expression*

SUSTAINING APPLE PRODUCTIVITY AMID INSECTICIDE BANS: AVAILABILITY OF CONTROL MEASURES FOR WOOLLY APPLE APHID (*Eriosoma lanigerum*)

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Abstract

Among numerous pests threatening orchards, the woolly apple aphid (*Eriosoma lanigerum* Hausmann) stands out as one of the most significant in apple production. In recent decades, protection has relied heavily on synthetic pesticides, causing resistance issues, while certain substances have been withdrawn due to negative environmental impacts. This study aimed to investigate the measures applied by growers in the Republic of Serbia for managing woolly apple aphid. A survey was conducted among 87 producers using face-to-face interviews and web-based questionnaires. The results showed that over 90% of respondents face occasional or constant problems with the woolly apple aphid. The majority rely on synthetic products (around 91%), while fewer apply mechanical (<6%) or biological methods (<4%). Due to dynamic regulatory changes, growers must adapt their strategies. Following the chlorpyrifos ban, the deadline for the total withdrawal of spirotetramat from use is also approaching, meaning the most frequently used insecticide will no longer be permitted. Alternatives used by some producers, including newer generation selective insecticides and broad-spectrum products based on flonicamid, sulfoxaflor, flupyradifurone, deltamethrin, and acetamiprid, do not represent adequate replacements. The issue is further compounded because most high-density orchards are established on the M9 rootstock, which is highly susceptible, while the high cost and availability of resistant rootstocks limit their adoption. With the shift toward integrated and organic protection, biopesticides emerge as a sustainable solution. The bioeconomy approach, such as converting invasive plant biomass with proven efficacy into botanical insecticides, offers a vital alternative for innovative, eco-friendly pest management.

Keywords: *Biopesticides, Botanical insecticides, Eriosoma lanigerum, Integrated pest management, Rootstock susceptibility*

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INHIBITORY EFFECT OF EXOGENOUS METHIONINE ON DROUGHT STRESS IN TOMATO SEEDLINGS

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Abstract

Drought is one of the most frequently discussed issues that poses a threat to the future of the world, especially because of the damage it causes to agricultural production. Researchers are working on alternatives for areas and situations where water is scarce in crop production. One of these is exogenous plant treatments. Methionine has also recently begun to be used for this purpose. In this study, which investigated the effects of different doses of methionine, an amino acid, on plant growth and development in water-deficient tomato seedlings, solutions prepared in 3 doses as 0, 10 mg/L and 20 mg/L were applied as sprays to the leaves, and the plants were irrigated at 100% of the field capacity (control) and 60% of the field capacity to create drought stress. Water stress reduced plant height, stem diameter, and leaf area by 22%, 5%, and 32%, respectively, while methionine application showed higher values for these parameters under both normal and water stress conditions. Water stress also reduced plant fresh weight, root fresh weight, plant dry weight, and root dry weight by 38%, 8%, 32%, and 5%, respectively. Methionine application increased these parameters, but the decrease under stress was less pronounced. In the study, water stress increased H_2O_2, MDA, proline, and sucrose contents, and CAT, POD, and SOD enzyme activities, while these parameters varied with methionine applications. Furthermore, methionine application under drought stress

resulted in increased expression levels of the *SISOD*, *SIHKT1.1*, *SIPR1*, *SILOX1*, *SIWRKY8*, *SIWRKY31*, *SIP5CS*, and *SICAT* genes in tomato shoot tissue compared to controls. The study results indicate that methionine may play an important role in providing water stress tolerance, and its effectiveness varies among doses. It is thought that further studies are needed to detail the mechanism of action.

Keywords: *methionine, water deficit, tomato, stress tolerance, antioxidant defense, Stress-responsive genes*

AMELIORATIVE EFFECTS OF STRIGOLACTONE ON TOLERANCE TO LEAD STRESS ON LETTUCE (*Lactuca sativa* L.) PLANTS

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Abstract

Soil contamination by heavy metals, particularly lead (Pb), which is considered the second most toxic metal, poses serious risks to plants and humans due to its accumulation from various anthropogenic activities. Even at low concentrations, Pb accumulation has a negative impact on plant morphology, physiology, and biochemical processes, resulting in a range of structural and functional disorders. Strigolactones (SLs) are a novel class of terpenoid lactones that play a vital role in regulating plant growth and development, particularly under stress conditions. The study examined the impact of varying exogenous SL concentrations (0, 10, and 20 µM) on plant growth and various physiological, biochemical, and molecular factors in lettuce under lead stress [using $Pb(NO_3)_2$ at 0 and 300 ppm]. The results revealed that Pb stress adversely affected plant growth, while SL treatments improved growth under both control and Pb-stress conditions. While Pb stress raised the levels of electrical leakage (EL), malondialdehyde (MDA), and hydrogen peroxide (H_2O_2), SL applications led to a reduction in these levels. Chlorophyll content decreased under Pb stress, but this reduction was alleviated by SL supplementation. Pb treatment also increase the activities of several antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), ascorbate peroxidase (APX), glutathione reductase (GR), glutathione S-transferase

(GST), glucose-6-phosphate dehydrogenase (G6PD), and 6-phosphogluconate dehydrogenase (6GPD). SL applications caused a significant increase in antioxidant enzyme activities under both normal and Pb stress conditions. However, Pb stressed plants had lower nitrate reductase activity (NRA) than the control plants while SL treatments increased NRA compared to the non-treatments. The content of other nutrients except Pb decreased significantly in lettuce seedlings grown under Pb stress. External SL applications increased the uptake of these nutrients, especially under Pb stress. The results of the mRNA expression analysis showed that SL treatment, Pb stress, and using both together affected the gene expression levels of *LsABCC3, LsCCD7, LsCCD8, LsD14, LsD27, LsHMA2, LsMAPK, LsMAX1,* and *LsMAX2.* Only Pb stress significantly decreased the expression of genes, particularly *LsCCD8* and *LsD14*, in both tissues. The combined Pb and SL treatment very significantly increased the expression of *LsMAX2* in both tissues by about 3-fold. These results suggest that SL applications play an essential role in helping plants survive in harsh environments.

Keywords: *antioxidant metabolism, gene expression levels, phytohormones, nitrogen metabolism*

EVALUATION ON PHYSICAL AND NUTRITIVE CHARACTERISTICS OF VETIVER (*Vetiveria zizanioides*) GRASS SILAGE

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Abstract

Some researchers implied that although vetiver (*Vetiveria zizanioides*) is a grass species, it had not able to provide sufficient water-soluble carbohydrate content and proper pH level for a quality silage. Contrary, vetiver grass was also reported to be edible herbage of high quality for cattle and goats particularly in the growing stage.

The study aimed to evaluate the physical and nutritive value of vetiver grass silage. The grass chopped with size 1-2 cm were used for silage by adding molasses levels (0, 2.5 and 5%) as well as the level of lactic acid bacteria (LAB) (0, 2, and 4%). Silage inserted into a special plastic bag and the air was removed by vacuum machine. The silages were ripened for 45 days. Each treatment was done four times replication. The variables measured were physical quality, pH, crude protein (CP) and relative feed value (RFV).

Result shown that increasing the level of LAB and molasses decreased pH. The physical quality of the silage ranged from "average" to "good". The addition of molasses did not effect on CP content and RFV of vetiver silage, but the addition of LAB reduced the CP content. The combination between LAB and molasses levels with the best physical quality was found in 4% LAB and 5% molasses levels.

Keywords: *vetiver grass, silage, additive, nutritive parameters*

ELEMENTAL CHARACTERIZATION OF BEAN (*Phaseolus vulgaris* L.) SAMPLES FROM NORTH MACEDONIA USING ICP-MS/MS

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Abstract

The elemental composition of food legumes is of considerable interest from both nutritional and food quality perspectives, as it provides information on essential mineral nutrients as well as potentially toxic trace elements. In this study, the multielement composition of 38 bean (*Phaseolus vulgaris* L.) samples originating from North Macedonia was investigated using inductively coupled plasma tandem mass spectrometry (ICP-MS/MS). Prior to instrumental analysis, the samples were subjected to microwave-assisted digestion using concentrated nitric acid and hydrogen peroxide, providing efficient decomposition of the organic matrix and enabling reliable multielement determination. A broad range of major, minor and trace elements was determined, including Li, Be, B, Na, Mg, Al, P, K, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Br, Rb, Sr, Mo, Ag, Cd, Sn, Sb, I, Ba, rare earth elements, Tl, Pb, Bi, Th and U. The obtained elemental profiles revealed considerable variability among the investigated bean samples, particularly in the concentrations of nutritionally relevant macro- and microelements, while potentially toxic elements were also assessed to provide information on the elemental safety profile of the samples. The generated multielement dataset provides a comprehensive characterization of beans originating from North Macedonia and demonstrates the applicability of ICP-MS/MS combined with microwave-assisted acid digestion for simultaneous determination of a wide range of elements in this complex plant-based food

matrix. The results may provide a useful basis for further assessment of nutritional quality, elemental variability and geographical differentiation of bean samples from North Macedonia.
Keywords: *multielement analysis, bean (Phaseolus vulgaris L.), microwave-assisted digestion, trace elements, ICP - MS/MS*

INFLUENCE OF THE ALTITUDINAL GRADIENT ON THE FLORISTIC COMPOSITION AND PRODUCTIVE FEATURES OF SOME HIGH NATURE VALUE GRASSLANDS IN THE POIANA RUSCĂ MOUNTAINS (WESTERN ROMANIA) - CASE STUDY

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Abstract

High-Nature-Value (HNV) grasslands in the Poiana Ruscă Mountains are found in protected areas, and their condition depends on proper management. The purpose of the research was to assess the status of key vegetation features to develop appropriate management recommendations for the interested entities (farmers, authorities, etc.). To characterise the vegetation, floristic surveys were carried out on *Agrostis tenuis* grassland type (from a typological characterisation perspective) of high natural value situated within the altitude range of 500–1,500 metres a.s.l.; these formed the basis for the typological and productive characterisation of the vegetation cover. Field data were used to characterise the floristic composition and to determine the productive potential of the areas analysed using the indirect method; thus, the pastoral value (PV 0–100), animal load (LU/ha) and potential usable yield were calculated (kg ha^{-1}). In terms of functional floristic composition, the grasslands of the Poiana Ruscă Mountains are dominated by *Gramineae*, followed by species from other botanical families; legumes (*Fabaceae*) are found in small numbers across most of the areas analysed. The productivity of grasslands is generally average, ranging from approximately 5

to 7.5 t ha^{-1} of fresh fodder (the *Agrostis tenuis* series and the *Agrostis tenuis–Festuca rubra* series), with the exception of *Poa pratensis* and *Festuca pratensis*, which can reach around 10–15 t ha^{-1} of fresh fodder or even more if they are managed and maintained appropriately. The lowest productivity was recorded in *Botriochloa ischaemum*-type grasslands (about 3–5 t ha^{-1} of green matter), followed by *Nardus stricta*-type grasslands (about 1.5–5 t ha^{-1} of green matter).

Keywords: *High-Nature-Value (HNV) grassland, altitude gradient, floristic composition, productivity*

THE ROLE OF PUBLIC GREEN SPACES AND TREES IN MITIGATING HEAT ISLANDS

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Abstract

Climate change and the increasing expansion and densification of urban areas contribute to the intensification of the urban heat island effect, creating unfavorable thermal conditions and increasing heat exposure in cities. Urban vegetation, particularly trees and shrubs, plays an important role in mitigating these effects by providing shade and reducing surface and air temperatures. This study examines the potential of urban green spaces to alleviate thermal stress, with particular emphasis on the role of tree planting and the differences in thermal conditions observed across different urban surfaces in the city of Osijek, Croatia. Temperature measurements were conducted during a summer day at locations differing in surface material and exposure to direct sunlight and shade. The results revealed pronounced thermal differences among urban surfaces and measurement conditions. The average temperature difference between different surface materials was 3.8°C, while the difference between measurements conducted in direct sunlight and shade reached 8.5°C. The maximum observed temperature amplitude was 7.5°C. These findings demonstrate the substantial influence of surface characteristics and shading on urban thermal conditions. The results highlight the importance of preserving and expanding urban green infrastructure, particularly through strategic tree planting, as an effective nature-based approach to reducing heat exposure and improving the thermal comfort and climate resilience of urban environments.

Keywords: *trees, public green spaces, temperature, cities*

HYDROLOGICAL REGIME OF THE TREBIŽAT RIVER BETWEEN KLOBUK AND HUMAC, 2017–2019: STAGE–DISCHARGE RELATIONSHIP, GAINING AND LOSING REACHES AND INTERANNUAL VARIABILITY

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Abstract

The Trebižat River is a typical sinking–resurging karst river of Western Herzegovina whose regime governs water supply, irrigation and the ecological status of the Ljubuško polje. Mean monthly discharge and stage at two gauging stations, Klobuk (upstream) and Humac (downstream), were analysed for 36 months (January 2017 – December 2019) to describe the intra-annual regime, the stage–discharge relationship, gains and losses of water in the reach and differences among hydrologically contrasting years. Discharge ranged from 2.78 to 61.31 m³/s at Klobuk and from 1.24 to 78.50 m³/s at Humac. Pardé coefficients show a markedly Mediterranean regime with a December maximum (2.51 at Klobuk, 2.75 at Humac) and an October minimum (0.19 and 0.14). Rating curves of the form $Q = a(h - h_0)^b$ describe the stage–discharge relationship with $R^2 = 0.9995$ (Klobuk) and 0.9979 (Humac). The Klobuk–Humac reach gains water at high flow (median +5.3 m³/s in the wet season) but loses it at low flow: in 16 of 36 months the discharge at Humac was lower than at Klobuk despite the inflow of the Vrioštica, and in the dry season the median difference was -0.47 m³/s (-13 %). The log–log relation between the stations places the transition from loss to gain at about 12 m³/s at Klobuk. 2017 was dry (mean discharge 10.1 m³/s), whereas 2018 and 2019 were wet (21.0 and 27.9

m^3/s). During the dry season bed losses and irrigation abstractions exceed tributary inflow, which matters for water management in rural karst areas.

Keywords: *karst, Trebižat, rating curve, losing reach, Pardé coefficient*

EFFECT OF DIFFERENT IRRIGATION REGIMES AND BIO-BASED SOLUTIONS ON SOIL MOISTURE DYNAMICS IN A PEAR (*Pyrus communis* L.) ORCHARD

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Abstract

Water availability is the main constraint to stable pear production in North Macedonia, where dry and hot summers are common. Theferoe, the main aim of this study evaluated the effect of three drip-fertigation regimes: every 3 days (V3), every 5 days (V5) and sensor-based scheduling (VS) combined with two bio-based soil amendments, biochar (BCh) and pelletized sheep wool (WP), and an unamended control (C), on soil water content (SWC) in the 0–60 cm layer of a mature pear orchard (cv. Williams) in the Kumanovo region in 2025 and 2026. The obtained results showed that average SWC ranged from 94.3% to 99.4% of field capacity (FC), and no treatment reached the technical minimum. The lowest and most variable SWC occurred in the control treatment with 5-day regime (V5C), which fell below the irrigation threshold (90% FC) on 6 days in 2025 and 22 days in 2026. Pelletized wool gave the highest average SWC in all three regimes in 2025 (+14 to +37 m^3 ha^{-1} compared with the control) and in the V3 regime in 2026 (+40 m^3 ha^{-1}), while receiving 3–6% less irrigation water. In addition, in 2025, a spring frost reduced fruit set by an estimated 80–90%, and yield in the controls was only 5.4–5.6 t ha^{-1}, whereas the treatments with biochar and wool yielded 9.4–12.4 t ha^{-1}, mainly because they retained about twice as many fruits per tree. In 2026, without frost, the amended treatments gave 3–17% higher fruit yield (21.0–25.1 t ha^{-1}) and higher irrigation water productivity than the controls.

Keywords: *drip fertigation; irrigation scheduling; biochar; sheep wool; soil water content*

FOOD TECHNOLOGY AND NUTRITION

CHICKPEA AND BUCKWHEAT TEMPEH CHIPS: SENSORY ACCEPTABILITY AND POSTPRANDIAL GLYCEMIC RESPONSE

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Abstract

Modern dietary patterns, characterized by a high consumption of processed snack products, are associated with an increased risk of metabolic disorders, including impaired glycemic regulation. In this context, there is growing interest in the development of functional snack products based on plant-derived ingredients and fermented foods.

The aim of this study was to evaluate the sensory acceptability and postprandial glycemic response following the consumption of chickpea tempeh chips and buckwheat tempeh chips. The study was conducted on 29 healthy subjects of both genders. Sensory acceptability was assessed using a 9-point hedonic scale, while capillary blood glucose concentrations were measured at baseline and 120 minutes after consumption. An independent-samples t-test and a mixed ANOVA model were used for statistical analysis. The results demonstrated high sensory acceptability of both products, with no statistically significant differences observed between them across any of the analyzed sensory parameters. Regarding glycemic response, no statistically significant increase in blood glucose levels was observed after consumption, nor was there a significant interaction between product type and measurement time. These findings indicate a stable postprandial glycemic profile for both products. Chickpea and buckwheat tempeh chips were found to be highly acceptable from a sensory perspective and exhibited potentially favorable metabolic characteristics, supporting the study hypothesis. However, given the study limitations, further research involving a larger sample size and more detailed monitoring of glycemic responses is warranted.

Keywords: *chickpea tempeh, buckwheat tempeh, functional food, sensory acceptability, glycemic response*

THE USE OF GELATIN-BASED EDIBLE FILMS ENRICHED WITH THYME, GARLIC, AND SAGE ESSENTİAL OIL IN COATING STRAINED CHEESE AND THEIR EFFECTS ON CHEESE QUALITY

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Abstract

The development of biodegradable edible films containing natural bioactive compounds has gained increasing attention as an alternative approach for food preservation. In this study, gelatin-based edible films containing %2 essential oils of thyme, garlic and sage were applied to strained cheese samples by dipping method. A control group without essential oil was also included for comparison. During the duration of 28 days of refrigerated storage, the impacts of edible coatings on the physicochemical, microbiological, antioxidant, phenolic, and color properties of strained cheese samples were evaluated. Physicochemical, microbiological, antioxidant, total phenolic content and color analyses were performed during storage. Garlic essential oil had a favorable effect on the total phenolic content of coated cheese samples, while films containing thyme and sage showed higher antioxidant and antibacterial properties among the essential oil treatments. Coatings containing essential oils helped to prevent microbiological development and preserve product quality while they were refrigerated. Although slight differences were observed in some physicochemical parameters, pH and water activity values remained relatively stable during storage period. The findings suggest that gelatin-based films enriched with essential oils could be used as natural coating materials to maintaining quality characteristics and controlling microbial growth in dairy products during storage.

Keywords: *gelatin film, essential oils, strained cheese, edible coating, antimicrobial activity*

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CHOKEBERRY POMACE AS A FUNCTIONAL INGREDIENT IN GLUTEN-FREE COOKIES: EFFECTS ON QUALITY AND ANTIOXIDANT PROPERTIES

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Abstract

The demand for gluten-free products is increasing due to the prevalence of celiac disease and gluten intolerance. However, gluten-free products often exhibit poor nutritional and sensory quality. This study investigated the use of chokeberry pomace as a functional and sustainable ingredient in gluten-free cookies. Four formulations were prepared: a control sample and three samples enriched with dried and ground chokeberry pomace at levels of 1.10%, 2.17%, and 3.23% (w/w). The effects of pomace addition on proximate composition, bioactive and antioxidant properties, physicochemical characteristics, and sensory properties were evaluated. The addition of chokeberry pomace had no significant effect on proximate composition, energy value, or most physical properties, except for color parameters. However, it significantly increased total phenolic content (TPC), total flavonoid content (TFC), and antioxidant capacity (FRAP) in all enriched samples, with the highest values observed in cookies containing 3.23% (w/w) chokeberry pomace, where TPC, TFC, and FRAP values were 5.13, 4.06, and 17.82 times those of the control, respectively. In addition, IC50 values decreased with increasing pomace level, indicating enhanced antioxidant activity. Pomace addition also significantly affected pH and total titratable acidity, resulting in lower pH values and higher acidity, which may contribute to improved product stability. Sensory evaluation showed that cookies with the highest level of chokeberry pomace achieved the highest acceptability scores. The results demonstrate that chokeberry pomace can be valorized as a functional ingredient to improve antioxidant and sensory properties of gluten-free cookies while contributing to the sustainability of the agri-food system.

Keywords: *chokeberry pomace, gluten-free cookies, antioxidant capacity, sensory properties, physicochemical parameters*

CULTIVAR AND HYDROCOLLOID EFFECTS ON VITAMIN STABILITY IN 3D-PRINTED CORNELIAN CHERRY PRODUCTS

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Abstract

This study evaluated the content of selected vitamins (vitamin C, nicotinic acid, and thiamine) in fresh and 3D printed samples of three cornelian cherry (*Cornus mas* L.) cultivars (Kasenlaker, Pančevar, and Šonbruner), and investigated the influence of different hydrocolloids (wheat starch, guar gum, arabic gum) on vitamin stability. Cornelian cherry is an underutilized fruit species characterized by high nutritional value, particularly its richness in vitamin C, phenolic compounds, and antioxidants, making it a promising raw material for functional food development. The results showed that the Šonbruner cultivar had the highest vitamin C content, while Pančevar and Kasenlaker exhibited moderate levels consistent with reported literature data. Among the tested hydrocolloids, wheat starch significantly increased niacin content and improved thiamine stability in most samples. In contrast, guar gum led to the greatest reduction in vitamin levels, except in the Šonbruner cultivar, where an increase in niacin was observed. Arabic gum showed a moderate and cultivar-dependent effect, with less pronounced vitamin losses. Overall, the findings demonstrate the potential of cornelian cherry as a valuable ingredient for functional 3D-printed foods and highlight the importance of selecting appropriate hydrocolloids to preserve bioactive compounds during processing and support nutritional quality.

Keywords: *3D food printing*, *Cornelian cherry*, *vitamin C*, *nicotinic acid*, *thiamine*

THE INFLUENCE OF AWARENESS ON THE DEVELOPMENT OF FOOD DEFENSE SYSTEMS AGAINST FOOD TERRORISM - PROTECTION MOTIVATION THEORY (PMT)

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Abstract

Guided by the fact that deliberate food contamination, which falls within the bioterrorism framework, can have significant consequences on public health, panic and fear spread, it is necessary to use appropriate methods and tools to reduce these risks. Intentional food contamination could have devastating economic consequences and lead to a loss of public confidence in food safety and the effectiveness of public institutions responsible for this area. The paper is focused on researching the level of awareness of responsible staff within public catering facilities in terms of the risk of food terrorism using the Protection Motivation Theory (PMT) method using the Likert scale. In order to be able to make a judgment on the prepardness to respond in the event of food terrorism in public catering facilities. Based on the results it can be concluded that there is generally a very poorly developed system of preparedness for defense of public catering facilities in the case of food terrorism in FB&H. Assessing the level of awareness of managers, especially from the aspect of their ignorance of food terrorism, has led to the impossibility of making factual conclusions that some of the public catering facilities (hospitals, kindergartens, public institutions, etc.) are at a higher or lower level of preparedness for response in the case of food terrorism acts.

Keywords: *bioterrorism, public health, Protection Motivation Theory (PMT)*

COMPARATIVE ANALYSIS OF GREEK, SET AND STIRRED YOGURT ON SARAJEVO MARKET

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Abstract

Yogurt is the most popular fermented milk produced by lactic acid fermentation carried by starter culture composed of *Lactobacillus delbrueckii* spp. *bulgaricus* and *Streptococcus termophilus.* It is a product with nutraceutic, therapeutic and probiotic effects. There are several types of yogurt: set, stirred, greek, drink, frozen, dried, concentrated and aromatic (flavoured) yogurt. Greek type is traditionally strained yogurt variety and can be considered as type of concentrated yogurt with high percentage of fat and dry matter. The aim of this work is to compare greek, set and stirred types of yogurt at Sarajevo market by determination of their physical and some chemical properties. Because of its recent popularity all over the world the goal of the work was also to describe the properties and technology of greek yogurt. Physical properties, fat and lactic acid content were tested in yogurt samples. Average results for physico-chemical properties of yogurt samples were: pH 3,96, titratable acidity 44,80°SH, water activity 0,956, viscosity 847 mPas, fat and lactic acid content 5,23 and 0,966 g/100g resp. It can be concluded that Greek yogurt has significantly higher fat content than set and stirred yogurt. Water activity did not differ significantly among yogurt types. The highest value for viscosity was measured at set yogurt. It was noticed that stirred yogurt had a bit lower pH and higher value of titratable acidity than the other yogurt types. It was found that there are no statistically significant differences in the mean values of parameters for tested types of yogurt, except for viscosity, which was significantly higher at set yogurt.

Keywords: *Greek yogurt, set yogurt, stirred yogurt, physical properties, chemical composition*

MANUFACTURE OF MARE'S MILK KEFIR

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Abstract

Mare's milk has been recognized as a nutritionally valuable food with numerous therapeutic properties. This has caused its popularity to grow more and more. Kefir is a fermented milk beverage that is known for its sensory and dietary characteristics due to the diverse microflora of kefir grains. The combination of mare's milk and kefir therefore has the potential to be a high-value food. The aim of this work was to produce kefir from mare's milk with good sensory properties that would be highly acceptable to consumers. In the first phase, the amount of kefir culture produced from kefir grains required to obtain the best quality kefir was tested. It was found that the amount of 15% inoculum gave the best results. After that, kefir was produced from mare's milk, and from a mixture of mare's and cow's milk in the ratio of 70:30 and 50:50. Physicochemical analyses and sensory evaluation of kefir samples were performed. Kefir analyses included the content of fat, dry matter, mineral matter, lactic acid, acidity, pH value and free CO_2. The sensory evaluation was performed by an expert team using a scoring system of sensory characteristics of a maximum of 20 points, while the second sensory evaluation was performed by consumers. Kefir samples with the addition of cow's milk had a lower pH and a higher content of fat, dry matter, mineral matter, CO_2 and lactic acid compared to mare's milk kefir without the addition of cow's milk. Kefir made from a mixture of mare's and cow's milk in a ratio of 50:50 received the best sensory ratings from both the expert panel and the consumer, so it can be recommended for production.

Keywords: *Kefir, mare's milk, cow's milk, sensory evaluation, chemical composition*

RISK ASSESSMENT OF THE PRESENCE OF AFLATOXIN B1 IN MAIZE AND ITS IMPACT ON CONSUMER HEALTH IN BOSNIA AND HERZEGOVINA

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Abstract

Aflatoxins are among the most significant chemical hazards in food and feed due to their pronounced genotoxic and carcinogenic effects. Climate change, accompanied by rising temperatures, droughts, and extreme weather events, contributes to an increased risk of aflatoxin contamination in maize, particularly in the Balkan region, recognized as a high-risk area. The aim of this study was to assess the consumer health risk associated with the presence of aflatoxin B1 in maize and maize products in Bosnia and Herzegovina using available official control, laboratory data collected during 2025 and food consumption data. Dietary exposure assessment was performed using consumption data from the BH MENU study for adolescents and adults. In accordance with the European Food Safety Authority (EFSA) methodology, three exposure scenarios were applied: lower bound (LB), middle bound (MB), and upper bound (UB). Risk characterization was conducted using the Margin of Exposure (MOE) approach, applying $BMDL_{10}$=0.4 µg/kg bw/day). During 2025, a total of 127 maize samples were analyzed in Bosnia and Herzegovina, of which 16 samples were non-compliant with the maximum permitted levels for AFB1. Since quantified concentration values were not available in routine laboratory data, a weighted approach was applied to estimate average concentrations. All calculated MOE values were substantially below the EFSA reference value of 10,000, indicating a potential public health concern. The obtained results highlight the need for strengthened risk-based official controls, systematic monitoring, and harmonized data collection to improve future risk assessments and risk management measures.

Keywords: *aflatoxin B1, maize, risk assessment, dietary exposure, Margin of Exposure (MOE)*

ANTIMICROBIAL ACTIVITY OF ZINC OXIDE NANOPARTICLES SYNTHESIZED USING NATIVE PROPOLIS FROM THE REPUBLIC OF SERBIA

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Abstract

Zinc oxide nanoparticles (ZnO NPs) have attracted considerable attention in food and biomedical sciences due to their pronounced antimicrobial properties and potential applications in food preservation and active packaging systems. This study focuses on the green synthesis of ZnO nanoparticles using ethanolic extracts of native propolis collected from different regions of the Republic of Serbia. Propolis, a natural bee product rich in polyphenols, flavonoids, and phenolic acids, acts as both a reducing and stabilizing agent, providing an environmentally friendly alternative to conventional chemical synthesis methods. The main objective of this research is to investigate the role of bioactive compounds from Serbian propolis in the biosynthesis of ZnO nanoparticles and to evaluate their antimicrobial potential against selected pathogenic microorganisms. Five propolis samples from different geographical locations will be used to account for variability in chemical composition. ZnO nanoparticles will be synthesized via reaction of zinc acetate dihydrate with propolis extract under controlled conditions, including variation of pH, temperature, reactant ratio, and reaction time. The formation of nanoparticles will be confirmed using UV–Vis spectroscopy through characteristic absorption peaks of ZnO nanostructures. Antimicrobial activity will be evaluated using standard microbiological methods against representative Gram-positive and Gram-negative bacteria. It is expected that the synthesized nanoparticles will demonstrate enhanced stability and significant antimicrobial activity, particularly against Gram-positive bacteria, due to synergistic effects of propolis-derived phytochemicals.

Keywords: *zinc oxide nanoparticles, propolis, green synthesis, antimicrobial activity, nanotechnology*

INNOVATIVE THREE-DIMENSIONAL FRUIT DESSERTS WITH AEROGELS AND BY PRODUCTS: A Path Toward Personalized Nutrition

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Abstract

Three-dimensional (3D) food printing is an emerging technology that enables the production of personalized, ready-to-eat food with tailored shape, texture, and nutritional composition. A critical challenge in this process is the development of food inks that ensure smooth extrusion while maintaining structural stability after printing. While hydrocolloids are commonly used to achieve these properties, edible aerogels are gaining increasing attention as innovative functional materials for 3D food printing. Aerogels are highly porous, lightweight solids produced by replacing the liquid phase of a gel with gas while preserving its three-dimensional network, resulting in materials with exceptionally high surface area and porosity. Within the framework of the HRID project, fruit-based with by-prodacts food inks incorporating pea protein aerogels are being developed to enhance printability, stability, and functional performance. Due to their porous structure, pea protein aerogels effectively bind free water, reduce water activity, and prevent syneresis, thereby improving shelf life and microbial stability. In addition, their high porosity enhances flavor perception, allowing sugar reduction without compromising sensory quality. Pea protein aerogels are hypoallergenic and gluten-free, making them suitable for consumers with dietary restrictions, including hospital patients and individuals with food allergies. The integration of aerogels into fruit-based 3D food printing offers a promising approach for creating novel structures with controlled porosity,

tailored texture, and improved retention of bioactive compounds, opening new opportunities for functional, sustainable, and personalized fruit-based foods.

Keywords: *3D food printing, edible aerogels, fruit desserts, personalized fruit-based foods*

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GREEN SYNTHESIS AND ANTIMICROBIAL POTENTIAL OF ZINC OXIDE NANOPARTICLES USING NATIVE PROPOLIS FROM BOSNIA AND HERZEGOVINA

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Abstract

Propolis is a natural bee product rich in polyphenols, flavonoids, and other bioactive compounds with known antimicrobial and antioxidant properties. Due to the increasing demand for sustainable and environmentally friendly technologies, green synthesis of nanoparticles has emerged as an alternative to conventional chemical methods. Zinc oxide nanoparticles (ZnO-NPs) are of particular interest because of their antimicrobial activity and potential application in food preservation, food safety, and active packaging systems. The aim of this study is to develop and optimize the green synthesis of ZnO nanoparticles using ethanolic extracts of native propolis collected from different regions of Bosnia and Herzegovina and to evaluate their antimicrobial potential. Five propolis samples of different geographical origin will be used for the preparation of extracts, while zinc acetate will serve as a precursor for nanoparticle synthesis. Bioactive compounds present in propolis are expected to act as natural reducing and stabilizing agents during nanoparticle formation. The influence of synthesis parameters, including pH, temperature, reaction time, and extract-to-precursor ratio, will be investigated in order to obtain stable ZnO nanoparticles. Their formation and basic characteristics will be confirmed using available analytical methods, including UV–Vis spectrophotometry. The antimicrobial activity of the synthesized nanoparticles will be evaluated against selected foodborne pathogens, including Escherichia coli, Salmonella enteritidis, and Listeria monocytogenes. The expected results include the successful synthesis of stable ZnO nanoparticles with significant antimicrobial activity. The

findings could contribute to the development of sustainable materials for food preservation and food safety applications, particularly in active packaging technologies.

Keywords: *propolis, zinc oxide nanoparticles, green synthesis, antimicrobial activity, food safety*

CONSUMER AWARENESS AND ACCEPTANCE OF DOMESTIC PRODUCTS BEARING THE "Kupujmo domaće (387)" QUALITY LABEL

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Abstract

This scientific work explores consumer awarness and acceptance of B&H domestic products within the initiative and product labeling under „Kupujmo domaće (387)“ quality label as well as analyze quality perception from the consumers' perspective. Survey results show that consumers in Bosnia and Herzegovina recognize the „387“ label and generally have a positive attitude towards domestic products, with quality, origin, and price being the most influential factors. Special attention is given to the role of certificates and quality labels as essential signals of trust. A comparative analysis demonstartes that Croatia and Slovenia have developed stronger institutional systems („Kupujmo hrvatsko“, „Izbrana kakovost“), while the European Union provides the most advanced model of product protection and promotion through PDO, PGI and TSG labels. Compared to these cases, Bosnia and Herzegovina is still in the development phase, and further progress depends on stronger institutional support, legal frameworks, and consumer education. The findings suggest that the „Kupujmo domaće 387“ initiative has significant potential, but its full effect can be achieved only if aligned with broader European models and practices.

Keywords: *domestic products, loyalty, consumers*

UTILIZATION OF BY-PRODUCTS OF THE WINE INDUSTRY IN BOSNIA AND HERZEGOVINA – PERSPECTIVES AND REALITIES

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Abstract

This research paper deals with the analysis of the degree and method of utilization of by-products created in the process of wine production in Bosnia and Herzegovina. The by-products of the wine industry, such as pomace, wine lees, grape seeds, wine tartar and grapevine by-products, represent a valuable resource that can contribute to sustainability, reducing the ecological footprint, economic efficiency and the development of innovative products with high added value. The research was conducted using a survey method using a structured questionnaire (Google Forms) distributed to wineries throughout Bosnia and Herzegovina, with an effort to represent wineries of different sizes, economic indicators and from all wine regions. The goal was to determine the degree of utilization of by-products, identify the reasons for the current situation and offer recommendations for improving practices. The results of the survey show that there is a marked uniformity in the approach to the use of by-products among wineries in Bosnia and Herzegovina. No statistically significant differences were found in practices and attitudes towards by-products with regard to the size of the winery, the region they come from, or the economic indicators of the business (profitability). Most winemakers primarily use grape pomace for the production of distillate (rakija), while other by-products are used to a lesser extent or are treated as waste. This indicates limited diversification and insufficient awareness of broader possibilities for valorization of by-products. The paper concludes that there is significant potential for improving by-product management through education, technological innovation and institutional support, which would enable the wine industry in BiH to make a greater contribution to economic and sustainable development.

Keywords: *by-products of the wine industry, pomace, valorization of by-products, sustainable wine production, Bosnia and Herzegovina, survey, wineries*

MICROBIOLOGICAL CONTAMINATION OF KEFIR GRAINS USED IN KEFIR PRODUCTION BY THE BACKSLOPPING METHOD

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Abstract

The beneficial effects of kefir on the colonic microbiota and its status as a natural probiotic or synbiotic are attributed to specific microorganisms and their metabolic products. The aim of this study was to determine the extent to which contamination of five kefir grain samples, collected in their active form and successively reactivated under household conditions, affects the sensory and physicochemical acceptability of a kefir beverage produced by the backslopping method under laboratory conditions. The results showed that microbiological contamination, primarily by bacteria belonging to the family Enterobacteriaceae, negatively affects the sensory quality of the final product only when the level of contamination is extremely high. Due to the strong incorporation of microbial communities within the kefir grain matrix, the purification of contaminated grains is extremely difficult or even impossible, representing a major technological challenge for industrial facilities employing the backslopping method. In addition to its technological, qualitative, and economic implications for the dairy industry, this phenomenon is also closely related to biodiversity and national identity, as the availability and quality of kefir beverages constitute an important element of national branding and recognition.

Keywords: *kefir grains, backslopping method, microbiological contamination, Enterobacteriaceae, sensory acceptability*

EFFECT OF SMOKING DURATION ON THE OVERALL QUALITY OF "VISOČKA PEČENICA"

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Abstract

"Visočka pečenica" is a traditional dry-cured beef product ("Ruža") characteristic of the Visoko region. The aim of this study was to evaluate the effect of smoking duration on the overall quality of "Visočka pečenica" by examining sensory, technological, and chemical parameters, with particular emphasis on differences between two anatomical regions: the round ("Ruža") and the *Musculus longissimus dorsi* (MLD). In addition, indicators of lipolytic and oxidative changes (acid and peroxide values), as well as the contents of selected trace elements (Cu, Zn, Ni, and Fe) and toxic elements (Pb and Cd), were analyzed to assess the chemical stability and safety of the product. The results clearly demonstrated that smoking duration plays a key role in determining the quality of this traditional dry-cured beef product ("Ruža"). The highest sensory scores were recorded for samples from the round ("Ruža") region after eight days of smoking, while the optimal quality of MLD samples was also achieved on the eighth day. Prolonged smoking beyond this period led to increased drying, reduced juiciness, and an excessively pronounced smoky aroma. Chemical analyses revealed more pronounced lipolytic and oxidative changes in samples from the round ("Ruža") region compared with MLD samples. Principal component analysis (PCA) confirmed clear differentiation between anatomical regions and smoking durations. Overall, the results suggest that eight days of smoking represent the optimal smoking duration for achieving the highest quality of "Visočka pečenica", highlighting the significant impact of smoking duration on sensory properties, chemical stability, and product safety.

Keywords: *Visočka pečenica, smoking duration, quality, traditional dry-cured beef product ("Ruža"), sensory analysis*

MINERAL COMPOSITION AND CA:P IMBALANCE IN CEREAL GRAINS AND CEREAL-DERIVED FEEDSTUFFS

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Abstract

The mineral composition of cereal grains and cereal-derived processed feedstuffs is an important determinant of the nutritional quality of animal diets. The aim of this study was to evaluate the variability of essential macroelements (Ca, P, and Na) in maize, wheat, barley, maize feed flour, and wheat feed flour. A total of 27 samples of each feed type were analysed using standard ISO methods. After acid digestion, calcium and sodium were determined by atomic absorption spectrometry (AAS), while phosphorus was determined spectrophotometrically. Calcium content varied significantly among the analysed feedstuffs, ranging from 180.2 ± 45.4 mg/kg in maize feed flour to 1404.9 ± 226.5 mg/kg in wheat feed flour. Phosphorus content also showed significant variability, ranging from 1959.5 ± 663.0 mg/kg to 8448.8 ± 1102.5 mg/kg. Sodium concentrations were generally low (19.9 ± 6.8 to 59.1 ± 18.1 mg/kg). One-way ANOVA showed highly statistically significant differences among feed types for all analysed elements ($p < 0.001$). The Ca:P ratio indicated a consistent mineral imbalance in all samples. Phosphorus predominated over calcium (Ca:P < 1:1), which was especially pronounced in processed feed flours. This mineral imbalance and increased phosphorus concentration are likely consequences of processing, rather than of a real increase in mineral concentration. The results indicate pronounced heterogeneity in mineral composition between whole grains and their processed derivatives. In general, cereal-derived processed feedstuffs contained higher concentrations of the analysed macroelements than

whole cereal grains, which may significantly influence the nutritional value and mineral balance of animal diets.

Keywords: *mineral composition, cereal grains, processed feedstuffs, Ca:P ratio, animal nutrition*

PRELIMINARY STUDY ON THE PRODUCTION OF BIOLEATHER AND BIOPLASTICS USING KOMBUCHA

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Abstract

Kombucha is a symbiotic fungus that is often the subject of interest to the scientific and general public for its health benefits. This study has another dimension that concerns the use of kombucha for the production of bioplastics and bioleather in the context of developing environmentally friendly technologies and contributing to the green economy. Our research showed that the kombucha we used has a heterogeneous composition that includes one yeast (Saccharomyces/Zygosaccharomyces sp.) and five bacteria belonging to the genera *Gluconobacter* (2 isolates) and *Acetobacter* (3 isolates). For the production of bioleather and bioplastics, the conditions for growing kombucha were optimized, which included: using boiled green tea as a matrix with a concentration of 5g/L, 50g/L sugar and 5-10 ml vinegar that provided the optimal pH for kombucha growth. After cooling the tea, a SCOBY symbiotic culture of fungi and bacteria was added to the substrate. Fermentation was performed at 25°C with light aeration in a bath shaker in wide vessels to form a flat product whose thickness depends on the purpose of production from 7-21 day. After fermentation is complete, the layer of bacterial cellulose is removed and washed thoroughly with a solution of $NaHCO_3$. The material was dried, forming a flexible structure depending on the time and drying conditions.

The dried "skin" is coated with beeswax for waterproof protection but also to improve the visual appearance and flexibility of the material. Gained biomass of bioleather was 142g/L, while the dry mass of bioplastic was 20 g per liter of medium for two weeks.
Keywords: *kombucha, leather, plastics, optimization, production*

GREEN VALORIZATION OF SOYBEAN PROCESSING BY-PRODUCTS FOR SUSTAINABLE FOOD SYSTEMS: A CIRCULAR BIOECONOMY PERSPECTIVE

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Abstract

The food industry generates large quantities of agro-industrial by-products, creating an increasing need for sustainable technologies that improve resource efficiency while reducing environmental impact. Soybean processing by-products, particularly soybean hulls, represent an abundant renewable biomass rich in polysaccharides, proteins, dietary fiber and bioactive compounds, making them a promising source of value-added food ingredients and bio-based materials. Their efficient utilization is fully aligned with the principles of the circular bioeconomy and sustainable food production. This review summarizes recent advances in the green valorization of soybean processing by-products, with emphasis on environmentally friendly extraction technologies, including ultrasound-assisted, microwave-assisted, enzyme-assisted and deep eutectic solvent-based processes. The recovery of high-value components, such as pectin, cellulose, nanocellulose, dietary fibers, proteins and phenolic compounds, is discussed in relation to their structural characteristics, functional properties and potential applications in food systems. Particular attention is given to their use as natural emulsifiers, stabilizers, functional food ingredients, edible and biodegradable packaging materials, and active components for improving food quality and shelf life. The concept of integrated biorefinery is highlighted as an effective strategy for cascade biomass utilization, enabling the production of multiple high-value products from a single renewable resource while minimizing waste generation. Current evidence indicates that soybean processing by-products have considerable potential to support sustainable food technologies and the transition toward resource-efficient circular bioeconomy systems. Future research should focus on process integration, industrial scale-up, life cycle assessment and techno-economic evaluation to facilitate the commercialization of these sustainable technologies.

Keywords: *soybean processing by-products, circular bioeconomy, biomass valorization, biorefinery, green extraction*

CHANGES IN THE QUALITY AND MICROBIOLOGICAL SAFETY OF EGGS FROM LAYING HENS DURING STORAGE AT DIFFERENT TEMPERATURES

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Abstract

The preservation of egg quality and microbiological safety during storage is a crucial aspect of the food supply chain. This study aimed to evaluate the effects of storage temperature and duration on physicochemical quality parameters and microbiological status of Banat Naked Neck hen eggs over a 28-day storage period. A total of 240 eggs were divided into two groups and stored at room temperature (20–22°C) and under refrigerated conditions (4–6°C). Analyses were performed at 7-day intervals during the storage period. External and internal egg quality parameters were monitored, including egg weight, shell quality traits, albumen height, Haugh units (HU), yolk color, and the pH of albumen and yolk. Microbiological quality assessment included total bacterial count analysis and screening for *Salmonella* spp. and *Listeria monocytogenes*. The results showed that storage temperature had no significant effect on external egg quality parameters. However, internal quality was significantly better preserved under refrigeration. Albumin height decreased significantly ($p < 0.05$) at both temperatures during storage, with a higher value determined at refrigerator temperature on day 28 (4.20 mm). Similarly, HU values decreased significantly ($p < 0.05$), from about 43.2% at room temperature and 22.5% in refrigeration. Albumen pH increased significantly ($p < 0.05$) from 8.63 to 9.25 at room temperature and to 9.14 under refrigeration. Yolk pH also showed a significant upward trend during storage ($p < 0.05$), with no significant differences between treatments at the early storage period ($p > 0.05$). Shell quality parameters (thickness, strength, and deformation) and the yolk color did not change significantly during storage ($p > 0.05$). Microbiological analysis confirmed the absence of *Salmonella* spp. and *Listeria monocytogenes* in both groups, while total bacterial count increased significantly over time,

reaching 1.44 log CFU/mL at day 28, with higher values observed at room temperature. The results indicate that refrigeration effectively slows the deterioration of internal egg quality and limits microbial growth, thereby extending shelf life and maintaining microbiological safety during storage. These findings provide practical recommendations for egg producers, emphasizing the importance of proper storage temperature management to preserve egg quality, minimize quality losses, and ensure consumer safety throughout the storage period.
Keywords: *Banat Naked Neck hens, egg quality, storage temperature, microbiological safety*

DEVELOPMENT AND CHARACTERIZATION OF REDUCED-CALORIE JAM ENRICHED WITH PRUNES

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Abstract

Current nutritional trends highlight the importance of limiting sucrose consumption while promoting the intake of functional foods rich in bioactive compounds. Accordingly, the aim of this study was the development of a nutritionally enriched plum jam with reduced caloric value, using a combination of fresh and dried plums. The experimental part of the study was conducted in several phases. In the first phase, the optimal ratio of fresh to dried plums (80:20) was defined as well as the method of raw material preparation, while in the second phase the most suitable commercial low-esterified pectin was selected. The central part of the research included the production of jams with different fruit contents (60%, 70%, and 80%) using two different methods of dried plum preparation: direct cooking without prior rehydration and cooking after rehydration. Comprehensive physicochemical analyses were performed on the samples, including determination of soluble dry matter, pH value, total acidity, reducing and total sugars, sucrose, pectin, viscosity, as well as the content of bioactive components (total phenols and antioxidant capacity – FRAP). In addition, sensory evaluation was carried out using a scoring method. The results indicated that the preparation method significantly affected the physicochemical parameters. The process without prior rehydration ensured a higher concentration of dry matter, whereas rehydration in synergy with a high fruit content (80%) resulted in better viscosity and superior sensory properties, particularly in terms of taste and aroma. It was concluded that jam containing 80% fruit prepared using the rehydration process represents the optimal formulation that satisfies both technological stability and consumer requirements.

Keywords: *plum, rehydration, pectin, functional food*

SCHOOL MEAL SATISFACTION AND DIETARY PREFERENCES IN A CAMPUS STUDY

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Abstract

Proper nutrition of children and adolescents plays a crucial role in their growth, development, and academic performance. Assessing satisfaction with the school meal plan is an important aspect of improving school nutrition systems. The aim of this study was to examine the satisfaction of primary and secondary school students, as well as school staff within an educational campus, with the current school meal plan, and to analyze their dietary habits and food preferences. The study included a total of 215 respondents. Data were collected using a questionnaire and analyzed using IBM SPSS Statistics through descriptive and inferential statistical methods. The results showed that 32% of respondents finish their entire meal at school, while 39% often do so. More than half of the respondents reported being satisfied with the current meal plan, whereas 29% were dissatisfied or very dissatisfied. Furthermore, 47% of respondents expressed a desire for a greater amount of fruit in the new menu, while 29% requested an increase in both fruit and vegetables. The most preferred foods were chicken, burgers, and pizza, while stews were among the least preferred meals (52%). Inferential analysis revealed statistically significant differences between primary and secondary school students, as well as between primary school students and staff members. Secondary school students and staff reported lower levels of satisfaction with the school meal plan compared to primary school students. These results may contribute to the development of more balanced and acceptable school meal policies in educational institutions.

Keywords: *school nutrition, dietary habits, meal satisfaction*

PRODUCTION AND SENSORY ANALYSIS OF HUMMUS ENRICHED WITH MATCHA POWDER, SWEET POTATO, AND BEETROOT

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Abstract

The aim of this study is the production and evaluation of hummus formulations enriched with matcha powder, beetroot, and sweet potato as functional ingredients with potential nutritional and sensory benefits. Three different hummus formulations will be prepared by incorporating selected plant-based additives in order to investigate their influence on product quality and consumer acceptability. Physicochemical analyses will include determination of pH value and water activity (aw), as important parameters related to product stability and safety. In addition, sensory evaluation of the produced hummus samples will be conducted using selected sensory attributes such as appearance, color, texture, aroma, taste, and overall acceptability. The obtained data will be analyzed using descriptive statistics in order to compare differences between formulations and determine the influence of the added ingredients on the final product characteristics. The study is expected to contribute to the development of innovative functional hummus products with improved sensory and nutritional properties.

Keywords: *hummus, matcha powder, beetroot, sweet potato, sensory analysis*

INFLUENCE OF HEAT TREATMENT ON IRON CONTENT AND OVERALL QUALITY OF BEEF MEAT

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Abstract

Beef is a significant source of high-quality proteins, B vitamins and heme iron, which play an important role in the prevention of iron deficiency anemia. The nutritional and sensory quality of meat largely depends on the heat treatment method applied. The aim of this study was to examine the impact of different heat treatment methods on the nutritional composition, oxidative stability, and sensory acceptability of beef. Four heat treatment methods were applied: boiling in water at 100 °C (30 min), pan-frying without oil (8 min), sous vide cooking (85 °C, 60 min), and air frying (180 °C, 15 min). The content of moisture, protein, fat, ash and iron, pH and aw values, weight loss, oxidative parameters and sensory properties of the meat were analyzed. The results showed that air-fried beef achieved the highest sensory scores, particularly for tenderness, juiciness, and color, while maintaining a relatively high iron content among the heat-treated samples. Boiling led to the highest weight, moisture and iron losses and the lowest sensory ratings. The highest protein content was recorded in the sous vide-treated samples, while the highest fat content was determined in the pan-fried samples. Heat treatment increased peroxide and TBA values, especially in the air-fried samples. The obtained results confirm that the choice of heat treatment method significantly affects the preservation of nutritional value and quality of beef.

Keywords: *beef, iron, heat treatment, nutritional value, sensory analysis*

VALORISATION OF WINE PRODUCTION BY-PRODUCT GRAPE POMACE FOR ANTHOCYANIN RECOVERY

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Abstract

Grapes are important crop in the agricultural industry that generates significant amounts of by-products such as grape pomace, which contains several classes of bioactive compunds. The main uses of grape pomace are fermentation for the production of alcoholic beverages, livestock feed, and as fertilizer. Despite numerous studies on the valorization of grape pomace, real-world adoption still remains limited and is mostly used as animal feed. Grape pomace is a significant source of anthocyanins which are natural pigments responsible for the red color of fruits and vegetables. It is estimated that only 3% of waste is recovered. Utilizing grape pomace as a source of anthocyanins and a substrate for pyranoanthocyanin synthesis can contribute to sustainability in the wine sector. The treatment and end-of-life activities regarding grape pomace presents an economic and environmental challenge for the wine industry. Anthocyanins are recognized for their safety, antioxidant properties and potential use in medicine, cosmetics, food and nutraceutical products. Grape pomace was dried and skins and seeds separated with sieving. The influence of grape pomace mass and different extraction solvents on anthocyanin recovery was evaluated. Anthocyanin content, total phenolic content and antioxidant activity of grape pomace from grape varieties Pinot Noir, Barbera, Cabernet Sauvignon, Blau Frankisch and Refošk were determined to identify the most suitable substrate for subsequent pyranoanthocyanin synthesis. The concentrations of anthocyanins, total phenolics and antioxidant activity differed significantly different grape varieties pomaces. These findings will be used to select the most promising grape pomace substrates for subsequent pyranoanthocyanin synthesis and optimization of reaction conditions.

Keywords: *anthocyanins, pyranoanthocyanins, circular economy, grape pomace, valorization*

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BEYOND KNOWLEDGE: FOOD LITERACY AND POLICY PRIORITIES IN BOSNIA AND HERZEGOVINA

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Abstract

Food literacy is a critical yet policy-neglected determinant of dietary health in Bosnia and Herzegovina, which faces a substantial diet-related disease burden. This pilot study aimed to assess food literacy using SPFL-SF (Short Form Self-Perceived Food Literacy) scale and to provide evidence to policymakers. A convenience sample of 187 adults was formed in May 2026. Basic descriptive and inferential analyses were performed to measure food literacy levels and reveal factors behind them. Practical skills scored highest (cooking, 4.43; food quality assessment, 4.18), while behavioral competencies scored the lowest (resisting temptation, 3.01; meal planning, 3.04; label reading, 3.08; and healthy snacking, 3.10), with a mean score of 3.55. As confirmed by CFA (confirmatory factor analysis), the behavioral skills are behind literacy level (exceptional situations and food-stockpiling, meal planning and healthy snacking, resisting temptation). Results reveal that BiH's food literacy deficit is not primarily a knowledge problem (healthy eating and practical cooking skills are present) but rather a behavioral and environmental one, meaning the gap lies in translating that knowledge into daily practice, which is shaped by time pressure, the food environment, and affordability. So, the policy intervention should to follow directions: (i) youth-centered, addressing the behavioral dimension through education and training, awareness campaigns, curricuala and hackathons, embedded in local culture to strengthen relevance and uptake; (ii) food evnironment oriented fostering an enabling environment for practicing these behaviors through market and advertising regulation, and incentives for businesses (e.g. green gastronomy, tourism products such as *moba*, urban agriculture) that make quality food more accessible and visible to end users.

Keywords: *food literacy, behavioral change, health, food policy, Bosnia and Herzegovina*

MADZUN (Grape Molasses), TRADITIONAL FOOD PRODUCED FROM CARDINAL GRAPE VARIETY

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Abstract

Traditional foods are an important part of cultural heritage, passed down through generations, and consumers generally associate such products with distinctive sensory characteristics and high quality. Madzun is a traditional grape-based product obtained by concentrating grape juice, either by conventional thermal processing or by vacuum technology. Cardinal is an early-ripening table grape variety primarily intended for fresh consumption. However, due to its ability to accumulate relatively high sugar concentrations, it can also represent a suitable raw material for the production of distillates and traditional concentrated grape products such as madzun. In this study, three samples of madzun produced from Cardinal grapes were analyzed. One sample (K1) was produced using vacuum technology, whereas two samples (K2 and K3) were obtained by the traditional thermal processing method. The quality characteristics evaluated included total and individual sugars (fructose, glucose, sucrose, and maltose), water-soluble dry matter, and total phenolic content. Regarding hydroxymethylfurfural (HMF) content, the traditionally produced samples (K2 and K3) showed considerably higher concentrations compared with the vacuum-processed sample (K1). This difference can primarily be attributed to the processing conditions, particularly the temperature and duration of thermal treatment, since HMF formation is strongly influenced by the intensity of heat exposure. The results for mineral and heavy metal contents showed variability among the samples analyzed. These differences may be associated with several factors, including soil composition, environmental and growing conditions, vineyard fertilization practices, plant protection treatments, and technological processing. Sensory evaluation included the assessment of color, aroma, taste, sweetness, acidity, texture, and aftertaste, with a maximum overall score of 20 points. The sensory assessment was performed according to the principles of ISO 6564, ISO 8587, and ISO 11036. Based on the sensory

evaluation results, sample K1, produced using vacuum technology, received the highest overall score of 16.8 points, indicating the most favorable sensory characteristics among the evaluated samples.

Keywords: *sugars, phenolic compounds, hydroxymethylfurfural (HMF), minerals, heavy metals, sensory analysis*

INFLUENCE OF PRODUCTION TECHNOLOGY ON LIPOLYTIC AND OXIDATIVE CHANGES IN "VISOČKA PEČENICA"

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Abstract

"Visočka pečenica" is a traditional dry-cured meat product of Bosnia and Herzegovina, protected by a geographical indication at the national level. The aim of this study was to investigate the influence of production technology on lipolytic and oxidative changes in traditional "Visočka pečenica". The experimental production was carried out under traditional and industrial conditions. The technological differences between traditional and industrial production were reflected in the smoking duration, the temperature of the smoldering wood used for smoking, and the amount of salt added during salting. Samples were collected at two stages of the smoking process, halfway through and at the end, with 40 samples collected at each stage. Thus, a total of 80 samples were analyzed to assess the dynamics of lipolytic and oxidative changes during production. Lipolytic and oxidative changes were assessed by determining the acid and peroxide numbers, as well as malondialdehyde (MDA) content using the thiobarbituric acid (TBA) test. Comparison of the two production technologies showed higher acid numbers in samples from industrial production and higher peroxide numbers in samples from traditional production. Higher MDA content was observed in MLD (*M. longissimus dorsi*) samples from traditional production, whereas round samples from industrial production exhibited higher MDA content. Higher acid and peroxide numbers, as well as MDA content, were observed in the samples collected at the end of the smoking process compared with those collected at the halfway point, in both production technologies. The identified differences in production technology between the traditional and industrial producers contributed to the observed differences in the investigated parameters.

Keywords: *Visočka pečenica, traditional production, industrial production, lipolytic changes, oxidative changes*

QUALITY AND OXIDATIVE STABILITY OF COLD-PRESSED FLAXSEED OILS FROM DIFFERENT PRODUCERS IN BOSNIA AND HERZEGOVINA

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Abstract

Cold-pressed flaxseed oil is a nutritionally valuable product due to its high content of essential fatty acids and other bioactive compounds. However, its high content of polyunsaturated fatty acids makes it susceptible to oxidative changes. The aim of this study was to evaluate the quality and oxidative stability of cold-pressed flaxseed oils from different producers in Bosnia and Herzegovina. Oxidative stability was evaluated in five samples (L1, L2, L3, L4, and L5) at an elevated temperature of 63°C by monitoring changes in peroxide numbers using the Schaal-Oven test over 24, 48, 72, 96, and 120 hours. In addition, the effects of natural antioxidants, namely wild oregano, rosemary, and sage essential oils (0.20%), as well as synthetic antioxidants, propyl gallate (PG), butylated hydroxytoluene (BHT), and butylated hydroxyanisole (BHA) (0.01%), on the oxidative stability of the samples were investigated. The results of the oxidative stability analysis using the Schaal-Oven test showed an increase in peroxide numbers with prolonged exposure to the elevated temperature of 63°C in all oil samples. Sample L2 exhibited the lowest oxidative stability compared with the other tested samples. Among the synthetic antioxidants, PG was the most effective in samples L1, L2, L3, and L4, whereas BHT was the most effective in sample L5. Among the natural antioxidants, wild oregano essential oil was the most effective in samples L1, L3, L4, and L5, while rosemary essential oil was the most effective in sample L2.

Keywords: *flaxseed oil, quality, antioxidants, oxidative stability*

FERMENTED FOODS AT THE CROSSROADS OF NUTRITION AND FUNCTIONALITY

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Abstract

Fermented foods have been part of the human diet for centuries, initially developed to preserve foods and extend their shelf life. Their role has since expanded beyond preservation, gaining particular relevance in modern diets, where ready-to-eat and highly processed foods increasingly replace traditional fermented products. This review examines the functional significance of fermented foods through their microbiota, metabolites, and fermentation-induced changes in the food matrix. During fermentation, microorganisms modify food composition and produce bioactive compounds, including organic acids, peptides, exopolysaccharides, vitamins, GABA, and bacteriocins. The functional value of fermented foods therefore reflects the combined effects of the food matrix, microbiota, microbial metabolites, and their interactions with the gut microbiome. Traditional fermented foods are particularly valuable because of their diverse microbiota and technological and functional potential. However, fermented foods should not be equated with probiotic foods, nor functional potential with proven health benefits. Preserving and characterizing traditional fermentation ecosystems may support the development of functional foods suited to modern dietary patterns.

Keywords: *microflora; fermentation; microbial metabolites; fermented and functional foods*

KOMBUCHA CULTURES FROM BOSNIA AND HERZEGOVINA: FERMENTATION POTENTIAL AND QUALITY CHARACTERISTICS

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Abstract

Kombucha is a fermented tea beverage produced by a symbiotic culture of bacteria and yeasts (SCOBY), whose microbial activity can influence the fermentation process and product quality. This study aimed to characterize SCOBY cultures collected in Bosnia and Herzegovina and assess their fermentation potential under standardized conditions.

Six SCOBY cultures from different producers were collected, three from the Sarajevo region and three from the Banja Luka region. Following reactivation, all cultures were fermented for 14 days using the same substrate under standardized conditions. The resulting beverages had a mean pH of 3.46, soluble solids of 4.35 °Bx, total titratable acidity of 6.39 g/L as acetic acid, CO_2 content of 42.15 mg/L, and ethanol content of 0.10% (v/v). Mean counts in the SCOBY and fermented beverage were 3.74 and 4.57 for lactic acid bacteria, 4.59 and 5.52 for acetic acid bacteria, and 3.28 and 4.14 for yeasts, expressed as log CFU/g and log CFU/mL, respectively. The beverages showed high sensory quality, with a mean score of 18.21/20.

Geographical origin had no significant effect on physicochemical changes, indicating that fermentation variability was primarily associated with individual SCOBY characteristics. These findings demonstrate the diverse fermentation potential of kombucha cultures collected in Bosnia and Herzegovina and provide a basis for their further microbiological and molecular characterization.

Keywords: *Kombucha; SCOBY; fermentation; microbiota; fermentation potential; quality characteristics*

INFLUENCE OF EXTRACTION CONDITIONS ON POLYPHENOL RECOVERY AND ANTIOXIDANT CAPACITY OF DIFFERENT BEAN TYPES

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Abstract

Beans (*Phaseolus vulgaris* L.) are an important dietary source of phenolic compounds with antioxidant properties, whose efficient recovery may be strongly influenced by sample preparation and extraction conditions. This study aimed to evaluate the total polyphenol content (TPC) and antioxidant activity of different bean samples. The samples were extracted with 70% ethanol under magnetic stirring for 2 h. Total polyphenol content was determined using the Folin-Ciocalteu assay, while antioxidant activity was evaluated using three complementary methods: DPPH radical scavenging activity, ABTS radical cation scavenging activity, and ferric reducing antioxidant power (FRAP). Differences in TPC were observed among the investigated bean types, with pinto beans exhibiting the highest polyphenol content. Correlation analysis was performed to evaluate the relationship between TPC and the antioxidant responses obtained using the three assays. The results demonstrate variability in the phenolic content and antioxidant properties of different bean types and emphasize the importance of sample preparation and homogenization when evaluating phenolic compounds, particularly when comparing beans with different seed coat characteristics. These findings contribute to a better characterization of the antioxidant potential of beans and may support further studies on the relationship between bean type, phenolic composition, and antioxidant capacity.

Keywords: *bean (Phaseolus vulgaris L.), polyphenols, antioxidant activity, Folin-Ciocalteu assay, spectroscopy*

CADMIUM: CONTENT IN ANIMALS' LIVER AND INTAKE ASSESSMENT

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Abstract

Monitoring of cadmium (Cd) content in animal tissues is necessary and effective tool in order to secure animal originating food hygiene and the protection of public health. The present study was conducted to examine the Cd level in bovine, pork and chicken liver samples as well as to assess the Cd intake associate with liver consumption in Serbia. Liver samples (n=191) were collected within Serbian National Residue Monitoring Program during 2024-2025. Levels of Cd were determined by inductively-coupled plasma mass spectrometry (ICP-MS). Significantly ($p<0.05$) the highest Cd mean level was established in bovine liver (bovine: 0.061 mg kg^{-1}; pig: 0.040 mg kg^{-1}; chicken: 0.023 mg kg^{-1}), but none of them exceeded Maximum Residue Level (MRL) for Cd (0.5 mg kg^{-1}). According to European Food Safety Authority (EFSA) the average intake of liver for adults (consumers only) in Serbia (pig liver - 0.72 g/kg bw/day; chicken liver - 0.83 g/kg bw/day) and obtained Cd levels, consuming these animal entrails contribute up to 14.1% of tolerable daily intake (0.36 µg/kg bw/day). This could represent a slight health risk for consumers considering the fact that Cd is toxic heavy metal well known as an environmental and food chain contaminant. Generally, the obtained results suggest comprehensive and periodic control of different type foodstuffs to ensure the quality and safety of food with respect to human health.

Keywords: *Cadmium, Liver, Serbian National Residue Monitoring Program*

COMPLIANCE OF A KARST DRINKING-WATER SOURCE WITH NATIONAL AND EU PARAMETRIC VALUES: THREE-YEAR EXCEEDANCE ANALYSIS AND WATER QUALITY INDICES FOR THE VRIOŠTICA SPRING (BOSNIA AND HERZEGOVINA)

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Abstract

Raw water of the Vrioštica karst spring, the drinking-water source of Ljubuški (Bosnia and Herzegovina), was sampled monthly from 2017 to 2019 (n = 36) and compared with the parametric values of the national Rulebook on the health safety of drinking water and Directive (EU) 2020/2184. Electrical conductivity, pH, permanganate index, ammonium, nitrate and chloride never exceeded their limits and remained at medians of 3–23% of the parametric values. Sulphate exceeded 250 mg/L in 2 of 36 samples, both in October at the end of the dry season, and turbidity exceeded 1 NTU in 4 samples, all during autumn–winter recharge. Total coliforms were present in all samples, *Escherichia coli* in 31 (86%) and intestinal enterococci in 17 (47%); colony counts exceeded 20 CFU/mL (37 °C) in 29 and 100 CFU/mL (22 °C) in 33 samples; *Clostridium perfringens* was never detected. Only 4 samples were free of both faecal indicators and none met all microbiological values. The CCME Water Quality Index computed on seven physico-chemical parameters was 91.7 for the whole period, 100 in the wet and 91.7 in the dry season, whereas the index for colony counts was 5.7. The weighted-arithmetic WQI classified every sample as "excellent", masking the sulphate

problem. The physico-chemical quality of the source is very good and its only exceedance, sulphate, is seasonal and of natural origin, while continuous low-level faecal contamination requires permanent disinfection. Compliance statistics should be reported by hydrological season, and raw-water colony-count exceedances should not be counted as failures.

Keywords: *drinking water, karst spring, Directive (EU) 2020/2184, CCME WQI, faecal indicators*

ANIMAL PRODUCTION

CONSERVATION OF INDIGENOUS CATTLE BREEDS: THE KEY TO A SUSTAINABLE FUTURE AND BIOLOGICAL STABILITY

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Abstract

The loss of indigenous cattle breeds in Serbia, primarily Busa and Podolian cattle, would result in an irreversible loss of valuable genetic heritage. These breeds possess exceptional resilience, low maintenance requirements, longevity, and the ability to adapt to climate change. Their preservation is crucial for sustainable development in four aspects: biodiversity conservation, disease resistance, cultural heritage preservation, and the socio-economic development of rural areas. Protection is implemented through in situ conservation, aiming to preserve the breeds and increase their population in their natural habitat, while ex situ conservation is still not widely practiced. A drastic decline in the population size of indigenous cattle occurred during the 20th century due to the introduction of more productive breeds, mechanization, industrialization, and rural-to-urban migration. Today, the main breeding goals are to increase the number of animals, maintain health, and preserve breed characteristics. The current population size and characteristics of the Busa and Podolian cattle populations in Serbia are:

Busa (3,087 individuals): small build, strong legs, a distinctive deer-like muzzle, an eel stripe along the spine, and short horns. They are mostly solid-coloured, and the croup is often higher than the withers.

Podolian breed (429 individuals): silver-grey colour, long head, and a robust forequarter. It is recognizable by its exceptionally long horns, with a span of up to two metres. Bulls reach a weight of up to 900 kg, and cows up to 600 kg.

The stated numbers include all age categories. Both breeds are in a high-risk zone, making urgent and permanent conservation of their unique genetic code essential.

Keywords: *Indigenous breeds, genetic resources, Busa, Podolian cattle, Republic of Serbia*

METHANE EMISSIONS ON DAIRY FARMS IN THE CENTRAL BOSNIA REGION

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Abstract

Enteric fermentation, a natural process of ruminant digestion, represents the most significant source of methane emissions in agricultural production. This study aimed to predict methane emissions across three selected dairy farms within the Central Bosnia Region. Basic animal data were collected from each farm, the ration structures were determined (all farms utilized total mixed rations), dry matter intake was measured, and the nutritional value of the rations used throughout the calendar year was evaluated, focusing on parameters relevant to greenhouse gas emissions. Methane emissions were determined using three mathematical models. Model A was based on gross energy intake. Model B, the most complex model, utilized animal characteristics, ration composition, and milk fat content (Niu et al., 2018). Model C was based on the gross energy content of the rations and default methane conversion factors (Y_m) according to the IPCC Tier 2 models (2006), utilizing actual gross energy intake. The gross energy content of the rations was determined according to the NRC (2001). Compared with literature data, the results of this study indicate that methane emissions on the investigated dairy farms were higher than those reported in earlier research. These differences can be explained by the structure and nutritional composition of the rations, specifically, a higher proportion of roughage with high NDF content and a lower proportion of concentrate feeds, which directly influence rumen fermentation and methane production.

Keywords: *methane emission, dairy cows, TMR quality, energy content*

PARTICIPATORY BREEDING OF LOCAL PRAMENKA SHEEP FOR BIODIVERSITY PRESERVATION IN HIGH NATURE VALUE PASTURES OF CENTRAL BOSNIA AND HERZEGOVINA

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Abstract

Pastoral systems in BiH and the wider ADRION area provide functions beyond livestock production, including biodiversity conservation, landscape maintenance and ecosystem services. Yet they are increasingly affected by rural depopulation, labour shortages, weak market recognition, fragmented institutional support and the loss of local genetic resources. These pressures are most visible in mountainous areas, where extensive sheep husbandry remains one of the few viable forms of land use and where local breeds underpin High Nature Value (HNV) grasslands. In this context, the ECOBREEDS action "The breeding program for preserving biodiversity" promotes a participatory breeding approach centred on local Pramenka sheep in the Travnik/Vlašić area. Locally adapted strains are valuable genetic resources, suited to mountain pastures characterised by rough forage, steep terrain, prolonged grazing, climatic variability and low-input management. Preserving these traits is essential for pastoral livelihoods, local products and semi-natural grasslands. The framework engages family farms, advisory actors and experts in co-defining breeding priorities that reflect both production and environmental needs. Rather than a top-down model, it emphasises robustness, fertility, longevity, sound feet and legs, grazing capacity on difficult terrain, and suitability for milk and lamb production. Through farm visits, simplified characterisation and collective learning, it generates practical, context-specific criteria with a low administrative burden. By linking breeding to ecosystem services, the initiative supports species-rich grasslands, limits shrub encroachment, aids soil and water regulation, and sustains lamb and Travnik/Vlašić cheese production, connecting local breed conservation with biodiversity protection, rural resilience and landscape management across the ADRION area.

Keywords: *Pastoralism; Pramenka sheep; biodiversity; HNV pastures; ecosystem services*

PRODUCTION POTENTIAL AND NUMBER OF IMPORTED DAIRY GOAT BREEDS IN THE REPUBLIC OF CROATIA

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Abstract

The aim of this study was to present the production potential and representation of imported, herdbook dairy goat breeds raised in the Republic of Croatia (RC), as well as the prospects for the development of this production sector. The study included data from research conducted on imported goat breeds - Alpine, Saanen, and Murciano-Granadina - which are also reared in the RC. In the RC, 4,166 herdbook Alpine goats, 621 Saanen goats, and since 2023, 55 Murciano-Granadina goats are reared. The analysis of the population size of these breeds revealed a decrease in Alpine and Saanen goats, and a slight increase in Murciano-Granadina goats, whose breeding began in 2022. The reasons are multiple, ranging from increasing depopulation of rural areas and lack of labour to the advanced age of farm owners, fragmentation of land, as well as poorly organized markets for goat products and goat milk purchase. The development of the dairy goat sector in the RC has good potential considering the increased demand for goat milk and goat cheese, which is accompanied by growing interest in acquiring highly selected dairy goat breeds.

Keywords: *dairy imported breeds, goats, production potential, population size, Republic of Croatia*

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MICROBIOLOGICAL QUALITY ASSESSMENT OF SILAGE USED IN ANIMAL NUTRITION

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Abstract

Ensiling is a widely used method for preserving high-moisture forage through natural fermentation processes in which lactic acid bacteria convert soluble carbohydrates into organic acids, primarily lactic acid, thereby preventing feed spoilage. The quality and nutritional value of silage depend on the type of forage, its chemical composition, and the concentration of fermentation products. The aim of this study was to evaluate the microbiological quality of silage samples by determining the abundance of saprophytic bacteria, yeasts, and molds, as well as the presence of *Salmonella spp*., *Escherichia coli*, and *Staphylococcus aureus*. In addition, phytopathogenic fungi were isolated and identified to the genus level. The results showed that all samples, except sample three, exhibited pH values within the recommended range for good-quality silage. The highest total bacterial counts were recorded in samples collected from Farm 2 (surface layer; 167.90×10^3 CFU/g) and Farm 3 (deep layer; 139.44×10^3 CFU/g). The highest yeast and mold counts were detected in samples from Farm 3 (surface layer; 365.20×10^2 CFU/g) and Farm 2 (deep layer; 152.72×10^2 CFU/g). *E. coli* and *Salmonella spp.* were detected in most samples, whereas *Staphylococcus aureus* was absent only in samples collected from Farm 2. No samples tested positive for *Clostridia*. Fungal genera identified included *Aspergillus, Penicillium, Fusarium, Alternaria*, and *Mucor*. Based on microbiological criteria and regulatory limits for animal feed, the analyzed silage samples were generally of satisfactory microbiological quality. However, comprehensive evaluation of silage quality also requires the assessment of its nutritional characteristics.

Keywords: *silage, microbiological quality, Salmonella, Escherichia coli, phytopathogenic fungi*

INNOVATIVE TECHNOLOGIES IN SHEEP FARMING FOR HEALTH MONITORING AND EARLY DETECTION OF HOOF DISEASES

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Abstract

Digitalization in sheep production significantly facilitates feeding, health monitoring and productive capacity of animals. The application of digital technologies in sheep production enables early detection of viral, bacterial and acarine diseases, which enables timely response and effective control of pathogens. The purpose of this paper is to analyze the methods of applying modern devices and digital equipment in monitoring changes in sheep health caused by pathogens. Special emphasis is placed on the application of thermal cameras in the modern detection of lameness, which is one of the most widespread diseases in the Republic of Croatia. The paper is based on a systematic review of scientific and professional literature, with a presentation of the application of digital technologies on a family farm as a case study. The results indicate the effective possibility of applying thermal cameras, collars, sensors and wearable devices that monitor food intake and physiological parameters. The collected data is processed via digital platforms and software solutions that enable disease prediction using various algorithms. An example is the increase in joint and hooves temperature as an early indicator of lameness. Therefore, the aim of this paper is to show how technology can contribute to livestock production in the timely detection of sheep diseases, which directly affects the increase in productivity and profitability of the farm.

Keywords: *digitalization of sheep farming, animal health, sheep diseases, lameness*

TISSUE COMPOSITION OF OHRID BELVICA (*SALMO OHRIDANUS* STEINDACHNER, 1892)

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Abstract

To investigate the tissue composition of Ohrid belvica (*Salmo ohridanus*, Steindachner, 1892), a study was conducted on specimens collected during both the vegetative and reproductive developmental phases. Sampling was performed at three locations in Lake Ohrid, Kalishta, Kaneo, and Eleshec, at depths ranging from 45 to 70 m. The specimens had an average body mass ranging from 90 to 100 g and an average total body length between 217 and 225 mm. Tissue composition was determined by dissection, and the individual components (scales, skin, muscle, and bones) were weighed to determine their percentage contribution. The results showed that differences in the proportions of muscle and bones between the two developmental periods were minimal and not statistically significant. Scales accounted for 1.01% of the dressed body weight during the vegetative period and 1.05% during the reproductive period. Skin represented 8.91% and 9.19%, muscle 85.95% and 85.40%, and bones 5.14% and 5.41% during the vegetative and reproductive periods, respectively. The obtained results indicate that the developmental period has no significant effect on the tissue composition of Ohrid belvica.

Keywords: *Salmo ohridanus*, *tissue composition*

SEASONAL DISTRIBUTION OF UDDER-HEALTH STATUS AND ITS ASSOCIATION WITH MILK PRODUCTION AND COMPOSITION IN HOLSTEIN COWS

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Abstract

Mastitis represents a major production disease in dairy cattle, with substantial implications for udder health, milk yield, and milk composition. This study analysed the seasonal distribution of udder-health status and its associations with milk production in Holstein cows. The dataset comprised 2,509,222 test-day records collected from 01/2013 to 12/2022 within the national milk recording. Records were classified as healthy, subclinical mastitis, or clinical mastitis based on somatic cell count, and analysed separately by season. Daily milk yield, fat, protein and lactose content, log-transformed SCC (SCClog), and milk urea concentration were analyzed using a linear mixed model accounting for the lactation curve, parity age at first calving, region, and herd size. The highest proportion of healthy cows was recorded in winter (65.70%), whereas autumn showed the highest proportion of combined subclinical and clinical mastitis (38.51%). Across all seasons, daily milk yield declined progressively from healthy to subclinical and clinical mastitis groups. A similar pattern was observed for lactose content, whereas fat, protein, and SCClog were generally higher in mastitis-affected cows. Seasonal variation was also observed in milk urea concentration. These findings highlight consistent associations between udder-health status and milk traits across seasons and emphasize the importance of continuous SCC monitoring and season-specific mastitis prevention in Holstein herds.

Keywords: *Holstein cows; mastitis; udder health; milk production; somatic cell count*

EFFECT OF LACTATION STAGE ON MILK PRODUCTION AND ESTIMATED AMMONIA EMISSIONS IN HOLSTEIN COWS

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Abstract

Reducing ammonia emissions from dairy production is an important component of improving the environmental sustainability of the dairy sector. The objective of this study was to evaluate changes in milk production and estimated ammonia emissions in Holstein cows according to lactation stage. Milk recording data were analysed, and cows were classified into four lactation-stage groups: <100, 100–200, 200–300, and >300 days in milk. Descriptive statistical parameters were calculated for daily milk yield and estimated daily ammonia emission. Mean daily milk yield was highest during the first 100 days of lactation (25.95 kg/cow/day), remained relatively high between 100 and 200 days (25.13 kg/cow/day), and subsequently decreased to 20.89 and 16.87 kg/cow/day during 200–300 and >300 days of lactation, respectively. In contrast, estimated ammonia emission increased from 74.57 g/cow/day during the first 100 days to its highest value of 77.74 g/cow/day between 100 and 200 days. Thereafter, ammonia emission decreased to 76.63 g/cow/day during 200–300 days and to 74.57 g/cow/day after 300 days. The results indicate that lactation stage is associated with distinct patterns of milk production and estimated ammonia emission. The highest estimated ammonia emission occurred during the second lactation stage, while milk production progressively declined as lactation advanced. These findings highlight the importance of considering lactation stage when developing management and nutritional strategies aimed at reducing ammonia emissions from dairy production.

Keywords: *ammonia emission, dairy cattle, Holstein, lactation stage, milk yield*

ACKNOWLEDGEMENT

This research was funded by the European Union - NextGenerationEU (the project “Optimization of the sustainability of animal production under climate change conditions: integration of genetic, environmental, and technological factors”).

INFRARED THERMOGRAPHY IN THE FIELD OF MARE'S MILK PRODUCTION

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Abstract

Infrared Thermography (IRT) assesses mare lactation, udder condition, and timing of milking, and assists in the pregnancy of the mare. IRT in animals is a non-invasive diagnostic technique used to detect symmetry and asymmetry in surface temperature gradients. Heat is often dissipated through the skin by evaporation and other means to balance the internal and external temperatures of the mare. Thermal imaging is the most effective and non-invasive technique for studying temperature distribution by measuring bilateral anatomical sites and identifying significant differences between thermal images, making it an ideal tool in the mare milk industry. The skin surface is a highly efficient radiator, and it is possible to detect infrared emissions from the skin and create a thermal map of the temperature distribution by non-invasive means, and the skin of the mare's udder is sparsely covered with hair and thin, making it suitable for such imaging. By detecting increased heat in the udder area due to increased blood flow/metabolic activity, offering a non-contact method of confirming udder condition, especially useful in mares used in late lactation for milking. The development of technology with advances in image processing allows for a more reliable display of the condition of the udder and the mammary glands themselves. The thermal image reading itself is greatly influenced by the ambient temperature and coat conditions. The method involves taking thermal images of the udder area to detect thermal changes associated with the condition of the mare's mammary glands.

Keywords*: surface temperature, fairies, lactation, fertility, mare*

ACKNOWLEDGEMENT

This research was funded by the European Union - NextGenerationEU (the project “Optimization of the sustainability of animal production under climate change conditions: integration of genetic, environmental, and technological factors”).

SUPERNUMERARY TEATS IN CATTLE: PREVALENCE, GENETICS, AND COMPARATIVE ANALYSIS ACROSS ANIMALS AND HUMANS

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Abstract

Supernumerary teats (SNT - hyperthelia, extra teats, accessory teats, or rudimentary teats) represent one of the most often occurring anatomical anomalies in dairy and beef cattle worldwide. Defined as any teat in excess of the standard four found in cows, they appear with considerable variation in prevalence across breeds, individuals, and anatomical positions. In dairy cattle breeding SNT are undesired condition because of aesthetic reasons, possible disturbances of machine milking, and perhaps most important, because supernumerary mammary glands may act as a reserve for bacteria that cause mastitis. Supernumerary teats are clearly separate and distinct from the main teats. These teats are usually located behind the main teat and are much smaller. This review integrates current knowledge on the morphology, inheritance, frequency, clinical significance, and management of SNT in cattle breeding, while offering a systematic comparative analysis with the condition as it manifests in other domestic and wild mammals, as well as in humans. Evidence suggests that SNT in cattle are primarily hereditary. The economic, reproductive, and welfare implications of ST in dairy cattle are significant, making this an area of sustained scientific and practical interest.

Keywords: *supernumerary teats, hyperthelia, inheritance, cattle, mammary gland*

DETECTION OF MASTITIS IN DAIRY COWS USING INFRARED THERMOGRAPHY

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Abstract

Mastitis remains one of the most prevalent and economically important diseases affecting dairy cattle worldwide. Its occurrence varies considerably among geographical regions, reflecting differences in management systems, environmental conditions, milking practices, herd size, diagnostic methods, and animal health programs. Good farm management is one that can prevent udder diseases and thus reduce production costs. Modern technological methods such as infrared thermography (IRT) can help prevent the occurrence of mastitis. Infrared thermography is diagnostic tool which can detect mininor changes in skin temperature and can therefore recognize inflammatory changes in the udder closely related to mastitis. Due to the great influence of the environment and the animal itself, it is crucial to ensure adequate conditions at the location of the recording and combine IRT with other mastitis detection methods.

Keywords: *mastitis, detection, infrared thermography, dairy cows, risk factors*

THE ROLE OF SMALL RUMINANTS IN AGROFORESTRY SYSTEMS FOR FOREST RESTORATION AND BIODIVERSITY CONSERVATION

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Abstract

Agroforestry systems combine woody vegetation with livestock production and may contribute to sustainable land management and biodiversity conservation. Small ruminants, particularly sheep and goats, can play an important role in these systems through controlled grazing of forest and degraded areas. The aim of this review was to analyse the potential of sheep and goats as a sustainable grazing tool for forest restoration and biodiversity conservation within agroforestry systems. The review focused on the effects of small-ruminant grazing on vegetation management, natural regeneration, and habitat diversity with particular attention to differences between sheep and goats in their feeding behavior and their potential use for managing herbaceous and woody vegetation. Furthermore, the effect of grazing intensity and management practices on vegetation development and biodiversity was also considered. Available data indicates that appropriately managed grazing can contribute to maintaining diverse vegetation structures and supporting biodiversity, while uncontrolled or excessive grazing may hinder natural regeneration and negatively affect vegetation diversity. Therefore, the integration of small ruminants into agroforestry and forest-management practices may represent a practical approach to combining livestock production with vegetation management and biodiversity conservation.

Keywords: *Agroforestry, small ruminants, forest restoration, biodiversity conservation, grazing management*

BEHAVIORAL LATERALIZATION IN HORSES IN THE CONTEXT OF TRAINING AND WELFARE

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Abstract

Behavioral lateralization in horses manifests as the asymmetric processing of sensory stimuli and side preference, reflecting the functional specialization of the cerebral hemispheres. This paper aims to systematically review relevant, recent scientific and professional literature to present current knowledge regarding cerebral, sensory, and motor lateralization in horses, examine factors influencing its expression, and assess its implication for training and welfare. Research results covering visual, auditory, and olfactory preferences, limb preference during standing and movement, and biomechanical asymmetry were analyzed, alongside the influence of conformation, age, sex, breed, and rider experience. Existing findings indicate that the left hemisphere is more frequently involved in processing familiar and predictable stimuli, whereas the right hemisphere plays a prominent role in processing novel, emotionally and socially relevant information. Visual and auditory lateralization have been documented with relative consistency, while research on olfactory lateralization remains limited. Motor lateralization exhibits greater variability, as behavioral preferences overlap with conformational differences, weight distribution, health status, and the effects of training. Distinguishing between physiological functional asymmetry and compensatory patterns associated with pain or lameness presents a methodological challenge. Studies conducted during riding confirm that observed laterality is also influenced by rider asymmetry. Varying definitions of laterality, sample sizes, breed composition, and measurement methods significantly hinder the direct comparison of results across studies, as well as the drawing of firm conclusions. An integrated assessment of multiple sensory, motor, and biomechanical

characteristics – while simultaneously considering scientific status and training conditions – provides a scientifically grounded framework for understanding individual differences, adapting work and training, and preserving the horse's functional balance and well-being.
Keywords: *horses, lateralized behavior, training, welfare*

AGRICULTURAL AND FOOD ECONOMICS

THE ROLE OF FOOD PACKAGING IN PRESERVING QUALITY AND REDUCING FOOD LOSSES DURING DISTRIBUTION

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Abstract

Food losses during distribution remain a major challenge for agri-food supply chains, leading to economic losses, reduced food availability, and increased environmental impacts. Packaging has evolved from a protective container into a strategic component of quality management, contributing to the preservation of food quality and the reduction of losses throughout the distribution process.This paper presents a review of recent scientific literature on the role of food packaging in preserving product quality and minimizing food losses. The analysis includes studies addressing conventional, active, intelligent and sustainable packaging solutions, with particular emphasis on their application in food distribution and logistics. The reviewed literature indicates that appropriate packaging effectively protects food from mechanical damage, moisture, oxygen, light and microbial contamination, thereby extending shelf life and maintaining sensory and nutritional characteristics. Furthermore, innovative packaging technologies improve product monitoring, traceability and quality control during transportation and storage. Sustainable packaging materials also contribute to reducing the environmental impact of food supply chains. Food packaging is a key element of modern agri-food supply chains, contributing to quality preservation, food loss reduction, and more sustainable distribution. Further research should focus on the wider implementation of smart and environmentally friendly packaging solutions in food logistics.

Keywords: *food packaging, food quality, food losses, agri-food supply chains, sustainable packaging*

A BEHAVIORAL ANALYSIS OF YOUTH SOCIOECONOMIC STATUS AND MIGRATION INTENTIONS IN NORTH MACEDONIA USING THE THEORETICAL DOMAINS FRAMEWORK

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Abstract

Rural communities in North Macedonia face deep demographic and socioeconomic transformations, primarily characterized by population decline, aging, and a persistent youth exodus. Traditional studies often rely strictly on structural indicators, overlooking the personal perceptions and behavioral motivations that drive young people to stay in or leave rural areas. This study provides a behaviorally informed assessment of the socioeconomic status, migration intentions, and agricultural career choices of rural youth by applying the Theoretical Domains Framework (TDF) integrated with the COM-B (Capability, Opportunity, Motivation) model for Behavior change. Utilizing a mixed-methods approach, primary data were collected in 2023 through a structured survey administered to 550 young individuals (aged 18–40) across all eight statistical planning regions. A final sample of 523 valid questionnaires was analyzed using an adapted TDF lens to link objective contextual constraints with subjective behavioral drivers. Respondents expressed high satisfaction with private life domains like health, family, and social circles. Conversely, they reported profound dissatisfaction with economic opportunities, employment availability, and institutional settings—specifically noting systemic corruption and politicization. While 72% do not plan immediate relocation, a substantial portion contemplates medium-term migration, with 71% targeting international destinations. Furthermore, a breakdown in traditional generational farm transfer is evident, as only 40% express willingness to inherit family farms. The study demonstrates that the TDF is a highly effective diagnostic tool for agricultural and rural

development. Reversing the rural exodus requires integrated, behaviorally targeted policies that enhance opportunity and motivation by improving institutional transparency and modernizing agriculture through digitalization.

Keywords: *rural youth, TDF, migration, North Macedonia*

WHO SHAPES OUR MEAT CHOICES? CHANGING DIETARY NARRATIVES AND THE TRANSFORMATION OF MEAT CONSUMPTION

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Abstract

Contemporary meat consumption is influenced not only by economic factors and product availability, but also by evolving dietary recommendations, lifestyle trends and changing perceptions of desirable protein sources. While studies on meat consumption have traditionally focused on income, prices and demographic characteristics, increasing attention is being directed toward the role of dietary narratives in shaping consumer preferences and food choices. The aim of this paper is to examine how changes in dietary recommendations, public discourse and emerging dietary patterns contribute to the transformation of meat-related food choices. The paper is based on a review of scientific literature and recommendations related to meat consumption. The analysis focuses on the evolution of dietary recommendations, the emergence of the lean protein concept, the growing influence of fitness culture, and the increasing popularity of vegetarian, vegan and flexitarian dietary patterns. Over recent decades, the perception of meat has changed considerably. While meat was traditionally viewed as an important source of nutrients, contemporary discussions increasingly emphasize health, lifestyle and food quality. In this context, poultry and other sources of lean protein are often presented as preferable alternatives to red meat. At the same time, fitness-oriented lifestyles and protein-focused dietary approaches have contributed to changing attitudes toward meat consumption, while flexitarian diets have promoted reduced rather than completely eliminated meat intake. The paper argues that contemporary meat choices are shaped by a combination of scientific recommendations, lifestyle trends and broader social narratives. Understanding current patterns of meat consumption therefore

requires an approach that incorporates social and cultural influences alongside traditional economic determinants.

Keywords: *meat consumption; dietary recommendations; lean protein; fitness culture; flexitarianism*

OPEN BALKAN AND AGRI-FOOD TRADE INTEGRATION: EVIDENCE FROM A PPML GRAVITY MODEL

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Abstract

Regional economic integration represents an important mechanism for improving trade cooperation and strengthening the competitiveness of agri-food sectors in the Western Balkans. Following the liberalization process established through CEFTA, the Open Balkan initiative has created a new framework for intensifying regional economic cooperation and facilitating trade flows among participating economies. The main objective of this paper is to examine the effects of the Open Balkan initiative on the bilateral trade of agri-food products. In order to evaluate the impact of regional integration on agri-food trade flows, a gravity model based on panel data is estimated using the Poisson Pseudo-Maximum Likelihood (PPML) estimator. The empirical analysis covers bilateral agri-food trade between the Open Balkan countries and their trading partners in the period 2010–2023. Besides the Open Balkan variable, the model includes standard gravity determinants such as economic size, geographical distance, historical ties, and WTO membership. The results indicate that regional integration positively affects trade flows of agri-food products, particularly exports of participating economies. Geographical proximity and historical connections significantly contribute to stronger trade integration, while economic size positively influences bilateral trade. The findings confirm the importance of regional cooperation and trade facilitation mechanisms for improving the international competitiveness of the agri-food sector in the Western Balkans. This paper contributes to the literature on regional trade integration and agri-food trade in the Western Balkans by providing evidence on the trade effects of the Open Balkan initiative using a modern gravity modeling approach.

Keywords: *Open Balkan, agri-food trade, regional integration, gravity model, PPML*

SUSTAINABLE AGRICULTURE AS AN INSTRUMENT FOR THE SUSTAINABLE TRANSITION OF COAL MINING REGIONS

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Abstract

The transition of coal-dependent regions is a development process that requires diversification, land restoration, resource protection and rural resilience. Agriculture holds untapped potential to contribute in all of these aspects, but remains an underused instrument in the transformation of coal-mining local communities to ahcieve targets of the Green Agenda for the Western Balkans and the regional objective of climate neytraluty by 2050. This paper examines sustainable agriculture's role in the transition of six coal-mining local self-government units: Banovići, Breza, Gacko, Kakanj, Ugljevik and Živinice. Within the BiSuTra project framework, the study applies a qualitative, strategic-level comparative analysis based on situational analyses, participatory validation and a comparative matrix. The matrix applies uniform criteria covering agricultural resources, constraints, land pressures, climate and environmental risks, processing capacities and market linkages. The analysis identifies shared challenges, including land degradation, fragmented holdings, weak processing and advisory capacities, limited monitoring, and growing drought, erosion and flood risks. At the same time, they differ significantly in institutional capacities, support budgets, market position, production traditions and place-based agricultural assets. Based on these findings, priority measures were grouped into thematic packages related to land protection and restoration, climate resilience, digitalization and monitoring, knowledge transfer, local value chains, branding and rural diversification. Sustainable agriculture cannot resolve the transition challenges alone, but with well-designed measures adapted to local

conditions, it can contribute significantly to the achievement of environmental, economic and social objectives in the studied self-government units.

Keywords: *sustainable agriculture, coal mining regions, sustainable transition, land restoration, rural diversification*

BEYOND LABELS AND CERTIFICATIONS: UNDERSTANDING THE PARADOX OF BEE PRODUCTS CONSUMER BEHAVIOR

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Abstract

The bee product market is characterized by a notable gap between consumer expectations and their actual knowledge of product quality and authenticity. This study examines the factors influencing consumer trust and purchasing behavior by testing eight hypotheses related to demographic characteristics, sensory competence, technological traceability, and consumer knowledge. Data were collected from 479 respondents in the Western Balkans and analyzed using Pearson's χ^2 test. The results challenge the assumption that geographical location (urban versus rural) significantly influences purchasing behavior, indicating a relatively homogeneous market. Sensory competence was found to be associated primarily with consumption frequency and personal engagement rather than formal education. Furthermore, technological tools such as QR codes demonstrated limited effectiveness as indicators of product quality, functioning mainly as supplementary security features. An important inconsistency was observed between certification preferences and product knowledge, as 43.05% of respondents who prioritized Halal certification were unable to identify the type of solution they were using. Additionally, less experienced consumers frequently overestimated their ability to assess product quality. Overall, the findings suggest that consumer trust is more strongly associated with direct purchasing experiences than with digital traceability tools or certification labels. These results highlight the need for improved consumer education and more effective communication strategies to bridge the gap between perceived and actual knowledge of bee products.

Keywords: *honey, bee products, digital traceability, Halal certification, consumer psychology*

CONSUMER PREFERENCES IN COFFEE SELECTION IN THE BOSNIA AND HERZEGOVINA MARKET

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Abstract

Coffee consumption represents a significant aspect of the dietary habits of the population, while understanding the factors influencing consumers' choice of a particular type and brand of coffee is of considerable importance for producers, distributors, and marketing professionals. The aim of this study is to examine consumer preferences in the selection of coffee in the market of Bosnia and Herzegovina, with particular emphasis on the influence of socio-demographic characteristics, consumption habits, perceived quality, price, brand, marketing activities, and consumer loyalty. The empirical research was conducted using a survey method based on a structured questionnaire, which included questions related to respondents' socio-demographic characteristics, coffee consumption habits, factors influencing purchasing decisions, brand loyalty, and the impact of promotional activities on consumer purchase decisions. The collected data were analyzed using descriptive statistical methods to identify the dominant patterns of consumer behavior. The findings are expected to provide a better understanding of the key determinants of coffee choice in the Bosnia and Herzegovina market and to highlight the relative importance of quality, taste, price, brand, and marketing communication in the consumer decision-making process. The study is expected to contribute to a better understanding of consumer preferences and to provide useful insights for the development of more effective marketing strategies and the adaptation of product offerings to consumer needs and preferences.

Keywords: *consumer preferences, coffee, Bosnia and Herzegovina market, consumer behavior, brand, marketing*

POLICIES SUPPORTING WOMEN IN RURAL DEVELOPMENT: A COMPARATIVE ANALYSIS OF THE EU AND BOSNIA AND HERZEGOVINA

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Abstract

Women in rural areas encounter various barriers, including gender and pension pay gaps, a disproportionate burden of unpaid domestic work, and limited access to services and financial resources for their entrepreneurial activities. The literature indicates that, despite these challenges, women are increasingly driving environmental and social innovation in rural communities. However, despite ongoing efforts in EU policies and legislation, gender inequalities persist, particularly in rural contexts. This suggests that policies promoting gender equality must include targeted measures addressing the specific needs of rural women and provide tangible support mechanisms. The aim of this paper is threefold: (1) to identify and compare the key barriers faced by women in rural areas across the European Union and Bosnia and Herzegovina; (2) to analyse agricultural policy measures supporting rural and farm women in Croatia and Bosnia and Herzegovina; and (3) to propose policy recommendations based on examples of good practice from selected countries, including Spain, Ireland, and Montenegro. The analysis draws on a comparative policy review, combining an examination of existing literature with an assessment of national and EU-level policy frameworks affecting rural women. By identifying current policy gaps and highlighting effective approaches, the paper contributes to the development of more gender-sensitive rural development strategies and offers actionable recommendations for policymakers. Its findings have practical implications for improving the design and implementation of agricultural and rural development policies, particularly within the context of the Common Agricultural Policy (CAP) and related national frameworks.

Keywords: *gender equality, CAP, rural areas, women*

INPUT–OUTPUT ANALYSIS OF ENERGY PRODUCTION IN THE BIOGAS PLANT OF FARMA SPREČA

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Abstract

Increasing demands for sustainable agricultural production, efficient management of organic by-products, and improved energy efficiency have led to the growing application of renewable energy sources in agriculture. Biogas plants represent one of the most efficient solutions in livestock production, as they enable the simultaneous treatment of organic biomass, production of electricity and heat energy, and the generation of digestate as a valuable organic fertilizer. The biogas plant of Farma Spreča Ltd., Kalesija, is the first facility of its kind in the Federation of Bosnia and Herzegovina integrated into a cattle farming system. The aim of this paper is to analyze the relationships between inputs and outputs in the energy production process of the Farma Spreča biogas plant using the input–output analysis method. The analysis includes quantitative and value-based indicators of inputs and outputs in the production process in order to assess the efficiency of resource utilization. The study is based on data collected during 2025, and descriptive statistical methods and input–output analysis are applied in data processing. It is expected that the results will confirm the relevance of input–output analysis as a methodological approach for assessing energy production efficiency from biomass and highlight opportunities for improving the economic and environmental performance of biogas plants. The findings will provide a basis for further research and for improving sustainable management of organic by-products and energy production in agriculture.

Keywords: *biogas plant, input–output analysis, biomass, energy production, sustainable agriculture*

POTENTIAL OF SPECIALISED SALES STORES FOR DOMESTIC AGRICULTURAL AND FOOD PRODUCTS IN BOSNIA AND HERZEGOVINA

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Abstract

Analysis of consumer habits and preferences is a significant area of research in modern economics, particularly amid growing interest in domestic agricultural and food products. The paper aims to examine the extent to which consumer attitudes and perceptions, primarily the perception of the availability of domestic products, perceived market barriers, and attitudes towards specialised retail outlets, influence the hypothetical intention to purchase domestic agricultural and food products in such outlets. The paper employs descriptive statistics and multiple binary logistic regression on data collected through a structured questionnaire, distributed via direct surveys at fairs and electronically. The results show that the purchase intention model is statistically significant and that both cognitive and behavioural factors explain part of the likelihood of purchasing in specialised outlets. A key predictor is the perception of insufficient representation of domestic products in traditional retail outlets, which significantly reduces the likelihood of strong purchase intention in specialised stores. This suggests that some consumers perceive the lack of domestic products more as a problem with existing chains than as a signal to turn to specialised channels, which should therefore be viewed as complementary rather than the primary response to the identified issue. Respondents who are more sensitive to high prices also more frequently express willingness to shop at specialised outlets, suggesting that a significant portion of consumers perceive specialised outlets as a channel that can 'justify' higher prices through added value. Additionally, the fact that respondents without a clearly defined purchase intention most often cite specialised outlets as a desirable incentive for more frequent shopping indicates their dissatisfaction with existing channels and the need to seek a new, alternative sales channel that would address the shortcomings of current points of sale.

Keywords: *domestic agricultural and food products, specialised retail stores, consumer behaviour, consumer preferences, local market*

HONEY FRAUDS IN THE EU: ECONOMIC DECEPTION WITH BROADER MARKET AND HEALTH CONSEQUENCES

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Abstract

Honey fraud has become a growing concern within the European Union, extending well beyond economic deception and consumer rights violations. Practices such as the addition of sugar syrups, manipulation of honey composition, and false labelling of geographical origin undermine fair competition. It also harms honest producers, and reduce consumer confidence in the agri-food sector and regulatory authorities responsible for market oversight. The consequences of honey fraud are not limited to economic losses. Adulterated or illegally processed honey may contain residues of antibiotics, pesticides, or other contaminants that do not comply with EU food safety requirements. As a result, consumers may be exposed to potentially harmful substances. That makes honey fraud not only a commercial issue but also a potential public health concern. This presentation explores the scale and complexity of honey fraud in the EU. It examines its economic impact, identifies regulatory challenges, and discusses the limitations of current detection and authentication methods. Particular attention is given to the relationship between food authenticity and consumer health protection. Moreover, it highlights the need to address honey fraud from both food safety and market integrity perspectives. Strengthening enforcement measures, improving analytical capabilities, and enhancing cooperation among competent authorities are essential for tackling this problem effectively. By adopting a comprehensive approach, EU can better protect consumers and support legitimate honey producers. Furthermore, in this way it can contribute to improved preservation of the integrity, transparency, and credibility of the European food market.

Keywords: *food safety; honey fraud; EU market integrity; public health; food fraud*

WESTERN BALKAN AGRI-FOOD SYSTEMS: BETWEEN CONTEXT, REALITIES AND POLICY RESPONSES

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Abstract

The agri-food systems in the Western Balkan countries operate in a complex context of (inherited) structural constraints, contemporary market pressures and evolving policy expectations linked to EU integration. Agriculture remains economically and socially important across the region, but policy responses often need to balance (or trade-off) immediate sectoral realities with longer-term transformation goals. The contribution applies a comparative regional analysis of Western Balkan agri-food systems, drawing on agricultural statistics, policy documents, sectoral indicators and recent evidence on agricultural performance, farm structures, trade, rural development and climate adaptation. The analysis combines descriptive indicators with policy review in order to identify common regional patterns and country-specific differences. The findings show that Western Balkan agri-food systems are characterised with uneven competitiveness, persistent rural and demographic challenges and increasing exposure to climate-related risks. At the same time, the region shows important production potential, strong local food traditions, opportunities for value chain upgrading, regional cooperation and closer alignment with EU policy frameworks. Policy instruments have gradually evolved, but gaps remain in implementation capacity, investment support, advisory services, innovation and evidence-based targeting. Future policy responses should move beyond sectoral support alone and address agri-food systems as integrated economic, social, environmental and territorial systems. Strengthening resilience, competitiveness, generational renewal, climate adaptation and institutional capacity will be essential for a more sustainable and inclusive transformation of Western Balkan agriculture.

Keywords: *Western Balkans; agri-food systems; agricultural policy; rural development; EU integration*

COMPARATIVE ANALYSIS OF MOTIVES AND PRACTICES OF URBAN AGRICULTURE IN THE CONDITIONS OF CRISIS AND MODERN SUSTAINABLE DEVELOPMENT

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Abstract

Urban agriculture has evolved from a survival-oriented activity into a multifunctional approach supporting sustainable urban development, food security, and resilient food systems. This study investigates changes in the motives, practices, and perceptions of urban agriculture in Bosnia and Herzegovina across three socio-historical contexts: the 1992–1995 war period, the COVID-19 pandemic, and the contemporary period. A mixed-methods research design was employed, combining qualitative and quantitative approaches. Qualitative data were collected through semi-structured interviews with 30 key informants, while quantitative data were obtained from a survey of 212 respondents using instruments based on the Food-Related Lifestyle framework and the Theory of Planned Behaviour. Structural Equation Modelling (SEM) and methodological triangulation were applied to integrate and validate the findings. The results demonstrate a clear transformation in the role of urban agriculture, during the war period, food production was primarily driven by survival and household food security, whereas contemporary participation is increasingly motivated by food quality, health, environmental sustainability, psychological well-being, and support for local food systems. SEM analysis revealed that attitudes were the only statistically significant direct predictor of the intention to engage in urban agriculture ($\beta=0.327$, $p<0.001$), whereas subjective norms ($\beta=-0.034$, $p=0.528$) and perceived behavioural control ($\beta=-0.002$, $p=0.930$) showed no significant effects. The integration of qualitative and quantitative findings further validated the transition of urban agriculture from a crisis-response strategy to an instrument of sustainable urban development. The proposed typology of urban agriculture practices provides a practical framework for understanding diverse forms of urban agriculture and offers valuable

guidance for future urban planning and policy development aimed at strengthening resilient and sustainable food systems.

Keywords: *urban agriculture; food security; sustainable food systems; Theory of Planned Behaviour; Food-Related Lifestyle*

NUTRITION LITERACY AND PERCEIVED BARRIERS TO HEALTHY EATING AMONG THE GENERAL POPULATION AND PHYSICALLY ACTIVE INDIVIDUALS IN BOSNIA AND HERZEGOVINA

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Abstract

Aligned with the principles of the New European Bauhaus initiative which facilitate sustainable, inclusive, and health-centric living environments, the global food system requires structural transformations that directly support individual well-being. In this context, nutrition literacy has emerged as a key factor in shaping healthy eating patterns and preventing chronic non-communicable diseases. This study aimed to examine the level of nutrition literacy and the perceived barriers to healthy eating among the general population and physically active individuals, those with distinct nutritional demands in Bosnia and Herzegovina. An online survey was conducted between May and July 2024 using a convenience sample (N = 338), and data were analyzed with standard descriptive and inferential statistics. Nutrition literacy was assessed using the reduced Short Nutrition Literacy Scale. Results indicated a moderate overall level of nutrition literacy, with physically active individuals demonstrating significantly higher literacy scores and fewer perceived structural barriers compared to the general population. Women and younger respondents scored higher on functional and interactive literacy, while men showed somewhat stronger critical evaluation of nutrition information. The most frequently reported barriers to healthy eating were lack of time, difficulty controlling cravings, and difficulty assessing the nutritional content of food. These findings underscore the need for targeted educational and public health interventions to strengthen nutrition literacy and reduce the barriers that hinder healthier dietary behavior. By addressing these specific behavioral and structural barriers, future initiatives can better align with the core values of the New European Bauhaus initiative, fostering sustainable, healthy, and highly inclusive food environments in Bosnia and Herzegovina.

Keywords: *nutrition literacy, dietary change, behavior, food policy, sustainable consumption*

THE ECOSYSTEM SERVICES APPROACH AS A TOOL FOR SUSTAINABLE RANGELAND MANAGEMENT

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Abstract

Rangelands are among the most extensive terrestrial biomes and provide a broad range of ecosystem services (ES) essential for human well-being and environmental sustainability. Although several ES classification frameworks have been developed over the past two decades, the Millennium Ecosystem Assessment (MEA) remains a key conceptual reference, identifying biodiversity as the ecological foundation supporting four ES categories: supporting, provisioning, regulating and cultural services. While many studies focus on individual indicators or specific services, a comprehensive understanding of ecosystem multifunctionality can be achieved by integrating multiple indicators across ES categories into bundles and synthetic indices. This keynote will illustrate how MEA-based ES assessments can support the co-design and co-management of rangelands worldwide. Case studies will be presented, covering methodological approaches and levels of system complexity, from local-scale assessments to integrated evaluations of ES provision under alternative management strategies, climate change scenarios and land-cover configurations. The keynote will highlight how ES assessments can move beyond ecological evaluation to become decision-support tools, fostering participatory approaches and adaptive management of rangelands under rapid global change.

Keywords: *Multifunctionality, Millennium Ecosystem Assessment, Ecosystem service bundles, transformative change, decision-support systems*

THE IMPACT OF INFLATION ON THE ECONOMIC SUSTAINABILITY OF STRAWBERRY PRODUCTION AND THE REAL INCOME OF PRODUCERS

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Abstract

Berry fruit production in Bosnia and Herzegovina has attracted considerable producer interest over the last two decades because of its perceived profitability and capacity to generate relatively high income on limited land. Raspberry, blueberry, and strawberry production was promoted as a promising farm enterprise, leading to an expansion of production areas in 2005–2015. However, later market developments, including unstable farm-gate prices, rising input costs and a reduction in the number of growers, raised concerns about real economic sustainability under inflationary pressure. The relevance of this issue is illustrated by strawberry prices, which increased from BAM 3.4/kg in 2015 to BAM 7.5/kg in 2024, with significant fluctuations over the period. At the same time, key input and labour costs increased: NPK fertilizer prices rose from BAM 0.80/kg to BAM 1.26/kg, while average monthly wages in agriculture increased from BAM 830 to BAM 1,512. Existing literature provides limited evidence on the simultaneous long-term dynamics of input prices, producer prices and profitability in berry production. This research aims to determine whether rising input costs in strawberry, raspberry and blueberry production were compensated by increases in producer prices, or whether producers' economic position deteriorated in 2015–2024. The analysis is based on existing technological enterprise budgets, assuming constant technology, and focuses on input prices, producer prices, production costs, economic efficiency, Farmer Terms of Trade, and real producer income. The expected results will identify the main sources of inflationary pressure and indicate which berry crop shows the greatest resilience to cost-price changes.

Keywords: *berry fruit production; input prices; producer prices; economic sustainability; Farmer Terms of Trade*

TURNING ROUTINE COMPLIANCE INTO VALUE: A QUALITY 5.0 MATURITY FRAMEWORK FOR FOOD SYSTEM TRANSFORMATION

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Abstract

Food systems are under increasing pressure to deliver safe, nutritious, and climate-friendly food while improving competitiveness and reducing environmental, water, energy, and carbon footprints. At the same time, regulatory requirements continue to expand, requiring extensive documentation and evidence of compliance. In response, many food companies react ad hoc, managing each regulation separately, which results in fragmented datasets that satisfy specific compliance obligations yet remain disconnected from strategic management and the creation of broader economic, environmental, and social value. The objectives of this study are (i) to reveal the opportunities that arise when fragmented datasets are used efficiently to support strategic commitments, and (ii) to develop a practical solution: a diagnostic quality system assessment framework. This easy-to-use framework will enable rapid evaluation of the readiness of agribusiness quality management systems to evolve into integrated Quality 5.0-based management platforms that support ESG implementation and evidence-based sustainability reporting. This pilot study identifies practical bottlenecks and combines expert insights with modern theoretical approaches into a flexible framework for assessing internal quality systems. It helps companies move beyond regulatory compliance toward a data-driven management style that creates value for customers, employees, suppliers, communities, investors, and the environment, while ensuring transparent disclosure of economic, environmental, social, and governance performance. The study results reveal that environmental and social performance and reporting are not merely a matter of reputation but an urgent priority, one that facilitates the business transition, boosts competitiveness, reduces environmental and social impacts, and actively contributes to Society 5.0.

Keywords: *Quality 5.0, Integrated management systems, Agribusiness, ESG, Diagnostic framework*

ECONOMIC EFFICIENCY OF OKRA PRODUCTION WITH PROTECTED GEOGRAPHICAL INDICATION IN BRČKO DISTRICT OF BOSNIA AND HERZEGOVINA

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Abstract

Okra (*Abelmoschus esculentus* L.) is a traditional vegetable crop in Brčko District of Bosnia and Herzegovina, where production is predominantly carried out on small family farms and characterized by a high share of manual labour. The production has particular importance due to the protection of the product under a Protected Geographical Indication, confirming its connection with the production area, traditional knowledge and specific production practices. Despite the importance of this product, its economic aspects on family farms in Bosnia and Herzegovina remain relatively under-researched. The aim of this study is to analyse the economic efficiency of okra production in Brčko District of Bosnia and Herzegovina, with particular emphasis on the level and structure of production costs, production value, financial result, economic efficiency and the importance of direct financial support. The research is based on administrative data on okra production in Brčko District for the period 2018–2025, while the data used for analytical production calculations and the determination of economic indicators were collected from selected producers for 2025. Analytical production calculations were developed for 14 family farms on a per-unit-area basis, including production yields, selling prices, variable costs, financial support and family labour input. Economic performance was assessed using financial result, production cost, economic efficiency and gross margin indicators. The research will enable the identification of key factors determining the economic performance of okra production and provide a basis for assessing its economic sustainability, as well as the importance of agricultural support measures for maintaining this traditional production in Brčko District of Bosnia and Herzegovina.

Keywords: *okra, economic efficiency, production costs, analytical calculation, agricultural support*

DETERMINANTS OF PURCHASE INTENTION FOR ORGANIC FOOD: AN EMPIRICAL STUDY ON A SAMPLE OF AGRICULTURAL STUDENTS IN SERBIA

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Abstract

The primary objective of this study was to examine the psychometric properties of the measurement instrument and to test the structural model of intention regarding the purchase and consumption of organic food among the student population. The study was conducted online during August 2026 via the Google Forms platform, utilizing a sample of $N = 485$ full-time students from agricultural faculties in Zemun and Novi Sad (57.53% female, mean age $M = 22.45$ years, $SD = 1.78$). Data were collected by distributing the survey link through student Facebook and Viber groups. Model reliability and validity were assessed using factor loadings, average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha, while direct effects were tested using path analysis within structural equation modeling. Psychometric analysis revealed excellent characteristics of the measurement model across six constructs, with all Cronbach's alpha (0.902–0.937) and CR (0.895–0.938) values substantially exceeding the 0.70 threshold, while AVE values (0.698–0.806) confirmed adequate convergent validity. Path analysis results demonstrated that all tested hypotheses for direct effects were statistically significant ($p < 0.001$). Awareness of consequences exerted the strongest direct effect on the attribution of responsibility ($\beta = 0.456$) and behavioral attitude ($\beta = 0.453$). Furthermore, subjective norms had a significant positive impact on personal norms ($\beta = 0.283$) and the final intention to purchase organic food ($\beta = 0.301$). The findings confirm that the applied instrument is highly reliable and valid for examining pro-environmental consumer behavior. The results suggest that agricultural students' intention to purchase organic food is strongly shaped by awareness of consequences, personal

responsibility, and social norms, which carries important implications for developing strategies in green marketing and education.

Keywords: *organic food, pro-environmental behavior, determinants of intention, theory of planned behavior, agricultural students, Serbia*

TRANSNATIONAL KNOWLEDGE TRANSFER AND BUSINESS SUPPORT IN THE FOREST-BASED GREEN ECONOMY THROUGH THE PANNON FUTURE FOREST PROJECT

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Abstract

Peripheral rural regions possess valuable natural resources but often lack entrepreneurial support systems capable of converting them into sustainable local value. The Pannon Future Forest project addresses this challenge in two predominantly rural border areas: the Hungarian–Slovenian border and the central Croatian–Hungarian border. It focuses on three fields of the forest-based green economy: forest-based bioeconomy, climate-tech solutions, and innovation in sustainable forest and land management.

This paper presents the project's transnational knowledge-transfer and stakeholder-engagement framework. The approach combines a European benchmark of business practices and support initiatives, engagement of business support organisations as "catalysers", capacity-building and co-valorisation workshops, mapping of prospective business actors, roadshow events, and assessment of entrepreneurs' support needs. The staged process examines natural resources within their socio-economic context and translates identified potential into valorisation scenarios and strategic actions.

Implementation has produced a published Benchmark Study, a multilingual practice-oriented brochure and a completed three-workshop knowledge-building series, while the transnational

Mentor Network is being formed. By the time of presentation, the Transnational Valorisation Strategy will also be completed, consolidating regional resource assessments, valorisation scenarios and strategic actions. By linking knowledge building with entrepreneurial discovery, the framework enables new ideas to develop together with the institutions expected to support them. It aims to strengthen rural innovation capacity, support smart specialisation and facilitate sustainable business initiatives without compromising natural values. Its methodology is transferable to other peripheral regions seeking to connect bioeconomy resources, advisory structures and entrepreneurship.

Keywords: *forest-based bioeconomy, knowledge transfer, business support organisations, rural development, smart specialisation*

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CLOSING THE KNOWLEDGE-TO-PRACTICE LOOP: THE GAMBIA-EU COMMUNITY OF PRACTICE FOR CLIMATE-SMART AGRI-FOOD SYSTEMS

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Abstract

Climate-smart agriculture (CSA) requires both technical knowledge and regular cooperation among vocational education, extension services, producers, agribusinesses and public institutions. AGREEN GAMBIA (Project 101242911) foresees the establishment of The Gambia-EU Community of Practice as a mechanism for such cooperation. This professional paper outlines a practical model for this planned activity, based on the project design and the training and extension needs documented in The Gambia Livestock Master Plan. The proposed model groups stakeholders at three levels: public authorities and policy actors at macro level; technical and vocational education and training (TVET) providers, trainers, extension services and agribusinesses at meso level; and farmers, rural women, youth and entrepreneurs at micro level. Within this structure, the Community of Practice would have four main functions: jointly identifying priority skills; translating them into relevant training content; supporting trainers in the use of practical and accessible teaching methods; and enabling farmers' experiences to inform further training and policy discussion. Cooperation could combine stakeholder meetings, field demonstrations, peer exchange and low-bandwidth online communication. Because the Community of Practice is a planned project activity, the paper presents a design proposal rather than implementation results. The model provides a clear basis for organising participation, knowledge exchange and feedback while supporting the future implementation of climate-smart agricultural training in The Gambia.

Keywords: *climate-smart agriculture, TVET, Community of Practice, knowledge transfer, advisory services*

NEW RURALIZATION MIGHT EASE THE BURDEN OF URBAN WASTE THROUGH DECREASE IN ITS GENERATION

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Abstract

Urban waste production in Croatia has been dramatically increased during the last three to four decades, mainly due to urbanization and shift from more or less self-sufficient rural and suburb households to households almost entirely supplied from shopping centers. Previously homestead produced fresh and stored foods, and glass-bottled beverages, are nowadays almost entirely packed, mainly into plastics (much less into glass and metal ambalage) before consumption, thus generating enormous waste. The consequental excessive burden of urban waste led to attempt of partial recycling in Croatia. Currently, before its collection, household waste in Croatia is mainly separated into paper, organic kitchen garbage, metal, glass, plastic and rest of non-sorted (mixed) waste. Most of sorted waste is easy to reuse, but plastic waste appears to be economically and environmentally too expensive to recycle, and sometimes ends in accidental wildfires. Burning it for energy production is not feasible in Croatia since we have no adequate burning facilities yet. Plastics seem to be the greatest problem, not only for its disposal or reuse, but also due to environment pollution from production of plastic ambalage as well. In such circumstances, the idea of new ruralization might offer sustainable solution to growing urban waste problem since rural population produces less waste than urban dwellers, and waste from rural households is easier to reuse than urban waste. New ruralization would bring other benefits like inhabitation of abandoned villages, ecological cultivation of countryside, recovery of biodiversity, relief of housing shortage in cities and relief of sofisticated supply chains in cities.

Keywords: *urbanization, ruralization, pollution, cities, countryside*

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ECONOMIC IMPLICATIONS OF KETOSIS OCCURRENCE ACROSS PARITIES IN HOLSTEIN DAIRY COWS

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Abstract

Early prevention of metabolic disorders is essential for maintaining dairy cows healthy and productive and for reducing economic losses in milk production. The occurrence of metabolic disorders, especially ketosis may result in reduced milk yield and consequently affect farm income. This study aimed to assess the occurrence and persistence of ketosis in Holstein dairy cows according to parity and to quantify associated losses in milk production and economic value. The analysis was based on more than 4 million test-day records collected within the national milk recording system in Croatia. The occurrence and persistence of ketosis were evaluated across parity groups, and its association with milk production was determined. Based on the estimated reduction in milk yield, production losses were quantified and expressed in euros. The analysis provided insight into parity-related differences in the occurrence and persistence of ketosis and their consequences for milk production and economic efficiency. The obtained results may support the identification of parity groups at greater risk of ketosis and contribute to targeted approaches for early assessment and prevention of metabolic disorders in Holstein dairy herds.

Keywords: *Ketosis, Holstein cows, parity, production losses, economic implications*

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BIBLIOMETRIC PENETRATION CURVES AND GROWTH FORECASTS TO 2035 FOR UNMANNED AERIAL VEHICLES IN SEVEN AGRICULTURAL SUB-DOMAINS

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Abstract

Unmanned aerial vehicles (UAVs) entered agriculture as a single technology, but they are adopted at very different speeds in different agricultural applications. This paper measures that difference. Annual counts of peer-reviewed articles combining UAV terms with the vocabulary of seven agricultural sub-domains (crop monitoring and phenotyping, spraying and application, weed detection, irrigation and water stress, disease and pest detection, yield prediction, livestock) were retrieved from the open bibliographic index OpenAlex for 2005–2025, each with a documented noise filter and with its own host literature as denominator, so that UAV penetration of every subdomain can be expressed in articles per 1,000. Four growth models (exponential, logistic, Gompertz, Bass) were fitted by Poisson deviance in a toolbox-free MATLAB pipeline, compared with a quasi-likelihood information criterion, backtested and bootstrapped (1,000 replicates) for 90 percent forecast intervals to 2035. UAV penetration in 2025 ranged twenty-fold, from 5.4 per 1,000 in livestock to 100.6 per 1,000 in crop monitoring. Three sub-domains have an identifiable saturation level: crop monitoring has reached it (logistic plateau 99.5 per 1,000), spraying stands at 76 percent and livestock at 67 percent of theirs. In weed detection, irrigation, disease and pest detection and yield prediction no plateau can yet be identified and penetration still grows by 25–28 percent per year. Output forecasts agree to 2028 and diverge afterwards; the sub-domain ranking, not the absolute numbers, is the robust result. Implications for research planning, advisory services and the circular bioeconomy agenda are discussed.

Keywords: *unmanned aerial vehicles, precision agriculture, bibliometrics, technology diffusion, growth models*

INTEGRATING RESOURCE EFFICIENCY, RURAL POLICY AND FARM PRODUCTIVITY IN CIRCULAR AGRI-FOOD SYSTEMS OF SOUTHEAST EUROPE

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Abstract

Circular agri-food systems are increasingly considered a development model that links more efficient resource use, the economic sustainability of farms and the resilience of rural areas. In Southeast Europe this transition is particularly important because of high input costs, a fragmented production structure, limited investment capacity and the need to integrate local producers more strongly into sustainable value chains. This paper provides a review-based, conceptual and policy-oriented analysis of circular agri-food systems, focusing on the economic valorisation of resources, farm productivity and the institutional preconditions of rural development. Particular attention is given to water, energy, soil, fertilisers, by-products and biowaste as resources whose more efficient use can reduce production costs, increase added value and open new opportunities for local entrepreneurship. The role of digital tools, traceability, advisory services and short supply chains in managing production, market information and relationships along the value chain is also examined. The analysis is placed within the framework of the European Green Deal, the Farm to Fork Strategy and the Common Agricultural Policy, with reference to regional differences in administrative, financial and organisational capacities. Methodologically, the paper relies on a literature review, comparative regional analysis and an illustrative case-study approach, without original empirical measurement. The proposed conceptual model links resource efficiency, policy support, economic sustainability and innovation with farm productivity, competitiveness and rural resilience. The expected contribution is an interdisciplinary but primarily economically oriented framework for understanding circularity as a feasible instrument of rural policy, business decision-making and sustainable development of the agri-food sector.

Keywords: *circular agri-food systems, resource efficiency, rural policy, farm productivity, Southeast Europe*

FIG-BASED ENERGY BARS AS A SUSTAINABLE VALUE-ADDED PRODUCT: CONSUMER PREFERENCES, PRODUCTION POTENTIAL AND REGIONAL DEVELOPMENT PERSPECTIVE

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Abstract

Fig (*Ficus carica* L.) represents a nutritionally valuable raw material with significant potential for application in the development of functional food products. Within contemporary dietary trends, energy bars are increasingly recognised as a practical and nutritionally balanced snack suitable for fast-paced lifestyles. Figs are characterised by a high content of dietary fibre, natural sugars, vitamins, and minerals, making them a suitable base ingredient for energy bars. The aim of this study was to analyse consumer preferences regarding energy bars, with particular emphasis on fig-based products, and to present the aspects of their production process and nutritional characteristics. The empirical research was conducted using a questionnaire survey on a sample of 100 respondents. The collected data were analysed using descriptive statistical methods. The results indicate that respondents consume energy bars occasionally and generally perceive them as a healthy snack; however, regular consumption remains relatively low. Taste was identified as the primary determinant of product choice, while price and information about product composition also significantly influence consumer preferences. Despite their favourable nutritional profile and functional potential, fig-based energy bars are less preferred than conventional flavours available on the market. The development of fig-based energy bars may support sustainable food systems by promoting local raw materials and value-added food production. In conclusion, fig-based energy bars are a promising alternative to conventional snacks, although further product development and consumer awareness are needed to improve market acceptance.

Keywords: *fig* (*Ficus carica* L.)*, energy bar production, consumer preferences, functional food, local food systems*

LAND CONSOLIDATION AND SOCIOECONOMIC CHANGE: EVIDENCE FROM EGRI – NORTH MACEDONIA

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Abstract

Land fragmentation remains a major constraint to agricultural efficiency and competitiveness in North Macedonia. This paper examines the socioeconomic effects of the land consolidation project in Egri village (Bitola Municipality), the first fully completed land consolidation project under the national framework, supported by the Food and Agriculture Organization (FAO).

This assessment applies a mixed-methods approach combining survey research, four in-depth interviews with farmers and two focus group discussions with non-resident landowners. The findings indicate improvements in land accessibility, irrigation, operational efficiency, machinery use and production costs, alongside reduced land-related conflicts and stronger incentives for investment. However, benefits in productivity and access to markets are uneven, with larger farms better positioned to capitalize on improved land structures, while smaller farms continue to face economic and market constraints. The project also increased the visibility and participation of women and young farmers, although generational renewal remains uncertain. The Egri case demonstrates that land consolidation can contribute to rural development beyond physical land reorganisation. However, it cannot alone address structural challenges related to farm profitability, market access, climate risks and generational renewal. Complementary advisory services, targeted financial support, stronger market linkages and climate-smart agricultural measures are therefore needed to translate improved land structures into sustainable rural development.

Keywords: *land consolidation, rural development, fragmentation, livelihoods, generational renewal*

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