Use of by-products for the production of pullulan for postharvest management of strawberries

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Plastic-based materials have been widely used for fruit packaging, but their production results in the emission of substances harmful to the environment and human health. Pullulan, a polysaccharide produced by *Aureobasidium pullulans*, could therefore represent a sustainable alternative for use as a fruit coating to limit the development of postharvest fungal diseases. *A. pullulans* AP1 strain was tested for its ability to produce polysaccharides using different culture substrates: EPS (esopolysaccharide medium) and three different media based on by-products of mushroom basal bodies, molasses and grape skins. After ten days of fermentation, different results regarding pullulan production were observed. Of the by-product substrates, molasses produced the best results for pullulan production. The polysaccharide obtained was tested on strawberries cv 'Agnese' as coating. Before and after storage, the following quality parameters were evaluated: hardness, pH, soluble solids and weight. The potential of the coating as an antifungal treatment was also evaluated against *Botrytis cinerea*. The treatment showed promising results in terms of fruit quality and protection. This study demonstrates that developing a biopolymer such as pullulan with an optimal chemical composition and optimising costs could be a significant step forward in the management of food and fruit after harvest.

Keywords: Postharvest – Fruit Quality – *Botrytis cinerea* – Polysaccharide - Molasses

Quiescence in Postharvest Pathogens

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Fruits and vegetables are highly perishable commodities, and improper handling during harvesting, transportation, or storage can result in significant postharvest losses and waste. The Food and Agriculture Organization (FAO) of the United Nations estimates that about one-third of global food production—roughly 1.3 billion metric tons—is lost or wasted each year (Sagar et al., 2018). In the case of horticultural products, losses can reach up to 60%, occurring at various stages of the supply chain, from harvest to household consumption (Prusky & Romanazzi, 2023). Postharvest fungal infections may be initiated before, during, or after harvest, but often remain dormant in a quiescent stage until fruit ripening and senescence (Prusky, 1996; Prusky et al., 2013). This is different from fungal pathogens that show a complete full cycle in living tissue e.g. Ustilago (Yu et al., 2023) which are not studied here. Disease prevention is typically achieved through a combination of fungicide treatments and optimized storage conditions (Adaskaveg et al., 2023). Symptoms usually become visible only after prolonged cold storage or during shelf life, just before consumption. Notably, while most freshly harvested fruits and vegetables harbor quiescent infections, the mechanisms governing fungal quiescence and host resistance in unripe fruits remain poorly understood (Adaskaveg et al., 2000; Prusky et al., 2013). Although recent advances have introduced stable and robust sensing materials with high sensitivity for detecting fruit infections by pathogens, no practical applications have been implemented to date (Archana et al., 2024). This knowledge gap underscores the importance of investigating the factors that regulate quiescence and its activation, as such insights could inform the development of novel disease management strategies aimed at reducing reliance on postharvest fungicides while preserving fruit quality over time (Guan et al., 2018).

Identification, detection and management of seedborne squash pathogens

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Squash is one of the most important vegetable crops, and it can be affected by several fungal pathogens. Samples of asymptomatic and symptomatic squash fruits were collected from Tunisia and Italy. Following blotter test, seedborne fungi were identified in seeds extracted from these fruit samples. The most frequent fungi in Tunisia seed samples were *Alternaria alternata*, and *Stagonosporopsis cucurbitacearum*. For the fruits from Italy, the most frequently identified fungal species in seed samples were *A. alternata*, and *Stemphylium vesicarium*. Seedborne fungi were identified in all fruit samples tested, including asymptomatic fruit. Considering that *S. cucurbitacearum* can cause medium-high economic losses in the field, even with low seed infection, our research focused on setting up a rapid and sensitive protocol, based droplet digital polymerase chain reaction (ddPCR). Blotter and ddPCR tests showed a high degree of correlation ($R^2 = 0.986$, $p \leq 0.01$). Our ddPCR protocol provided rapid detection and absolute quantification of *S. cucurbitacearum*, offering a useful support to the standard procedure. To control these fungi, antifungal activity of seven essential oils was studied by tests performed *in vitro* and *in vivo* conditions. Both assays showed that *Cymbopogon citratus* essential oil was the most effective to reduce seedborne fungi and to control transmission of *S. cucurbitacearum* from seeds to plantlets.

Keywords: *Cucurbita* spp., fungal pathogens, pathogen detection, techniques

Sustainable technologies for reducing postharvest fruit losses and improving quality

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Reducing postharvest losses and maintaining fruit quality are critical for sustainable fruit production and supply. Our research focuses on integrating innovative technologies and preharvest strategies to minimize losses and enhance fruit quality in key crops such as kiwifruit, peaches and sweet cherry. In kiwifruit, accurate prediction of optimal harvest time is essential to reduce postharvest losses, while preharvest factors, including effective pollination and targeted hormone treatments, significantly influence fruit storability, particulaky fruit softening. We evaluated the use of ozone (O_3) application in kiwifruit, demonstrating its potential to delay ripening and reduce decay during storage. In peaches, ultraviolet-C (UV-C) irradiation was applied to improve postharvest quality by enhancing antioxidant activity and delaying senescence. Additionally, we explored the use of priming agents, such as melatonin and nitric oxide, which effectively reduced postharvest losses and promoted the accumulation of health-beneficial compounds in stored cherries fruit. Overall, our findings highlight the importance of combining precise preharvest management with sustainable 'green' postharvest technologies to enhance fruit quality, extend shelf life, and reduce food loss, contributing to more sustainable horticultural production systems.

Keywords: Fruit quality, postharvest losses, priming agents, sustainable technologies.

Inhibitory effect of soluble metabolites of *Trichoderma afroharzianum* on the mycelial growth of postharvest pathogens

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FAO estimates that 14% of global crop production is lost due to plant diseases, 42% of which are caused by molds, resulting in significant economic losses. Pesticides remain one of the most effective tools for controlling post-harvest diseases of fruits and vegetables. One of the main objectives of the European Green Deal is to reduce pesticide use by 50% by 2050. Ideal solutions could include the development of biological control agents from different biocontrol agents. Effective antagonistic capabilities of *Trichoderma spp.* include mycoparasitism, production of extracellular lytic enzymes, and production of secondary metabolites, including volatile and non-volatile substances.
In our experiment, we tested non-volatile secondary metabolites of *Trichoderma afroharzianum* strain *in vitro* against several postharvest pathogens (*Colletotrichum godetiae, Botrytis cinerea, Fusarium oxysporum, Alternaria solani*). We applied the filtrate at a concentration of 30% to the PDA agar, and then measured the colony diameter of the cultures to determine the inhibitory effect of the soluble metabolites of *T. afroharzianum*.
In our results, with the exception of *Colletotrichum godetiae*, the filtrate of *Trichoderma afroharzianum* inhibited the development of mold colonies to varying degrees at a concentration of 30%.

Keywords: *Trichoderma afroharzianum*, Postharvest pathogen, secondary metabolites, *in vitro*

Control efficacy of a new SIGS-based biofungicide against *Penicillium digitatum* on citrus fruits.

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Penicillium digitatum (Pd) is one of the most important post-harvest pathogens affecting citrus worldwide. This study aimed to develop a new biofungicide based on Spray-Induced Gene Silencing (SIGS) to control *Pd* infections in oranges. The approach involved exogenous application of double-stranded RNA (dsRNA) designed to silence key fungal genes related to RNA silencing mechanisms (*Pd_ds1, Pd_ds2, Pd_ds3, Pd_ds4*) and pathogen development (*Pd_ds5*). To evaluate their effectiveness, dsRNAs were applied to wound sites on orange fruits prior to artificial inoculation with Pd. Disease severity and incidence were assessed seven days after infection. Among the tested dsRNAs, those targeting *Pd_ds1, Pd_ds2*, and *Pd_ds3* significantly reduced disease severity and incidence compared with the control ($p < 0.05$). Gene silencing of *Pd_ds1, Pd_ds2, and Pd_ds3* inhibited disease development by 84.2%, 89.8%, and 84.2%, respectively. These results demonstrate that SIGS can effectively suppress *Pd* infection when applied preventively. The study highlights the potential of SIGS technology as an environmentally friendly strategy for developing biofungicides and offers a promising new approach for managing post-harvest citrus diseases.

This research titled "Innovative Solutions for Sustainable and Environmentally Friendly Crop Protection of Greece's Horticultural Crops in the Europe of the Future" (TAEDR-0535675), was implemented within the framework of the National Recovery and Resilience Plan "Greece 2.0", with funding from the European Union – NextGenerationEU.

Keywords: RNAi, Green Mold, Postharvest, Disease Management

Management of Postharvest Decay of Fresh Citrus Fruits without Using Conventional Chemical Fungicides

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Postharvest decay caused by fungal infections is among the most important causes of economic losses for the fresh citrus fruit sector worldwide. Major diseases are green and blue molds, caused by *Penicillium digitatum* and *Penicillium italicum*, respectively, which are currently controlled by postharvest conventional chemical fungicides such as imazalil, orthophenylphenol, pyrimethanil, etc., and sour rot, caused by *Geotrichum citri-aurantii*, with no effective fungicides available in the EU. The continuous use by the industry for many years of these agrochemicals has arisen important health and environmental problems, and the development of novel safe and sustainable alternatives is increasingly needed. According to their nature, alternative postharvest antifungal treatments can be physical, low-toxicity chemical, and biological. Hot water, ozone, food preservatives or GRAS salts, essential oils and other natural extracts, antagonistic microorganisms as biocontrol agents, and edible coatings formulated with antifungal agents that could replace the conventional fungicide-amended waxes applied in packinglines, are among the most studied alternatives. However, due to the inherent limitations of these alternative methods, their use should be part of the so-called nonpolluting integrated disease management (NPIDM) programs, a broader control strategy based on considering appropriate nonpolluting actions before, during, and after harvest to minimize decay impact.

Keywords: 3-5 keywords

Broad-Range Trichoderma-Based Biocontrol to Reduce Preharvest Fruit Loss Caused by Walnut Fruit Rot Pathogens

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Walnut fruit rot represents a significant source of preharvest food loss, driven by a complex pathogen spectrum affecting the hull, shell, and kernel. Across our recent studies, multiple fungal species have been identified as major causal agents, including *Botrytis cinerea sensu lato*, *Diaporthe eres*, and *Botryosphaeria dothidea*, all capable of infecting immature fruits and initiating kernel decay. These pathogens pose increasing risks under production conditions that favor prolonged moisture retention and asymptomatic early-season infections. Our work has systematically assessed broad-range *Trichoderma* strains as biological control agents, demonstrating strong in vitro antagonism, with several isolates achieving 76–100% inhibition against *B. cinerea* and substantial suppressive effects against other fruit-rotting taxa. The results indicate that *Trichoderma*-based protection can disrupt pathogen establishment at multiple infection courts, including bud, shoot and hull tissues, thereby reducing the inoculum load and mitigating subsequent fruit loss. Integrating these biocontrol agents with cultural measures that limit humidity and remove latent infection sources provides a viable strategy to reduce waste at the production stage. Overall, the findings highlight that broad-spectrum *Trichoderma* formulations represent an effective and sustainable tool for minimizing preharvest walnut losses, supporting global efforts to reduce food waste along the horticultural supply chain.

Keywords: Trichoderma biocontrol, Walnut fruit rot, Preharvest fruit loss

Physico-Chemical Characterization and Antifungal Activity of Tunisian Marine Macroalgae Against *Botrytis cinerea*

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The use of marine macroalgae in agriculture has gained increasing attention due to their richness in bioactive compounds and their potential as natural alternatives to chemical pesticides. Macroalgae have demonstrated effectiveness as biofertilizers, bio stimulants, and biological disease-control agents. In this study, four marine algal species collected from the Tunisian coastline *Ulva* sp.(Sfax), *Cladophora* sp.(Mahdia), *Hypnea muciformis* (Sfax) and *Hypnea muciformis* (Mahdia), were evaluated for their physico-chemical characterization (moisture, ash, lipid, fatty acids cotent, protein, pigment composition) and some functional proprieties, , (swelling capacity, water solubility index , water holding capacity , and oil holding capacity).Cold and hot macroalgae extracts were prepared and assessed *in vitro* using two complementary methods: direct contact essays on solid media and volatile-mediated inhibition assays to evaluate their anti-fungal activity against *Botrytis cinerea*. The physicochemical characterization of macroalgae revealed variability in parameters such as powder color, water activity, dry matter content, ash, proteins, fatty acids, and mineral composition. Analysis of their functional properties indicated that all the studied parameters were temperature dependent. The *in vitro* antifungal assays revealed that cold extracts exhibited stronger inhibitory effects in the direct contact method compared with hot extracts. Furthermore, volatile organic compound (VOC) assays performed with the cold extracts confirmed the presence of volatile metabolites in the algae, although detectable antifungal interactions occurred only at high concentrations. The physico-chemical composition and functional properties highlight the richness of macroalgae in bioactive compounds and a potential antifungal effect for sustainable biocontrol applications.

Keywords: Macroalgae, Physicochemical proprieties, Antifungal activity, *Botrytis cinerea*

Quantifying Food Loss and Waste in Turkey: A Critical Step Towards Achieving Climate Targets

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Achieving Turkey's ambitious net zero climate targets necessitates a sharp focus on mitigating methane emissions from the waste sector, where preventing food loss and waste is a critical priority. However, developing effective mitigation strategies is currently hampered by the absence of a comprehensive, nationwide study. Existing data is fragmented, with the primary official source-Turkish Statistical Institute (TÜİK) household waste statistics-providing an incomplete picture that overlooks significant losses across the supply chain. This study aims to fill this critical data gap by conducting the first systematic quantification of food loss and waste across the entire Turkish food system. By establishing this baseline, the study will identify the key "hotspots" of food loss and waste within the Turkish context. These evidence-based recommendations are designed to inform national policy, optimize resource use, and significantly curb methane emissions from decomposing organic waste. We firmly believe that the findings of this research will provide the indispensable data foundation required to integrate food loss and waste reduction as a central, actionable component of Turkey's net zero climate-neutral roadmap, turning a pressing environmental challenge into a tangible opportunity for sustainable development.

Keywords: Net zero, Climate change, Food waste, Food loss

FoodWaStop Guidelines for valorisation of fruit, vegetable, cereal and animal product processing side-streams - an update

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Within the framework of the FoodWaStop COST action, we have undertaken to develop a practical guideline that can be used as a starting point for developing a valorization strategy for various stakeholders. Key pillars of the strategy are as follows: treat by-products as food-grade products from the point of origin with hygiene and traceability; stabilise promptly and make resulting products visible and attractive to potential downstream users. It is foreseen that, facilities operating under formal food safety systems are best placed to capture side streams or by-products suitable for food/feed valorisation. Proposed strategy follows a multipurpose, hierarchical logic: recover multiple products from one feedstock and route each fraction to the highest feasible tier – food upcycling (top), feed, plant/soil applications, packaging/biomaterials, with energy recovery as the final step. Current policy misalignments can bias biomass toward energy; programmes should reward higher-tier routes and discouraging premature energy recovery. The guideline therefore promotes cascading biorefineries that preserve complexity where it adds value, prioritise food/feed uses. It is also noted that regulatory clarity is pivotal: primarily distinguishing waste from by-product/side stream to enable by-products/side-streams to retain and reuse in food chain and maintain traceability.

Keywords: side-stream, by-product, strategy, multipurpose valorisation

Interaction of polyphenols with a biomimetic membranes system

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Polyphenols exhibit a wide range of interactions with biological membranes, with some inducing membrane aggregation and others enhancing membrane fluctuations. In this study, we investigate how structural features of polyphenol extracts influence their effects on biomolecules and cells, with a specific focus on interactions with biomimetic lipid membrane assemblies containing cholesterol (DMPC/25% chol). Even minor variations in polyphenol structure significantly modulate membrane properties such as fluidity and fluctuation behavior. These effects were quantified using a synergistic combination of neutron reflectometry (NR) and small-angle neutron scattering (SANS). NR enabled sub-nanometer resolution characterization of solid-supported lipid bilayers, whereas SANS provided insights into polyphenol–liposome interactions and low-resolution structural changes in solution.

We examined polyphenol extracts obtained from the viticulture waste (1) vine canes of red (Pinot Noir), and white (Fetească albă) *Vitis* sp. varieties, and from the mushroom (2) *Boletus edulis*. Vine cane extracts were rich in shikimic, ellagic, gallic acids, catechin and quercetin, while *Boletus* extract contained high levels of flavonoids, with all extracts comprising diverse polyphenol classes. NR data reveal that *Boletus* extract does not significantly alter membrane structure or composition but interacts with membranes via hydrogen bonding, showing affinity for lipid headgroups. In contrast, Fetească albă and Pinot Noir extracts penetrate the bilayer interface, displacing lipids and, at higher concentrations, promoting multilayer formation. SANS measurements demonstrate that at a polyphenol-to-membrane ratio of 1:10, both Pinot Noir and Fetească albă extracts strongly interact with liposomes, inducing aggregation and phase separation. Such fundamental insights are highly relevant to applied sciences, informing food science on the stability and delivery of polyphenols in functional foods and guiding pharmacological design by predicting encapsulation efficiency, protective effects, and interactions within liposomal or nanoparticle carriers.

Keywords: Polyphenols, Membraines, Structure, drug delivey

Trials for Scaling Up Valuable Compound Recovery from Distillery Vinasse (Times New Roman 14 font; Bold, centered)

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This study presents the technical work required to transition the lab-scale valorization of distillery vinasse into an industrial process, bridging the gap commonly referred to as the "valley of death" in Technology Readiness Level (TRL) progression. Our study focused on defining industrially compatible thermal extraction conditions. We used a pressure-assisted system to test vinasse across different solids concentrations, temperatures, and durations. Crucially, the achieved high extraction yields eliminated the need for 121 °C processing. This key finding means the operating pressures remain below 1.5 bar, successfully circumventing EU pressure equipment regulations. This avoidance of high-pressure mandates significantly reduces machine costs, making the technology economically viable. Using RSM, we modeled the extraction yield of target high-value compounds, including proteins, fibers and different fractions of saccharides. A key contribution of this work is the characterization of vinasse's physical properties—specifically its viscosity, density, and specific heat—at various process conditions. These measurements provide the essential pre-engineering data needed for the design and sizing of industrial transport and heat exchange systems. The final outcome is a proposed, integrated plant configuration featuring a crossflow filter and an industrial cooker, providing a clear and scalable design for distilleries to adopt a sustainable biorefinery model.

Keywords: distillery vinasse, TRL, plant scale-up, valuable compounds, biorefinery

Green valorization of quince (*Cydonia oblonga*) waste using Natural Deep Eutectic Solvent by ultrasonic-assisted extraction

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This study evaluates the sustainable valorization of *Cydonia oblonga* processing waste utilizing natural deep eutectic solvents (NADES) combined with ultrasonic-assisted extraction (UAE). To assess the effectiveness of recovering polyphenolic compounds and antioxidant capacity, a choline chloride/glycerol (ChCl/Gly) system was developed and compared to traditional 75% ethanol extraction. Using ChCl/Gly NADES resulted in a considerably greater total phenolic content (TPC) of 897.93 mg GAE/dm³ compared to ethanol extraction (437.76 mg GAE/dm³). This indicates the NADES-UAE system's enhanced solvation and cell wall breaking capabilities. The DPPH and ABTS assays revealed a significant correlation ($R^2 > 0.95$) between antioxidant activity and TPC, indicating the NADES extract's capability for radical scavenging. The findings indicate the efficacy of green extraction technologies in converting quince waste into bioactive components for nutraceutical and functional food applications. This technique promotes circular bioeconomy initiatives by reducing solvent toxicity and energy consumption while increasing extraction yield and functional value.

Keywords: *Cydonia oblonga*; NADES; ultrasonic-assisted extraction; food waste valorization

Citrus by-product bioformulation (Bioact-LM) to control blue mold and brown rot in postharvest value chain

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This study reports the development and evaluation of Bioact-LM, a citrus by-product bioformulation, aiming at reducing postharvest losses caused by fungal and oomycete pathogens while valorising citrus by-products within a circular bioeconomy. Bioact- LM, obtained by fermenting lemon peel with Lactiplantibacillus plantarum strains N3B2 and M2B2, was assessed in vitro against a broad panel of postharvest pathogens from multiple genera, including Alternaria, Aspergillus, Cladosporium, Colletotrichum, Fusarium, Mucor, Penicillium, Plenodomus, Rhizopus, and several Phytophthora species. In vitro assays demonstrated antifungal and anti-oomycete activity through direct inhibition and via the release of volatile organic compounds (VOCs). Chemical analyses indicated that acids produced by lactic acid bacteria, including lactic, acetic, and salicylic acids, contributed to the activity. In vivo tests on apples and oranges reduced the severity of blue mold caused by Penicillium italicum and limited brown rot caused by several Phytophthora species, extending shelf-life. Overall, Bioact-LM effectively reduced postharvest losses and valorized citrus by-products within a circular bioeconomy framework, offering a sustainable and biodegradable alternative to synthetic fungicides.

Keywords: Blue mold; Phytophthora brown rot; Bioformulation; Lactiplantibacillus plantarum; Antifungal activity.

Turning Pomegranate By-Products into Sustainable Protein Sources

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Pomegranate, valued for its taste and nutritional benefits, has experienced growing production and consumption. However, its processing generates by-products such as peels and seeds that can cause environmental issues if not properly managed. This study investigated the use of pomegranate by-products for sustainable mycoprotein production using filamentous fungi (*Aspergillus oryzae*, *Rhizopus oligosporus*, and *Neurospora intermedia*). Both fresh and expired pomegranate juice supported fungal biomass growth (up to 0.024 g/mL), though fresh juice was more effective for protein production. Cultivation of *A. oryzae* on pomegranate peel yielded 0.39 g biomass/g peel and increased protein content from 30.89 to 85.41 g/kg. Supplementing the medium with yeast extract further boosted biomass yield (0.49 g/g peel) and protein content (198.63 g/kg). Overall, pomegranate peel shows strong potential as a substrate for fungal biomass production, contributing to sustainable food and feed development.

Keywords: Agro-Food waste, Waste management, fruit waste, sustainability

From waste to value: the use of black soldier fly larvae in agrofood waste management to produce protein and promote circular bioeconomy

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Food loss and waste management is a crucial challenge worldwide, especially in Morocco where significant losses occur along the food supply chain. Black soldier fly (*Hermetia illucens*, BSF) larvae provide a sustainable and green solution by converting organic loss and waste into valuable and exploitable biomass and frass biofertilizer. Our study assessed the effects of five diet formulations (D1–D5), including locally available by-products such as bread waste, maize, alfalfa, potato waste and livestock feed pellets, on BSF larval growth performance, feed conversion, survival, proximate composition and bioconversion efficiency. Our results highlighted that the diets with balanced protein–energy profiles, particularly D4 (consisting of poultry feed pellets, alfalfa and maize) and D1 (with bread waste, alfalfa and potato waste), reached the highest larval growth, feed conversion and bioconversion efficiency. D1 supported lipid-rich larvae with high gross energy, while D3 and D4 enhanced high crude protein and ash contents, suitable for animal feed. These findings revealed that diet optimization using locally available food waste promoted both the benefits of BSF larvae rearing in organic waste decrease and production of targeted larval biomass, supporting circular bioeconomy strategies for sustainable food systems.

Keywords: *Hermetia illucens*, By-products, nutritional composition, growth performance

Ultrasound-assisted extraction of oils from berry seeds: A sustainable approach to agrofood waste valorisation

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The recovery of valuable compounds from fruit processing by-products represents an important step toward sustainable resource utilization and the development of a circular bioeconomy. This study investigated the extraction of oils from chokeberry (*Aronia melanocarpa*) and blackcurrant (*Ribes nigrum*) seeds using ultrasound-assisted extraction (UAE) as an alternative to conventional solvent extraction and cold pressing. The influence of UAE on oil quality parameters was evaluated, including carotenoid and chlorophyll content, oxidative stability, total phenolic content (TPC), and antioxidant activity determined by DPPH and ABTS assays. Fatty acid composition was analyzed using gas chromatography (GC). The application of ultrasound significantly enhanced extraction efficiency while reducing time and solvent consumption. Oils obtained by UAE exhibited higher concentrations of carotenoids, chlorophyll and phenolic compounds, greater antioxidant capacity, and improved oxidative stability compared with those extracted conventionally. GC analysis confirmed that the oils were rich in polyunsaturated fatty acids, particularly linoleic acid. These effects are attributed to the cavitation phenomena generated by ultrasound, which promote better mass transfer and protect thermolabile bioactive components. Overall, the results demonstrate that UAE is an efficient and eco-friendly technology for obtaining high-quality oils from berry seed waste, supporting the sustainable valorisation of agro-food by-products.

Keywords: chokeberry seeds; blackcurrant seeds; oil; ultrasound-assisted extraction

Optimizing Fig Preservation and Valorising Pruning Biowaste: Drying Performance and Bioactivity of Ficus carica L. Extracts

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Figs (*Ficus carica L.*) are highly perishable, leading to significant postharvest losses. This study integrates two approaches to reducing waste and enhancing value: improving fig drying and exploring bioactive compounds from pruning residues.

Hybrid solar drying was compared with traditional sun drying using "Pingo de Mel" figs. Hybrid drying reduced processing time from 5–7 days to 3 days while achieving similar moisture, water activity, and texture. It produced figs with slightly darker colour and markedly improved microbial safety, remaining free of fungal contamination for at least four weeks. Hybrid-dried figs also retained higher contents of phenolic compounds, including rutin and 5-O-caffeoylquinic acid, and showed superior antioxidant activity.

Pruning biowaste was valorised through leaf extracts prepared with different solvents. The 70% ethanolic leaf extract showed the highest phenolic content, while the 96% ethanolic leaf extract had the strongest antioxidant activity; considering yield, the 70% ethanolic leaf extract was most promising. Bioassays against *Tuta absoluta* revealed insecticidal potential only for the 70% ethanolic fig-leaf extract (43% mortality at 72 h). Additional in vivo grape assays and in vitro antifungal tests showed no significant activity.

Hybrid drying and targeted extraction offer complementary pathways for reducing waste and generating value from fig production.

Keywords: Hybrid solar drying, Ficus carica L., Phenolic compounds, Biowaste valorisation, Insecticidal activity

Funding: This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministerio da Ciência, Tecnologia e Ensino Superior) for the CERNAS Research Centre (UIDP/00681/2020, doi: 10.54499/UIDP/00681/2020) and LAQV-REQUIMTE (project UIDP/50006). The authors are grateful for the financial support from project INOVFARMER.MED that is part of the PRIMA Programme, supported by the European Union, Grant Agreement No. 1733, FCT/PRIMA/0005/2021. Susana M. Cardoso thanks FCT/MCTES for funding through the Institutional Call to Scientific Employment Stimulus. This article/publication is also based upon work from COST Action FoodWaStop, CA22134, supported by COST (European Cooperation in Science and Technology).

Sustainable Alternative Food Resources for Future Food by Widening Innovation into New Composites with Improved Health-Promoting Properties

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In 2009, FAO predicted an increase of around 34% of the world population by 2050, associated with an increase of 70% in food production demand; however, only in the last 10 years, we experienced an increase of around 12.5% in the world population. Therefore, providing food security to all people, whereas assuring safety and nutritionally optimized foods is a big challenge. Important goals should be considered for the Agenda 2030, such as providing good health and well-being, responsible consumption and production, climate action, local economy and income generation, among others. Therefore, globalization, accelerated economic development, urbanization, modernization of agricultural and food-processing techniques are emerging aspects that led to profound changes in dietary patterns, raising important health and sustainability concerns. In order to overcome undernutrition and obesity, large-scale shifts towards healthier and more sustainable diets are necessary across socioeconomic, cultural, and geographical background. The main purpose of this paper is to present an overview of the national project, funded by The Executive Unit for Financing Higher Education, Research, Development and Innovation (UEFISCDI), project 9PCE/2025, entitled ***S**ustainable **A**lternative **F**ood resources for future food by widening **I**nnovation into new composites with improved health-promoting p**R**operties* (SAFIR). SAFIR aims to provide enough scientific results and knowledge to support innovation in Romania, thus contributing to the development of sustainable food systems. At scientific level, SAFIR exploits the synergy between plant secondary metabolites and postbiotics as strategic combination designed to improve human health. SAFIR statement is to provide reliable answers for economy, environmental and societal problems, focusing on the development of food you can trust, by eco-functional uses of underutilized resources, in order to improve bioactive recycling. SAFIR is a project engaged in designing easy to use and economically viable technologies, by using three key elements resulted from side streams (apple and grape pomace, whey and brewery spent grains) and the ability of probiotics to produce postbiotics. The project aims to produce different powders as alternative for synthetic additives, whereas two approaches will be used to reformulate food, by replacing meat and/or fat from meat products and wheat flour from bakery products.

Keywords: underutilized food resources, bioactive, postbiotics, microencapsulation, functional food

From waste to functional materials: Biopolymer materials synthesis in the framework of a circular economy

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We are witnessing a continuous accumulation of waste generated across various sectors, creating significant environmental and economic challenges. To address this growing problem, it is essential to reduce waste and implement the principles of the circular economy, which emphasize resource recovery, reuse, and value retention. In this context, converting waste into biopolymer materials represents a promising strategy for waste valorization through sustainable material development. Biopolymers can be produced from a wide range of renewable sources, including agricultural waste, food industry by-products, and other organic residues. Their inherent biodegradability and versatility make them suitable candidates for developing eco-friendly films capable of replacing conventional plastics. Among various sectors, the food industry generates one of the largest proportions of waste. Of particular importance are waste streams rich in biologically valuable components that can be converted into value-added products. Owing to their rich chemical composition, agro-wastes represent a promising source for biofilm synthesis, offering biomaterials with properties comparable to those of synthetic polymers. Additionally, when properly refined and evaluated for health safety, they can even be used as edible materials that nutritionally enhance the packaged product and preserve/prolong product's shelf life.

Keywords: waste valorization, biopolymers, edible films and coatings

Intelligent systems for food waste management

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Food waste remains a major challenge for sustainability, resource efficiency, and climate goals. This study proposes a cross-cutting strategy combining system dynamics modelling with smart bin technology to improve household and commercial food management. The approach models the entire food supply-consumption-waste system, capturing dynamic feedback loops between purchasing, storage, consumption patterns, and waste generation. Smart bins, equipped with sensors and AI-enabled monitoring, provide real-time data on food types, quantities, and expiry, enabling predictive analytics and behavioural nudges to reduce waste. By integrating these data into system dynamics simulations, stakeholders can test policy interventions, optimise food redistribution, and design targeted awareness campaigns. The framework demonstrates how digital sensing, modelling, and feedback systems can work synergistically to minimise waste, enhance circular economy practices, and promote sustainable consumption patterns across households, retail, and institutional food systems. This paper will present recent outcomes of international collaboration project between UK, Norway and China

Keywords: Smart waste bin, sensor systems, systems thinking, food waste analytics

Sustainable Food Awareness Network (S-FAN): Study design

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The Sustainable Food Awareness Network (S-FAN) is a 24-month project aimed at reducing food waste in Greece through education, community engagement, and innovative communication technologies. S-FAN develops an integrated set of interventions, including educational videos, a social media campaign, podcasts, infographics, community workshops, webinars, research kit for educators, AR/VR technology and a documentery film that illustrates the journey of food "from farm to plate" and emphasizes sustainable dietary patterns. These actions target diverse groups, general public, educators, students, health professionals, and apprentice chefs, providing practical skills in meal planning, food storage, and waste reduction. Collaboration with schools, libraries, and community centers enhances outreach and ensures long-term sustainability. In addition, food waste will be measured in 100 families in Athens and Peloponnese while assessing the nature of food waste and the degree of food processing. By generating scientific data, digital strategies, and fostering community-based change, S-FAN aspires to serve as a model for future food-waste prevention initiatives and to contribute to national and international sustainability goals.

The Project is running in the framework of the 6th Call for Action, "Science and Society" of the Hellenic Foundation for Research and Innovation (HFRI), under the title "Current Nutritional Awareness" (Number: 17205)

Keywords: food waste, educational videos, sustainable food education, technology

Sustainable Food Awareness Network (S-FAN): Study design

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Keywords: food waste, educational videos, sustainable food education, technology

Drivers of Consumer Food Waste in Urban Restaurants in Kosovo: A Behavioural Perspective Using the Theory of Planned Behaviour

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Abstract

Restaurant food waste is a pressing sustainability issue in urban environments, yet empirical evidence from Southeast Europe remains scarce. This study investigates consumer behaviour in Prishtina, Kosovo's capital, through a survey of 115 restaurant patrons. The analysis applies an extended behavioural framework to assess how individual agency, social context, and economic cues shape waste outcomes. Structural modelling was used to evaluate the relative influence of perceived behavioural control, attitudinal dispositions, and hedonic drivers. Results indicate that perceived behavioural control-diners' ability to manage portion sizes and food choices—was the strongest predictor of reduced plate waste. Attitudes and subjective norms exerted limited influence, while price sensitivity and taste expectations shaped intentions but did not consistently translate into behaviour, highlighting the persistence of the intention–action gap. Gender differences were modest, with women reporting slightly greater consistency in avoiding waste. By situating the analysis within Prishtina's dining culture, the study underscores the importance of flexible menu structures, consumer empowerment, and culturally tailored awareness campaigns. These findings provide a basis for targeted interventions in the capital's hospitality sector and contribute to broader debates on sustainable consumption in emerging urban contexts.

Keywords: Food Waste; Urban Dining – Prishtina; Perceived Behavioural Control; Sustainable Consumption

Food Loss and waste Prevention, Case of Albania

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Abstract

In recent years, international actors and countries have implemented efforts to address these issues through innovative and multidisciplinary approaches. This paper identifies innovations that have the potential to be implemented at the EU and global levels. The integration of digitalization elements such as artificial intelligence (AI), blockchain, and smart sensors for monitoring food supply chains are being adopted to identify food by-products and reduce environmental impact. Food loss and waste is a significant environmental, economic, and social challenges in Albania and good practices across the world.

New technological platforms and social innovation models are enabling the redistribution of food products. Education campaign in food loose and waste plays a critical role in changing consumer behavior and reducing waste at all levels of supply chain. International cooperation and digital platforms are essential to harmonize methodologies and promote best practices globally. These innovations collectively represent an innovative method toward more sustainable and efficient food systems.

Key Words: Innovation; Food loose/Waste; Circular Economy; Agriculture;

JEL Code: Q18, O33; L66

Valorization Mediterranean fruit waste: Environmental perspectives and circular bioeconomy opportunities

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The Mediterranean basin is one of the world's major producers of fruits such olives, grapes, citrus, and pomegranates, resulting in considerable agro-industrial waste. If these residues are not managed properly, they can cause environmental problems such as greenhouse gas emissions, leachate formation, and nutrient loss. This study explores the environmental aspects of Mediterranean fruit waste valorization, focusing on solutions for converting organic residues into useful bioproducts while minimizing environmental consequences. Composting, anaerobic digestion, biopolymer and biochar manufacturing, and bioactive chemical recovery for the food, cosmetic, and nutraceutical industries are all examples of valorization processes. Life cycle assessment (LCA) studies show that waste valorization has a much lower carbon footprint and resource utilization than traditional disposal. Furthermore, including valorization into regional bio-based enterprises promotes waste reduction, renewable resource exploitation, and sustainable development objectives. Promoting circular bioeconomy models across Mediterranean agri-food chains can change fruit waste management from an environmental burden to a resource-efficient and economically successful system.

Keywords: Fruits waste valorization, environmental impact, circular bioeconomy

Basic substances for grapevine protection against downy mildew and powdery mildew

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Grapevine downy and powdery mildews cause major yield and quality losses if not properly managed. Control strategies still relies on fungicide treatments, but many have been banned or restricted due to environmental concerns, leaving growers with a lack of effective tools. Basic substances are safe compounds already used in food or medicine, and can be approved for plant protection in only 1–2 years at a low cost (≈50 000 €). This two-year (2024-2025) field experiment explored the effectiveness of approved basic substances on grapevine and other low-impact compounds following stand-alone application along the whole season. Sodium bicarbonate, soy lecithin, sodium chloride, milk, whey, and sweet orange essential oil (EO) exhibited the best results against powdery mildew on bunches, at the same level of sulfur applications. Different EOs, chitosan, soy lecithin, and cerevisane showed promising reductions of downy mildew on bunches and can be useful to support copper treatments or toward their replacement. These findings promote basic substances as viable, sustainable tools for grapevine fungal disease management but further field investigation are required to set up optimized application strategies and scale up their adoption

Keywords: foodstuf, safety, sustainability, protection.

Strategies for Preventing Food Loss and Food Waste in Modern Food Systems

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Food loss and food waste have become critical global challenges, threatening food security, economic stability, and environmental sustainability. Preventing these losses requires a holistic approach that spans the entire food supply chain—from production and post-harvest handling to processing, distribution, retail, and household consumption. This study highlights the primary causes of food loss and waste, including inadequate storage technologies, inefficient supply chain management, aesthetic quality standards, and consumer behavior. It also examines prevention strategies such as improved agricultural practices, investments in cold-chain infrastructure, optimized logistics, digital monitoring systems, and educational programs that promote responsible consumption. Emphasis is placed on collaborative efforts among governments, private sector stakeholders, and consumers to create resilient and sustainable food systems. Reducing food loss and waste not only conserves resources and mitigates greenhouse gas emissions but also contributes significantly to achieving global food security and sustainability goals.

Keywords: Food loss, Food waste, Supply chain, Sustainable food systems, Post-harvest management

Use of biopolymeric nanocapsules containing eugenol in nectarine coatings for the control of *Monilinia fructicola*

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Biopolymer-based formulations have shown promise in controlling fruit pathogens, as they reduce environmental impact while helping to maintain product quality, thereby minimizing economic losses. Biopolymers are biodegradable, low-toxicity macromolecules derived from renewable natural sources, such as chitosan and carboxymethylcellulose, which can be combined to form nanocapsules (NCs) through ionic interactions, enabling controlled release of antimicrobial agents. This study evaluated the effects of eugenol NCs based on chitosan and carboxymethylcellulose in protecting nectarines against *Monilinia fructicola*, a pathogen responsible for brown rot, a disease of global relevance. NCs were prepared using the Layer-by-Layer method, starting from an anionic template and depositing up to two polymer layers. The average sizes observed were 158 nm for the nanoemulsion, 360 nm for chitosan NCs, and 398 nm for carboxymethylcellulose NCs. In addition to demonstrating good adherence to the fruit surface, the NCs exhibited gradual eugenol release following first-order kinetics. Among the formulations tested, eugenol NCs with chitosan were the most effective in controlling brown rot, increasing the likelihood of fruits remaining symptom-free for up to 7 days. These findings indicate that nanometric systems composed of biopolymers and antimicrobial agents represent a sustainable alternative for postharvest fruit preservation.

Keywords: Biodegradable coatings, antimicrobial delivery system, sustainable agriculture

Valorization of Wasted Artichoke Leaves for Herbal Beverage Production and *in vitro* Gastrointestinal Stability of Bioactive Components

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This study aimed to develop functional beverages free of added sugar by utilizing herbal tea extracts derived from industrially discarded artichoke leaves, and enriching them with natural sweeteners and super fruit juices, including aronia, blackcurrant, and pomegranate. For this purpose, dried artichoke leaves (1%) were infused in boiling water for 5 minutes and the resulting extract was used as the primary raw material. Ascorbic acid (0.3%) was incorporated into the formulations prepared with stevia or without added sugar. The mixtures were bottled in 200 mL glass containers and pasteurized at 98 °C for 15 minutes. A series of analyses were conducted on the beverages, including °Brix, pH, titratable acidity, total phenolic content (TPC) (expressed as mg gallic acid equivalent/100 g) and total antioxidant capacity (TAC) using DPPH, FRAP, and CUPRAC assays (as μmol trolox equivalent/g). Additionally, the variations in TPC and TAC during *in vitro* gastrointestinal digestion were monitored. Finally, the beverages underwent sensory evaluation to assess overall consumer acceptability.

Keywords: Bioactive compound stability, artichoke leaf, waste evaluation, *in vitro* gastrointestinal digestion.

Sustainable Fluorine-Free Hydrophobic Coatings to Minimize Food Residue

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Food loss and waste are major global challenges that contribute to resource depletion and environmental pollution. A significant portion of food waste originates from residues that remain adhered to packaging or processing surfaces. In this study, a fluorine-free hydrophobic polymeric thin film was developed and deposited onto various substrate materials using a plasma-enhanced chemical vapor deposition (PECVD) technique. The coating, based on poly(ethylhexyl acrylate) (PEHA), provides a smooth and water-repellent surface that minimizes the adhesion of moist and sticky food residues such as sauces and dairy products. Surface characterization via contact angle measurements confirmed the hydrophobic behavior, while visual and gravimetric analyses demonstrated a substantial reduction in food residue retention compared to uncoated surfaces. This fluorine-free approach offers an environmentally safer alternative to conventional fluoropolymer coatings, aligning with sustainability goals by reducing cleaning requirements and food losses. The proposed surface modification strategy can be applied to food packaging and processing equipment to enhance resource efficiency and support circular economy initiatives.

Keywords: PECVD, Coating, Fluorine-Free, Hydrophobic

Use of essential oils for the control of gray mold on strawberries

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Strawberries can undergo fungal spoilage, which is mainly caused by *Botrytis cinerea*, responsible for gray mold. Essential oils (EOs) seem to have potential in controlling this fungus and may help reduce postharvest decay. This study evaluated the effectiveness of twelve EOs in controlling postharvest gray mold in strawberries at different concentrations during 5 days of storage after vapor exposure. Exposure to volatiles from the EOs of *Origanum vulgare*, *Cinnamonum zeylanicum,* MIX*, Thymus vulgaris* and *Rosmarinus officinalis* were found to be effective at a dose of 22.73 µL/L while the EO of *Citrus bergamia* was effective at 34.09 µL/L, *Malaleuca alternifolia* at 45.45 µL/L and *Thymus serpyllum* at 11.36 µL/L. EOs from *Lavandula hybrida*, *Lavandula officinalis*, *Helichrysum italicum* and *Thymus capitatus* showed no effectiveness against gray mold. All EOs showed symptoms of phytotoxicity at the highest concentrations tested. The panel tasting revealed the perception of the EOs after 24 h later for strawberries exposed to vapors of *O. vulgare*, *T. vulgaris*, *C. zeylanicum*, *M. alternifolia* and *C. bergamia* compared with propylene glycol like control. The results showed that panelists perceived sufficient differences only in comparison between control and *M. alternifolia*. The results suggest that some of these EOs may offer an innovative method to control postharvest gray mold.

Keywords: *Botrytis cinerea*, Essential oil, Postharvest, Shelf life, Strawberry.

Sustainable Management of Vegetable Harvest Side-streams: Practices and Opportunities

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Abstract

This study aims to assess the management practices of vegetable harvest side streams and explore their potential for sustainable utilization. Conducted in July 2025, the research involved 14 farmers in the Municipality of Viti, Republic of Kosovo. The study analyzed various management practices applied by farmers and examined the potential environmental and economic benefits of alternative sustainable utilisation of vegetable side streams. Findings revealed diverse management approaches: approximately 43% of farmers left the side streams in the field, assuming natural composting would occur, while 36% utilized them as animal feed, contributing to livestock development. Around 14% buried the side streams of vegetables in the soil, and 7% resorted to burning them. Farmers have reported that the causes of vegetable loss are rotting from improper vegetable storage (43%), a lack of market (21%), damage during transportation (14%), low-quality products (14%), and rotten/damaged vegetables in the field (8%). The research underscores the importance of avoiding burning and promoting composting and other side streams management techniques as sustainable alternatives. In addition, this approach aligns with the principles of a green economy by facilitating the consistent treatment of side streams, ultimately benefiting both the local community and the environment.

Keywords: vegetables, side streams, sustainable utilisation

Text (200 words maximum)

Keywords: 3-5 keywords

Assessment of Food Waste in Gastronomy Businesses: A Case Study from the Prishtina Region, Kosovo

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Food waste and loss represent a growing challenge in the gastronomy sector, with negative impacts on the environment, the economy, and overall resource efficiency. In Kosovo, this issue has remained insufficiently explored, even though preliminary observations indicate that 2% to 20% of prepared food is discarded due to poor inventory management, inaccurate demand forecasting, oversized portions, and product expiration.

This study examined the current situation of food waste in 10 gastronomy businesses in the Prishtina region, collecting both quantitative and qualitative data on management practices and the factors contributing to waste generation. The findings showed that most waste occurred during food preparation, as well as from inefficient inventory control and the absence of internal standards for waste reduction.

Overall, the results highlight the need for more structured strategies and sustainable approaches to help gastronomy businesses in Kosovo reduce food waste and improve operational efficiency.

Keywords: Food waste, Gastronomy businesses, Waste management, Kosovo, Case study

Monitoring nitrogen levels in soil – a way to reduce food waste

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One way to prevent food waste is to grow food properly, including using the right fertilisers. One of the most important components of mineral fertilisers is nitrogen, which occurs in two forms: ammonium and nitrate which are best absorbed by plants. The right amount of nitrogen in the soil enables proper root system development and stimulates the uptake of other nutrients, such as phosphorus and potassium. However, excess nitrogen in the soil is not recommended, as it can adversely affect plants, causing excessive growth and weakening their resistance to disease. This leads to poor-quality crops and faster food spoilage. Testing the soil for mineral nitrogen content provides information about its fertility and allows for optimising fertilisation. This paper presents new solid contact potentiometric sensors for the determination of ammonium and nitrate(V) ions. An innovative electrode substrate in the form of a gold microelectrode array consisting of several hundred individual microelectrodes was used in the construction of the sensors. This solution allows for shorter and simpler sensor preparation while maintaining good performance and stability of readings. The developed sensors have been successfully used to determine the mineral nitrogen content in soils and groundwater.

Keywords: determination of mineral nitrogen, nitrate, ammonium, soil analysis, potentiometric sensor

Electrochemical methods as a helpful tool in managing post-harvest losses of fresh fruit

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Electrochemical methods are an effective tool for assessing fruit quality, offering objective and precise measurements of various parameters. Non-destructive electrochemical methods deserve special mention, as their advantages make them a useful tool in reducing losses during fruit harvesting by enabling the assessment of ripeness and early detection of fruit spoilage or disease. Example is a chemoresistive sensor developed to detect ethylene without damaging fruit. Among the chemical sensors used to determine ethylene release, a large group are gas sensors based, among other things, on metal oxide semiconductors, characterised by low cost, miniaturisation potential, high sensitivity, good long-term stability and selectivity. Currently, the most popular and fastest growing devices are electronic noses using arrays of several gas chemical sensors. In the case of fruits, an electronic nose consists of a system of chemical sensors that react to volatile organic compounds emitted by the fruit, and this data is then processed by algorithms (e.g. artificial neural networks) to create an 'olfactory fingerprint' of the sample. By comparing the odour pattern with benchmarks for different degrees of ripeness or quality, the device can help determine ripeness, freshness and even help identify mould or other factors affecting the quality of fruits.

Keywords: electrochemical sensors, electronic nose, ethylene, fruit quality

Use of Rice Straw an Agricultural Waste in Ruminant Feeding

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Roughage sources are absolutely necessary in ruminant nutrition. However, the need for roughage is increasing due to reasons such as the increasing number of animals in parallel with the food needs of the increasing world population and the inability to produce enough roughage due to climate change. Agricultural waste products can be a good source to fill this roughage gap. Paddy straw is an agricultural waste product, and while there are methods around the world to use it as bioenergy, these are insufficient. In some regions, it is either burned or not used at all. It is possible to use this product, which is difficult to digest, as an alternative roughage source for animal feeding by increasing its digestibility with various additives and fermentation processes such as silage. At the same time, the cost of roughage can be reduced by using paddy straw, which is currently an agricultural waste and has no economic value. In addition, by using paddy straw for animal feeding, air pollution caused by burning and the decomposition of the soil in the area where it is burned will be prevented.

Keywords: Digestibility, Fermentation, Paddy Straw, Roughage

Preparation and Characterization of Antioxidant Peptides from Agricultural Organic Waste Carrot Tissues

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Carrot (*Daucus carota* L.) is an important tuber vegetable crop that has valuable components in terms of nutrition and health. Bioactive peptides are specific protein fragments that have various benefits on body functions with potential significant health effects for several different purposes. Protein hydrolysates are defined as mixtures of polypeptides, oligopeptides and amino acids obtained from protein sources by partial or intensive hydrolysis. Biopeptides are considered to have advantages over conventional molecular drugs, thanks to having features such as broad-spectrum therapeutic effect, low toxicity level and structural diversity. In this study, antioxidant activities of peptides obtained from carrot tissues by enzymatic hydrolysis were determined. Carrot vegetables which were not considered to be put on market after harvest were used, with the aim of waste utilization. Antioxidant activities of protein hydrolysates, produced using Flavourzyme 500 L enzyme, were determined through three different *in vitro* antioxidant experiments, namely ABTS, FRAP and ORAC, with values that were found to vary between 3.34-42.06 µM TE g^{-1} protein, respectively. Carrot hydrolysates obtained by enzymatic hydrolysis were found to have considerable antioxidant activity, therefore concluded to be used as a potential source of bioactive peptide, as well as contributing to recycling of agricultural organic waste.

Keywords: Carrot, protein hydrolysate, peptide, antioxidant, agricultural waste

PRESENT STATE AND FUTURE OF MANAGEMENT OF BIODEGRADABLE WASTE IN NORTH MACEDONIA - APPROACHING TO EU REGULATIVES

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Abstract

The management of biodegradable waste in North Macedonia is currently facing significant challenges. Although biodegradable waste, including food scraps and garden waste, constitutes a large portion of municipal waste, the infrastructure for separate collection and processing remains underdeveloped. Most organic waste is still disposed of in landfills, contributing to environmental issues like methane emissions. There is limited public awareness and participation in waste segregation, and waste management systems in many municipalities are outdated.

However, North Macedonia is committed to aligning with EU regulations, particularly the **EU Waste Framework Directive**. The country is working towards meeting EU recycling targets, including the **separate collection of biodegradable waste** and diversion from landfills. To comply, North Macedonia must invest in modern waste infrastructure, including composting facilities and recycling plants. Public education campaigns and stronger regulatory enforcement will be essential to boost participation and improve compliance.

In the future, North Macedonia's approach will likely involve expanding composting initiatives, adopting circular economy practices, and seeking EU funding for green projects. By following EU waste management policies, North Macedonia aims to create a more sustainable waste system, reduce environmental impact, and increase recycling rates in line with EU standards.

Keywords: biodegradable waste, North Macedonia, EU regulatives

NETTLE BIOMASS AS A SUSTAINABLE BIOFERTILIZER: ENHANCING SOIL HEALTH AND SUPPORTING CIRCULAR AGRICULTURE

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ABSTRACT

The growing global population continues to pressure food systems, threatening food security and agricultural productivity. Overreliance on chemical inputs has intensified environmental degradation, highlighting the urgent need for sustainable, low-cost alternatives derived from existing biomass resources. In this context, the valorization of plant-based agricultural residues and underutilized biomass offers a sustainable pathway to reduce waste, optimize resource use, and advance circular bioeconomy practices in agriculture. *Urtica dioica* L. (stinging nettle), a widely distributed perennial plant rich in essential nutrients and bioactive compounds, has emerged as a promising candidate for transforming biological resources into high value agro-inputs. Nettle biomass—often overlooked or discarded—can be converted into biofertilizers capable of enhancing soil health, improving seed germination and increasing plant vigor. By integrating nettle-based amendments into farming systems, it becomes possible to reduce dependence on synthetic fertilizers, repurpose natural biomass that would otherwise go to waste, and support nutrient cycling within the agroecosystem. This review highlights nettle's potential in sustainable agriculture and proposes future directions that align with waste prevention, effective biomass management, and resource valorization in modern organic farming.

Keywords: Biomass valorization, Bioactive compounds, Biofertilizer, Circular bioeconomy, Soil health, Sustainable agriculture

WG 2 Agrofood loss and waste management

Energy Potential of Nut Shell Biomass within the Framework of the Circular Bioeconomy

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Abstract:

Walnut, hazelnut, and almond shells constitute a significant source of lignocellulosic biomass with strong applicability in renewable energy production. As abundant by-products of nut processing, these materials integrate seamlessly into the principles of the circular bioeconomy, where biological waste is reintroduced into the value chain as a resource for sustainable energy generation. Their chemical compositioncharacterized by high carbon content, low ash fractions, and favorable proportions of volatile and combustible matter supports efficient thermochemical conversion. Heating values ranging from 18.74 to 21.32 MJ/kg confirm their potential as competitive solid biofuels. Among the examined species, almond shells exhibited the most advantageous fuel characteristics, while walnut and hazelnut shells also demonstrated noteworthy energetic performance. Valorizing these residual materials reduces waste, mitigates dependence on fossil fuels, and enhances the development of resilient, low-carbon bioenergy systems.

Key words: nut shells, renewable energy, heating value, waste valorization, circular bioeconomy

Quantitative Assessment of Production Losses and Waste Valorization Potential in the Georgian Grape Variety Saperavi

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Saperavi, a principal Georgian red grape variety distinguished by its teinturier characteristics, high sugar content, and rich phenolic profile, undergoes notable quantitative losses throughout the production chain. This study aims to assess product loss from vineyard harvesting to final vinification and to evaluate the potential for valorizing resulting waste materials. Findings indicate that vineyard harvest losses account for approximately 5 - 15%, primarily due to grape damage, overripeness, and phytopathological factors. An additional 1 - 5% loss occurs during transportation and storage, while sorting and pressing processes contribute a further 2 - 8% reduction in usable material. Post - pressing pomace - comprising skins, seeds, and stems - constitutes 20 - 30% of the initial grape mass and, despite being commonly treated as waste, contains high levels of phenolic compounds, antioxidants, and lipophilic substances. These properties highlight significant opportunities for secondary use, including alcohol extraction and the production of grape seed oil for pharmaceutical and cosmetic applications. Overall, cumulative losses throughout the Saperavi production chain reach 20 - 35% of the original grape mass. The quantitative assessment presented here provides a basis for optimizing resource efficiency, reducing waste, and advancing sustainable practices in viticulture and winemaking.

Keywords: Saperavi, Grape production losses, Waste valorization

Evaluation of agri-food sector byproducts and their used under the "One Health" approach

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The circular economy model applied to the agri-food sector is focused on addressing the problem of large volumes of waste generated, which represents one of the main challenges affecting both global environmental sustainability and economic performance. Agricultural byproducts are of particular interest as they can be rich sources of compounds relevant to the agri-food, pharmaceutical and cosmetic industries. Additionally, supplementing animal feed with bioactive-rich byproducts, - especially when incorporated into silage, thereby enhancing the value to the resulting feed- may positively impact animal welfare.

In this context, our research group is evaluating byproducts from different agricultural cultivations such as chestnuts, pistachios, peanuts and from olive oil and winemaking industries. In this sense, we conducted extraction optimization, chemical and nutritional characterization as well as microbiological and biological assessments. For instance, chestnut byproducts extracts stood out for their high content of hydrolysable tannins and hydroxybenzoic acids which exhibit strong antimicrobial and antioxidant potential, and they are also a good source of tocopherols (4.2 mg/g), showing a potential to inhibit antibiotic-resistant bacterial strains (inhibition of Methicillin-resistant *S. aureus* growth, 0.15 mg/ml). Those results highlight the potential of agri-food sector byproducts in the global concept of "One Health".

Keywords: Agriculture byproducts, waste, animal welfare, circular economy, One Health.

Chlorogenic and Caffeic Acid Recovery from Sunflower Cake: A Step Towards Circular Bio-Economy

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Sunflower cake, a by-product of oil extraction, represents a valuable yet underutilized source of proteins, phenolic compounds, and minerals. Traditionally used as animal feed and often regarded as agro-waste, it contains significant levels of chlorogenic and caffeic acids. While these phenolic compounds are sometimes considered antinutritional due to their interactions with proteins—leading to green discoloration, altered digestibility, and taste—they also exhibit beneficial bioactive properties, including antioxidant, antimicrobial, antidiabetic, and anti-inflammatory effects. Given their diverse applications in the food, pharmaceutical, and cosmetic industries, sunflower cake serves as a promising raw material for the extraction of these compounds. This study aimed to evaluate the chlorogenic and caffeic acid content in five sunflower genotypes from the collection of the Institute of Field and Vegetable Crops, cultivated at Rimski Šančevi, Serbia Phenolic compounds were extracted from defatted samples using 80% methanol, followed by centrifugation and filtration, and subsequently quantified via high-performance liquid chromatography (HPLC) with PDA detection. The concentration of chlorogenic acid ranged from 13.48 to 24.58 g/kg, while caffeic acid levels varied between 0.278 and 0.771 g/kg. Among the examined genotypes, Providens exhibited the highest chlorogenic acid content (27.58 g/kg), followed by NS Trifun (21.86 g/kg), whereas Providens and NS Veles stood out with notable caffeic acid levels of 0.64 g/kg and 0.77 g/kg, respectively. Conversely, NS Zmaj and NS Dositej contained the lowest concentrations of both acids. These findings highlight genotype Providens as an exceptional source of phenolic compounds, particularly chlorogenic and caffeic acids, reinforcing its potential for industrial and nutritional applications. By utilizing sunflower cake as a functional ingredient, its bioactive potential can be further harnessed, contributing to the development of nutritionally enriched and value-added products.

Keywords: sunflower cake, phenolic compounds, chlorogenic acid, agrofood waste valorization

Innovative Strategies for Sustainable Oil Production: Cold-Pressed Oils and Valorization of Oilseed Cakes

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Cold-pressed vegetable oils are increasingly valued for their nutritional and functional properties, offering consumers minimally processed products rich in bioactive compounds. However, mechanical extraction by screw presses generates significant amounts of oilseed cakes, which are often underutilized despite their high content of proteins, fibers, and antioxidants. This presentation highlights innovative strategies for integrating oil production into a circular bioeconomy model by combining high-quality cold-pressed oils with the sustainable valorization of oilseed cakes. Potential applications include the development of functional foods, nutraceuticals, animal feed, biodegradable packaging, and bioenergy. Emphasis will be placed on small- and medium-scale oil mills, which play a key role in local economies and can benefit from zero-waste approaches. By transforming oilseed cakes from by-products into valuable resources, the oil industry can enhance sustainability, reduce environmental impact, and create novel market opportunities.

Keywords: circular bioeconomy, functional foods, by-product valorization, small-scale oil mills, zero-waste approach.

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Fruit Seeds and Kernels as By-Products: Transforming Fruit-Processing Waste into Oil-Producing Raw Materials

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Stone fruits (plum, apricot, sour cherry, cherry, etc.) and berries (raspberry, blackberry, blueberry, etc.) are cultivated over extensive areas. In Southeast Europe, particularly in Serbia, a significant producer of these fruit types, nearly 3 million tons of stone fruits and over 500,000 tons of berries were produced between 2020 and 2023. While substantial quantities are consumed fresh, a considerable portion is processed into fruit products, alcoholic beverages, and similar items. During fruit processing, if stone and seeds are removed, they become waste. In fresh fruit, stone constitute 7–20% of the total weight, while seeds account for 5–15%. After proper and rapid processing, kernel and seeds can yield 40–60% and 5–20% oil, respectively, and can be utilized for producing "special" unrefined, cold-pressed oils. Alongside conventional sources such as sunflower, soybean, rapeseed, sesame, pumpkin, and olive, these oils can also be extracted from unconventional sources, including kernels, fruits, seeds, and kernels and seeds of various fruits and grapes, as well as cereal sprouts. This process yields a wide range of “special” oils with distinct characteristics that can be of significant nutritional and health value for human diets, as well as in cosmetics and pharmaceuticals.

Keywords: fruits, waste, oil production, “special” oils

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Bioethanol Production from Vegetable and Cereal Kitchen Waste

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Kitchen waste, classified as organic solid waste, originates mainly from households, restaurants, and cafeterias, contributes significantly to municipal solid waste. This type of waste constitutes a cost-effective, complex biomass with carbohydrates comprising up to 65% of its total solids, including starch, fats, and cellulose components. The utilization of starch-based kitchen waste as a renewable feedstock for bioethanol production offers an eco-friendly solution to waste management and sustainable fuel generation. This study focuses on the thermo-acid pretreatment of various starch-rich kitchen waste materials to enhance the hydrolysis of starch into fermentable sugars. The kitchen waste from local student restaurants was sorted into basic categories including peas, green beans, beans, rice, potatoes, and corn. Subsequent fermentation using yeast under defined conditions converts these sugars into ethanol.

Results demonstrate variability in ethanol yield depending on the type of kitchen waste, with peas showing the highest conversion efficiencies (65% of the theoretical value). The process not only reduces organic waste but also contributes to renewable energy production. Optimization of pretreatment parameters such as pH, temperature, and duration can further improve ethanol yield from vegetable and cereal kitchen waste.

Keywords: agrofood; kitchen waste; waste management; bioethanol;

Valorization of Raspberry Pomace as Waste product Innovative Extraction and Encapsulation Technologies

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Raspberry pomace, a nutrient-rich byproduct of juice processing, represents a valuable, yet underexploited source of bioactive compounds that has demonstrated numerous health benefits in the prevention or mitigation of chronic diseases. In alignment with initiatives aimed at transforming food waste into high-value resources, this study investigates a sustainable methodology to enhance the solubility of valuable bioactive compounds from raspberry pomace and enable their micellization using biocompatible polymers and deep eutectic solvents in a membrane micromixer system. Solid–liquid extraction was conducted employing 20% aqueous solutions of the targeted biocompatible solvents, followed by spectrophotometric quantification of total phenolics and anthocyanins. All tested biocompatible solvents extracted bioactives from freeze-dried raspberry pomace and enhanced their solubility relative to water, indicating their strong solubilization capacity. Activity coefficient modeling at infinite dilution further corroborated the affinity of the targeted solvents, affirming their appropriateness for solubilization and micellization processes. These findings establish a foundation for the integration of biocompatible solvents into membrane micromixing techniques to produce bioactive-loaded micelles with prospective applications in functional foods, nutraceuticals, and pharmaceuticals. The research underscores raspberry pomace waste as a promising raw material within circular bioeconomy strategies and highlights the significance of green extraction technologies in fostering sustainable transformation of food systems.

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Keywords: Raspberry Pomace, Food Waste Valorization, Circular Bio-Economy

Spray drying as a method of choice for obtaining high quality products from waste pear cake

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The fruit processing industry generates large amounts of waste, particularly fruit cakes, which poses a significant environmental challenge. Depending on the fruit type and processing method, 10–35% of the raw material becomes waste. Waste pear cake (WPC), including peel, pulp, stem, core, and seeds remaining after juice production, contains 44–79% dietary fibre (dry basis), as well as organic acids, triterpenes, and polyphenols, making it a promising raw material for functional ingredients. The novelty of this study lies in valorising WPC by combining ultrasound-assisted extraction, a powerful technique for recovering phenolic compounds, with spray drying. The ultrasound extract, obtained under optimised conditions (70% amplitude, 40 °C, 15 min, 55% (v/v) ethanol), was used as a liquid feed for spray drying. Spray drying parameters (carrier ratio, inlet/outlet temperature, flow rate) were optimised to produce powders with suitable physicochemical properties and high encapsulation efficiency. Maltodextrin (300%) was selected as the primary carrier, followed by formulations with next-generation natural carriers (inulin, pea and bean proteins, chitosan, pectin, and gum arabic). A clear effect of alternative carriers on encapsulation efficiency was observed, ranging from 68.83% to 93.18%, with the highest value for maltodextrin combined with gum arabic. HPLC analysis confirmed the presence of key bioactive compounds, including gallic acid, 5-hydroxymethylfurfural, epicatechin, quercetin, and morin. This study demonstrates a sustainable strategy for recovering high-value compounds from WPC and producing functional powders suitable for food, pharmaceutical, and cosmetic applications.

Keywords: Waste pear cake, Ultrasound-assisted extraction, Spray drying, Functional powders production, HPLC analysis.

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Electrospun nanofibers loaded with anthocyanins: A novel approach to chokeberry fruit waste valorization

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Recovering bioactive compounds from chokeberry (*Aronia melanocarpa*) waste generated during fruit processing has gained significant attention as a strategy for reducing environmental burden while obtaining valuable functional ingredients. In this study, ultrasound-assisted extraction (UAE) was integrated with electrospinning (ES) technology to develop novel functional nanomaterials. The extraction process was optimized using response surface methodology (RSM), which identified 45% ethanol at 60 °C as the optimal condition for maximizing both individual and total anthocyanin yields. Using various ratios of polyvinylpyrrolidone (PVP), hydroxypropyl-β-cyclodextrin (HP-β-CD), and hydroxypropyl-γ-cyclodextrin (HP-γ-CD), four types of electrospun nanofibers enriched with chokeberry waste extract were successfully formulated. The obtained nanofibers demonstrated favorable technological properties, and good thermal stability, making them suitable for further incorporation into functional materials. Chemical characterization revealed notable concentrations of cyanidin-3-O-galactoside, cyanidin-3-O-glucoside, and cyanidin-3-O-arabinoside, accompanied by strong antioxidant activity. FT-IR analysis confirmed molecular interactions and conjugation between carrier polymers and bioactive compounds. Additionally, PAMPA assays suggested that anthocyanins exhibit the capacity to cross gastric cell membranes through active transport mechanisms. Overall, the conversion of chokeberry processing waste into specifically tailored nanofiber formulations highlights a promising approach for generating value-added products with potential nutritional and health benefits for consumers, contributing both to waste valorization and innovative material development.

Keywords: chokeberry waste, anthocyanins, extraction optimization, electrospinning, nanofibers

Innovative Use of Supramolecular Solvents for Sustainable Astaxanthin Recovery from Freeze-Dried Salmon Waste

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Considering that the Atlantic salmon industry reaches ~2.72 million tonnes annually and that cutting Atlantic salmon into fillets generates about 30–40% waste, this represents approximately 0.8–1.1 million tonnes of processing by-products. These underutilised fractions are rich in proteins, oils, and carotenoids such as astaxanthin. Freeze-dried salmon waste is a valuable matrix for valorisation, and supramolecular solvents (SUPRAS) were investigated as a green extraction technique for astaxanthin recovery. Three SUPRAS systems (water and octanoic acid with ethanol, acetone, or ethyl acetate) were prepared and compared with a conventional reference method. Among them, the octanoic acid–ethyl acetate–water system showed the strongest pigment recovery.

Optimization was performed within the actual experimental space (25–200 mg, 23–60°C, 5–120 min). A grid search revealed that the predicted maximum within the domain occurred at the upper limits of the factors, specifically: sample mass ≈ 200 mg, temperature ≈ 60 °C and extraction time ≈ 120 min with measured values above 10.9 ± 1.6 μg/g, quantified by LC–MS/MS. This region corresponds to the physically reasonable conditions, reflecting the combined effects of increased solute availability, enhanced diffusivity, and sufficient time for mass transfer to approach equilibrium. These findings demonstrate the potential of SUPRAS as a resource-efficient extraction strategy for recovering carotenoids from food processing by-products.

Keywords: Salmon waste, Astaxanthin, SUPRAS extraction, Green chemistry, LC–MS/MS

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GREEN VALORIZATION OF $ScCO_2$-DERIVED ELDERBERRY FLOWER AND PANNONIAN THYME WASTE USING ULTRASOUND EXTRACTION AND SPRAY DRYING

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The rapid scientific, medical, and technological progress of the 21st century has accelerated industrial growth and improved the quality and quantity of manufactured goods. As living standards increased, global production levels also rose. However, this expansion has intensified one of today's major global challenges, which is effective waste management, recycling, and valorization. Despite growing awareness over the past two decades, global recycling rates remain low, and much of the waste produced is still disposed of in landfills or throughout incineration. Today, agriculture and food industry are one of the highest organic waste producers, and the large amount of that waste remains underutilized despite its high potential for further use.

This study reports on development of green and sustainable methods for valorizing plant material (Elderberry flower, and Pannonian thyme) left after supercritical CO_2 extraction ($ScCO_2$), a process typically used to isolate lipid compounds. The plant material left after the $ScCO_2$ extraction is often treated as waste, yet it still contains valuable bioactive polar compounds. By applying environmentally friendly ultrasound-assisted extraction (UAE), and extract-to-product conversion technique (spray drying), waste plant material was converted to dried extract which can be incorporated into various functional food or food supplements. The results of this study report on the process conditions of the UAE and spray drying, as well as characteristics of the obtained powders. Additionally, this study can serve as the benchmark for future valorization of similar plant wastes after lipid extraction procedures, for the benefits of the food industry.

Keywords: Valorization, waste plant material, spray drying

Food Waste Management in Households: Insights from Kosovo

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Food waste is among the most critical sustainability issues of the 21st century, associated with serious environmental, economic, and social consequences. This paper investigates food waste management in Kosovo's urban households, focusing on consumer behavior, drivers of waste generation, and citizens' attitudes toward measures for its reduction. In total, 305 households were interviewed in seven regions. The sample predominantly consisted of females (71.1%) and young adults aged between 18-25 years old (41.6%). It seemed that 35.7% of households throw away food one to two times a week, while 20.7% do so almost every day. Dinner was the meal at which most food was wasted, and there was an extreme increase in the amount of discarded food during festivities (86.6%). Insufficient meal planning, inadequate storing of food, and over-purchasing of food lead to food wastage. Alcoholic beverages, spoiled fruits and vegetables, fast food, and frozen products were the most regularly thrown away products, whereas staple products such as cheese, eggs, and milk were discarded less frequently. In general, findings point to the multilayered nature of food waste in urban Kosovo, stipulating the need for an integrated approach which entails education, improvements in infrastructure, and effective policy measures.

Keywords: food waste, urban households, consumer behavior, waste management.

MICROBIAL CHAIN ELONGATION FOR CAPROIC ACID PRODUCTION USING WASTE-DERIVED BIOCHAR

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Food-derived wastes and agro-industrial activities generate significant amounts of organic residues with high valorization potential that can be utilized as substrates in biotechnological conversions. Microbial chain elongation represents a promising biochemical process for converting such wastes into medium-chain carboxylic acids, such as caproic acid, within the framework of circular economy and sustainable waste management strategies. Nevertheless, enhancing microbial activity and overall conversion efficiency remains a critical research focus to improve the industrial applicability of chain elongation processes.

In this study, ethanol and acetate was utilized to produce caproic acid, which is a valuable substance as feed additive, through a biochemical process known as chain elongation by using pure culture. During the chain elongation reaction, biochar derived from the pyrolysis of wine pruning was utilized to enhance the metabolic activity of *Clostridium kluyveri*, thereby improving caproic acid production. To optimize caproic acid formation, the biochar production temperature, biochar dosage, and the ethanol/acetate ratio were systematically evaluated. According to the results, the addition of 15 g/L of biochar produced at 800 °C enhanced the chain elongation reactions, yielding up to 13.6 g/L of caproic acid. Moreover, the ethanol/acetate ratio influenced the caproic acid yield, with lower ethanol ratios inhibiting caproic acid production while the addition of biochars stimulated ethanol conversion.

Overall, the results demonstrate that caproic acid can be produced at relatively high yields. Wastes containing ethanol and acetate, such as winery wastes, fermentation-derived effluents, and syngas fermentation products, represent significant potential for caproic acid production through biochar-assisted chain elongation reactions.

Valorization of Artichoke Residual Waste through One-Pot Extraction of Phenolic Compounds and Inulin via Ultrasound and Microwave Assisted Techniques

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Artichoke is acknowledged for its valuable phytochemicals having various established health advantages due to their antioxidant, antimicrobial, anti-inflammatory and cardiovascular protective activities. It is also an excellent source of inulin, a prebiotic fiber, which is favorable for digestive system. The edible portion (head) of the globe artichoke is usually consumed while other remaining parts including leaves, stems and roots are discarded or left in the field as waste material. In this way, it not only wastes important bioactive compounds, but also creates environmental risks due to improper disposal practices. This study presents an innovative approach of one-pot extraction to retrieve the bioactive compounds mainly phenols and inulin in a single step extraction process. Modern extraction methods including microwave-assisted (MW) and ultrasound-assisted (US) techniques were practiced in this resource efficient extraction approach. The promising results with high recovery rates were achieved by optimizing the process conditions including solvent, time and temperature. The optimized MW one-pot extraction of artichoke roots yielded to 3.16 mg/g of phenolic compounds and 69.7% precipitated inulin recovery (RPI) while US one-pot extraction resulted in 3.78 mg/g of phenols and 65.5% RPI. This green extraction based one-pot conception is a sustainable and economical approach having a pertinent compatibility with circular economy paradigm.

Keywords: Agro-industrial Waste, Artichoke, Extraction, Valorization, Circular Bioeconomy

The antimicrobial effects of extracellular vesicles and extracts obtained from viticulture waste

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Viticulture generates substantial volumes of plant waste rich in bioactive molecules with potential antimicrobial value. In parallel, extracellular vesicles (EVs) derived from plant tissues are emerging as natural nanocarriers capable of delivering functional compounds with enhanced stability and biological activity. This study investigates the antimicrobial properties of both EVs and extract obtained from a variety of grapevine leaves, with the goal of identifying sustainable, high-value applications for these underused by-products. EVs were isolated and characterized for size distribution (165.3±64.7 nm), and morphology. The extract with a total phenolic content of 90.31±4.63 mg GAE/g dw and antioxidant activity of 80.53±1.23% (DPPH method) was prepared using enzymatic pre-treatment and fluidized bed extraction. Their antimicrobial activity was evaluated against a panel of food-relevant and opportunistic pathogenic microorganisms. Both fractions demonstrated inhibitory effects with distinct potency profiles, especially on the pathogenic Escherichia coli and Candida albicans. The findings support the concept that viticulture waste can serve as a source of naturally derived antimicrobial agents and highlight the potential of plant EVs as an innovative tool for bioactive delivery. Moreover, the work contributes to the development of circular strategies in viticulture by transforming waste streams into functional ingredients for food safety, agriculture, and biotechnology.

Keywords: viticulture waste valorization, leaves extracts and extracellular vesicles, antimicrobials

Valorising Food Waste with Insects: A Protocol for Cross-Country Comparative Research

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Insects are increasingly recognized as a circular solution for the valorisation of agricultural by-products, food processing sidestreams, and pre-consumer food waste, transforming them into high-value protein, lipids, and biofertilizers. Yet the insect farming sector across Europe faces diverse challenges shaped by regulatory frameworks, feedstock supply chains, climate, and market maturity. We present a research protocol designed to systematically investigate these country-specific barriers and opportunities in order to derive actionable policy and practice recommendations. The research will combine policy analysis with stakeholder mapping and interviews to generate robust cross-country insights. Key indicators include feedstock availability, regulatory clarity, energy and labour costs, market demand, and public perception, alongside broader measures of ecosystem maturity. A mixed-methods approach integrating qualitative thematic analysis with quantitative benchmarking will enable comparative dashboards and cluster analysis of challenge profiles. Outputs will include country-specific challenge maps, mitigation strategies, and policy briefs aligned with EU circular bioeconomy goals. By triangulating data from industry operators, feedstock suppliers, regulators, and buyers, the study will highlight both barriers and successful valorisation pathways. Ultimately, this protocol provides a replicable framework for understanding how diverse European contexts shape insect-based food waste valorisation, offering evidence-based recommendations to harmonize regulation, strengthen infrastructure, and accelerate adoption.

Keywords: Research protocol, insects, valorisation, barriers, opportunities

Valorization of Agro-Food Waste into Activated Carbon for Wastewater Treatment: A Circular Bio-Economy Approach Supporting Food Loss and Waste Prevention

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Abstract

Food loss and waste (FLW) represent major environmental, economic, and societal challenges across the agro-food sector. Within the FoodWaStop COST Action, the valorization of agro-food residues provides a powerful strategy not only to reduce waste generation but also to create high-value products that support a circular bio-economy. This poster presents ongoing research focused on converting common agro-food waste materials such as pistachio shells into activated carbon for the adsorption of contaminants from wastewater. These residues, often discarded throughout the food supply chain, possess unique lignocellulosic and mineral characteristics that make them ideal precursors for functional adsorbents. By optimizing activation processes and tailoring surface properties, the resulting bio-based activated carbons demonstrate high adsorption efficiency toward emerging pollutants and industrial dyes, contributing to cleaner water systems. This work directly supports WG4 through practical demonstration of agro-food waste valorization, converting low-value residues into sustainable materials. Additionally, it contributes to WG6 by promoting knowledge dissemination, interdisciplinary collaboration, and the translation of research outcomes into scalable, real-world applications. Overall, the study highlights how transforming food waste into functional activated carbon can significantly mitigate FLW impacts, reduce environmental burdens, and reinforce circularity within the agro-food sector.

Keywords: Food loss and waste (FLW), circular bio-economy, pistachio shells, activated carbon, wastewater treatment

Valorization of Moroccan Avocado Seeds: Extraction Efficiency, Bioactive Compounds, and antiaging activities.

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Avocado cultivation is among the most rapidly expanding agricultural sectors worldwide. Rising demand and sustained consumption have encouraged many farmers to invest in this highly profitable crop. However, they are increasingly confronted with difficult choices, as avocado production is widely criticized for its substantial water requirements and its generation of significant amounts of waste.

In Morocco, the main by-products of avocado cultivation include fruits that do not meet export standards, as well as leaves, skins, flowers, and pits. These residues can be valorized through composting to produce organic fertilizers or by converting non-edible fruits into value-added products such as oils, cosmetics, or flour.

Our initiatives aim to reduce the volume of unrecoverable waste generated annually along the avocado production chain, as part of a broader effort to transition from a linear to a circular economic model.

The present work aims to compare the oil extraction and recovery of bioactive compounds from Moroccan avocado seeds and peels cultivar (Hass) using a conventional method (extraction by Soxhlet (SE)) and an eco-friendly extraction by supercritical carbon dioxide (scCO2) with cosolvents. We report also, the fatty acids (FAs) profile, total phenolic content (TPC), and antioxidant activity (AA) of avocado seeds extracts. This study aims also to evaluate the ability of avocado seed oil to exhibit dermo-cosmetic activities, as well as in silico study to explore the main potential compounds related to these activities.

The highest extraction yields have been obtained by CO2 supercritical extraction and were observed when ethanol is used as solvent (at 5 wt%). The extraction with EtOH was found to attain the highest yields in seeds when compared with results in the literature of the extraction with hexane as a solvent for avocado.

The lipid fraction in avocado oil is characterized by high levels (above 55 wt%) of monounsaturated FAs (e.g., palmitoleic, oleic) and relatively low levels of polyunsaturated and saturated FAs (about 19 wt% or below). The identification of the bioactive compounds by LCMS showed the presence of tocopherols, polyphenols and phytosterols as a major secondary metabolite. The results of the inhibition of enzymes (collagenase and elastase) involved in skin ageing by avocado oil extracted from seeds showed an IC50 value of 388.99 µg/mL and 1062.5 µg/mL respectively.

Overall, these predictions provide a reliable scientific basis for future experimental studies on Moroccan avocado by-products, supporting process optimization and the development of sustainable valorization strategies for agro-industrial waste in Morocco.

Sensory Evaluation and Consumer Attitudes toward Oat - Plant Based Milk Alternatives: Factors Influencing Market Acceptance

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Abstract

This study investigated the sensory quality and consumer perception of commercial oat-based milk products to identify the main factors influencing their acceptability and purchase intention. A semi-trained panel evaluated multiple oat-based milk alternatives using a 5-point hedonic scale for appearance, odor, taste, aftertaste, and overall acceptability. Considerable differences were observed among samples, with flavor and aftertaste emerging as the primary determinants of positive sensory evaluation. Products with a more balanced flavor profile and smoother texture achieved higher acceptability, while those with off-flavors or a grainy mouthfeel were rated less favorably. In parallel, a consumer survey was conducted to assess attitudes toward oat milk and general preferences for plant-based beverages. Most respondents did not identify specific health benefits as a reason for consuming oat milk; only a small minority indicated this as a motivating factor. Instead, interest in plant-based options appeared to be influenced mainly by curiosity, dietary experimentation, or personal taste. Overall, the findings highlight that sensory quality - particularly flavor and texture - remains the key driver of consumer acceptance and purchase intention for oat-based milk alternatives. Enhancing these attributes may increase the competitiveness and market appeal of plant-based milk alternatives.

Keywords: plant – based milk, sensory evaluation, consumer perception

Efficacy of compost to reduce metal uptake and animal health risks in maize grown in different-pH polluted Italian soils

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This pot experiment demonstrates the efficacy of compost in reducing metal uptake and health risks in three animals fed on maize fodder grown on Cu (copper)- (200 mg/L) and Zn (zinc)-contaminated (300 mg/L) wastewater (WW) irrigated different pH soils. In results, the 2% compost amendment substantially decreased the roots and shoots metal concentrations and uptake by maize plants. Likewise, significantly affected the daily intake of metal (DIM) and health risk index (HRI) by animals. However, acidic pH soil still posed higher risks than calcareous pH soil. For Cu, the HRI exceeded the safe limit (> 1) for all animals in acid soil, with an order of buffalo > cow > sheep. In calcareous soil, Cu HRI exceeded (> 1) for buffalo, either with or without compost, while in sheep and cow, HRI dropped below (< 1) with compost amendment. For Zn, the DIM and HRI stayed below the safe limit (< 1) except in sheep in both soils without compost amendment. These findings suggest the potential threats of contaminated-wastewater irrigation to policymakers and livestock keepers; thereafter, compost as an environmentally friendly approach to minimize the metal contamination risks in maize fodder grown on contaminated soils.

Keywords: buffalo, cow, sheep, compost, copper, zinc, wastewater

Assessment of Black Cumin Cake as a Sustainable Plant Protein Source

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Black cumin (BC, *Nigella sativa* L.) seeds and oil are widely used in dietary supplements, bakery products, cosmetics, animal feed, and various food and pharmaceutical applications. In recent years, BC oil and seed-based skincare products have gained significant commercial interest. Owing to its antibacterial, antioxidant, antiinflammatory, antidiabetic, and antitumor activities, BC is also associated with immune-supporting and cholesterol-lowering effects. Nutritionally, it is rich in carbohydrates (30–40%), fats (30–40%), proteins (20–30%), fiber (5–10%), essential vitamins and minerals, as well as bioactive compounds such as linoleic acid, tocopherols, polyphenols, etc. BC cake, the main by-product of cold-press oil extraction, contains substantial amounts of proteins, phenolics, essential amino acids, and other valuable bioactives. Due to this composition, it represents a promising and sustainable plant-based protein source. Alkali extraction, isoelectric precipitation, and enzymatic treatments were applied to obtain protein concentrates and isolates. This study evaluates the potential of BC cake as an alternative protein ingredient and compares different extraction methods to improve protein yield and quality. By promoting the valorization of agro-industrial by-products, this research supports the development of sustainable plant-based protein alternatives and aligns with several United Nations Sustainable Development Goals, including Zero Hunger, Responsible Consumption and Production, and Climate Action.

Keywords: black cumin cake, plant-protein, protein source

Valorization of Garlic Peel Waste: Ultrasound-Assisted Natural Deep Eutectic Solvent Extraction of Phenolics and Antioxidants and Assessment of Their *In Vitro* Bioaccessibility

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A wide range of agro-industrial residues contain substantial amounts of bioactive constituents, particularly phenolic compounds that hold significant potential for use in food, cosmetic, and pharmaceutical formulations. Conventional organic solvents commonly employed for phenolic extraction pose several drawbacks, such as toxicity, flammability, and negative environmental impacts. In recent years, natural deep eutectic solvents (NADES) have gained attention as environmentally friendly alternatives, offering strong extraction capabilities for phenolic-rich matrices. A variety of extraction approaches can be applied to recover phenolic compounds from agricultural wastes, and NADES-based techniques have shown particular promise. Among innovative technologies, ultrasound-assisted extraction is considered highly effective due to its ability to enhance mass transfer and reduce extraction time. For phenolic extracts to exert their functional properties, their bioaccessibility must be ensured. Simulated gastrointestinal digestion models provide an ethical, reproducible means of assessing the proportion of phenolics that becomes available for absorption in the small intestine. In Türkiye, garlic is extensively incorporated into traditional cuisine to enhance flavor, leading to the generation of considerable quantities of garlic peel waste at both household and industrial scales. The present study investigates the ultrasound-assisted extraction of phenolics and antioxidant compounds from garlic peel waste using eight different NADES formulations. The resulting extracts obtained through this green extraction approach are subsequently evaluated for their in vitro bioaccessibility using a standardized digestion model.

Keywords: garlic peel waste, green extraction, *in vitro* digestion, phenolics, antioxidants

Submerged fermentation with *Trametes versicolor* using spent carob pulp for enhanced laccase production

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Trametes versicolor is a white-rot fungus known for its ability to produce extracellular oxidative enzymes, particularly laccase. Laccase has wide applications in food industry operations, including juice clarification, beer and wine stabilization, sediment removal, textural modification in bakery products, and treatment of food processing wastewaters. This study investigated whether supplementing a defined medium with 3%, 6%, or 10% spent carob pulp (CP), a by-product of carob syrup production, could enhance laccase production in submerged *T. versicolor* fermentations. Two strains (CCBAS614 and CCBAS1399) were cultivated under shake-flask conditions, and extracellular laccase activity was monitored throughout fermentation. At the end of the cultivation period, total glucan, β-glucan, α-glucan, dietary fiber, ash, protein, and dry mass were also quantified. Baseline laccase production without CP supplementation ranged between 0.3–1.2 U/mL for both strains. In contrast, supplementation with sterilized, milled CP led to pronounced increases in enzyme activity. The highest laccase activities were obtained with 10% CP supplementation: on day 6 for strain CCBAS614 (27.9 U/mL) and on day 4 for strain CCBAS1399 (14.0 U/mL). These findings demonstrate that spent carob pulp is a promising low-cost substrate for enhancing laccase production using *T. versicolor*.

Keywords: Trametes versicolor; Laccase production; Submerged fermentation; Spent carob pulp; Agro-industrial by-products

Exploring the Potential of Beeswax processing by-product in the Food Industry for Environmental Sustainability

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This study aimed to characterize the chemical composition and antioxidant potential of beeswax processing by-product residue (BBR), an underutilized material generated during beeswax purification. BBR samples were extracted using ethanol and subsequently analyzed to determine their bioactive compound profile and antioxidant capacity. The total phenolic content (TPC) of the extracts was measured as 7.12 ± 0.49 mg gallic acid equivalents (GAE) per gram, while the total flavonoid content (TFC) reached 3.16 ± 0.11 mg quercetin equivalents (QE) per gram. Antioxidant activity, evaluated through DPPH and FRAP assays, yielded values of 29.47 ± 1.38% inhibition and 4.91 ± 0.36 µmol Trolox equivalents (TE) per gram, respectively. HPLC-PDA analysis provided a detailed polyphenolic profile, revealing notable levels of caffeic acid (28.922 mg/mL), along with detectable amounts of catechin and cyanidin. These findings indicate that BBR contains meaningful concentrations of bioactive compounds, despite being considered a processing residue. The moisture content, measured at 0.46%, also supports the stability of the material for further processing. Overall, the results highlight the potential of BBR as a promising natural ingredient for use in sustainable food applications. Its antioxidant properties and phenolic richness suggest value-added opportunities for developing functional food products and supporting circular bioeconomy practices.

Keywords: Beeswax by-product, bioactive compounds, sustainable food systems, circular bioeconomy, food waste reduction

Acknowledgments

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Co-creating New Upcycled Foods with Irish Consumers

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Upcycled foods are made from ingredients that would otherwise not be consumed by humans. Their success in Ireland will depend on consumer acceptance. This study explores the development of upcycled food concepts in Ireland through a co-creation approach, involving consumers in the early stages of product development.

The study focused on the ideation phase using focus groups with 42 participants in Dublin. The discussions explored consumer awareness, attitudes, and ideas for upcycled foods. A total of 8 upcycled ingredients were considered, including imperfect fruits and vegetables, brewer's spent grain, beef offal, apple pomace, and whey. Participants selected preferred ingredients and created upcycled food concepts.

At the start, most participants were unfamiliar with the term "upcycled food," often linking it to leftovers. After the concept was explained, reactions were generally positive and connected to reducing food waste, although concerns about safety and price influenced willingness to buy. During the co-creation, 54 food concepts were developed. Energy bars were the most common, while beef offal was the least used ingredient.

These findings show that awareness of upcycled foods in Ireland is low, but openness increases once the concept is understood. Building trust in safety and quality will be essential for consumer acceptance.

Keywords: Upcycled food, Co-creation, Consumer acceptance, New product development, Ireland

Maltodextrin and Gum Arabic as Carriers for Hesperidin Encapsulation: Influence of Drying Technique on Microcapsule Properties

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This study evaluates freeze drying and spray drying as encapsulation techniques for pure hesperidin and hesperidin extracted from citrus peel, using maltodextrin and gum arabic as carriers. The goal was to enhance the stability and solubility of hesperidin. Physicochemical and structural characteristics of the resulting microcapsules were assessed and compared to a standardized high-purity hesperidin reference.

The solubility of the microcapsules was significantly improved, as indicated by high WAI (0.202–0.697 g/g), WSI (88.02–99.746%), and OAI (2.174–4.56 g/g) values. These improvements were primarily attributed to the amorphization of hesperidin, which was further confirmed by PXRD analyses. The microcapsules exhibited a light color, with color variation ranging from 12.57 to 47.49 and a high whiteness index (64.12–94.45). Encapsulation also positively influenced flowability: the Hausner ratio ranged from 1.023 to 1.304, while the Carr index ranged from 2.26 to 23.273%. Encapsulation efficiency varied between 7.56% and 65.29%, and all microcapsules demonstrated thermal stability above 110 °C. The best performance was observed in pure hesperidin encapsulated via freeze drying, while spray drying with maltodextrin produced satisfactory results for the citrus peel extract. Overall, the findings indicate that encapsulation protects hesperidin's bioactive properties from environmental degradation and enhances its solubility and flow behavior, thereby increasing its potential for use in pharmaceutical and cosmetic applications.

Keywords: citrus peel, citrus reticulata, encapsulation

Response Surface Optimisation of Oleogel-Based Beef Burgers Using Upcycled Grapeseed Oil: Impact on Quality Attributes and Cooking Characteristics

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High intake of saturated animal fat from comminuted meat products, particularly beef burgers, poses a major public health challenge. This study explores a sustainable approach by developing healthier beef burgers using oleogels structured with carnauba wax and upcycled grapeseed oil, a co-product naturally lower in saturated fatty acids. Response Surface Methodology (RSM) was applied to optimize critical formulation parameters: oleogel-to-beef fat replacement ratio, carnauba wax content, and total fat content. Water loss was selected as the primary minimization objective due to its association with oleogel structural integrity and model robustness.

The optimized formulation was chosen as 25% total fat, 53% of replacement by oleogel with 9% carnauba wax. Post-optimization burger characterization was carried out, including texture, colour, fat content, water-holding capacity, cooking loss, cooking shrinkage, fatty acid profile and oxidative stability measurements. Oleogel-based burgers performed comparably to 100% beef-fat control and commercial benchmarks. Notably, oleogel substitution reduced cooking shrinkage and hardness while maintaining the colour.

This work demonstrates how upcycled oils can be valorized through oleogel technology to produce well-structured solid lipids in complex meat matrices, offering a pathway toward healthier and more sustainable processed meat products, and contributing to the circular economy by utilizing food industry co-products.

Keywords: Oleogel, Response Surface Methodology (RSM), Beef Burger, Fat Replacement, Upcycled Oil

Sustainable Valorization of Brazilian Nuts in Gluten-Free Cookie Formulations

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The valorization of Brazilian nuts as a functional ingredient in gluten-free bakery products presents an opportunity to enhance both nutritional quality and product diversity. This study investigates the impact of incorporating Brazilian nut flour at levels of 0, 2, 4, 6, 8, and 10% (w/w) as a partial substitute for rice flour in gluten-free cookies. The physical characteristics—diameter, thickness, and volume—were evaluated to determine structural modifications induced by nut addition. Increasing Brazilian nut content generally resulted in a significant ($p < 0.05$) reduction in cookie diameter and volume, while thickness showed a slight but significant increase at higher substitution levels (8–10%). Colour parameters (L*, a*, b*) revealed progressive darkening of the cookies with increasing nut flour, demonstrated by lower L* values and higher a* and b* values ($p < 0.05$), reflecting the natural pigments and lipid content of Brazilian nuts. Statistical analysis using one-way ANOVA and LSD test confirmed that most differences among formulations were significant, particularly at substitution levels above 4%. Overall, the incorporation of up to 6% Brazilian nut flour maintained desirable physical and colour characteristics, while higher levels led to pronounced changes that may influence consumer acceptability. This study supports the sustainable valorization of Brazilian nuts in gluten-free cookie production.

Keywords: Brazilian nut flour, Gluten-free cookies, Valorization, Physical properties

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Biorefining hemp processing by-products by supercritical CO_2, pressurized liquid, and enzyme-assisted extractions for the recovery of value-added ingredients

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After the extraction of cannabinoids and oil, the residual hemp herbs (HHBE and HHAE), hulls (HSH) are either discarded or used as fertilizers, while press cake (HPC) is used as protein source. This study aimed at using green technologies such as supercritical CO_2 (SFE-CO_2), pressurized liquid extraction (PLE), enzyme-assisted extraction (EAE) and food grade solvents to isolate value-added fractions. Antioxidant capacity of the products obtained was evaluated by in vitro assays, while fatty acid, tocopherols and phytosterols, and cannabinoids profiles were analysed by GC or HPLC. SFE-CO_2 increased the amount of protein, moisture, ash, and carbohydrates in all samples, with HPC having the highest protein content. It was also confirmed that hemp by-products are good source of tocopherols and phytosterols. Ultrasound helped in reducing extraction time from 4 hours to 2.5 hours in HSH but did not have a significant effect on other samples. In addition, EAE helped in upcycling low protein samples into high protein products with HPC extract having 69.28±0.55 %. It can be concluded that the characterization of the recovered products demonstrated that hemp byproducts can be upcycled into various value-added products that could be used in various sectors such as functional foods, nutraceuticals and cosmeceuticals.

Keywords: Valorization, Agrifood, Hemp, Extraction, and Circular economy

Biotransformation of *Chlorella vulgaris* through lactic acid fermentation for improved functional value in food applications

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The increasing demand for health-oriented diets has intensified interest in microalgae due to their high nutritional value and bioactive potential. Although fermentation can enhance the nutritional quality of microalgal biomass, the rigid cell wall of *Chlorella vulgaris* presents a significant challenge. Accordingly, this study evaluates the suitability of *Chlorella vulgaris* as a substrate for fermentation by lactic acid bacteria. To enhance fermentation efficiency, various pretreatment methods were tested, including acid hydrolysis, combined ultrasonication-acid, and enzymatic hydrolysis. Among them, enzymatic treatment was selected for its superior release of fermentable carbon compounds essential for microbial growth. Subsequently, the effect of *L. plantarum* and *L. brevis* on fermentation performance was tested, with *L. plantarum* showing better results, achieving the highest microbial growth (from 6 to 10.12 log CFU/mL), lactic acid production (17.35 gL^{-1}), and the highest acidification rate, reflected by pH reduction to 3.6. Additionally, *in vitro* antioxidant capacity and antimicrobial activity were evaluated, and significant improvement was observed. The samples treated with viscozyme and combined treatment, and further fermented with *L. plantarum,* exhibited inhibitory effects against majority of strains. These findings demonstrate the potential of *Chlorella vulgaris* to generate value-added fermented products with enhanced functional properties to enhance formulations.

Keywords: fermentation, bioactive compounds, microalgae, chlorella vulgaris, antioxidant capacity

Screening of Natural Deep Eutectic Solvents for Selective Extraction of Antioxidant Rich Fractions from *Paeonia spp.*

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Abstract

This study applied the Hansen Solubility Parameter (HSP) model to screen and evaluate Natural Deep Eutectic Solvents (NADES) for the selective extraction of antioxidant-rich fractions from *Paeonia officinalis* and *Paeonia anomala* leaves and roots. Four NADES namely; N1 (Choline Chloride:Lactic Acid), N2 (Choline Chloride:Acetic Acid), N3 (Choline Chloride:Citric Acid), and N4 (Choline Chloride:Propylene Glycol) along with propylene glycol (PG) were selected based on predicted solubility affinity (Ra values) with methyl gallate. Ultrasound-assisted probe extraction (5 min, 35% amplitude) was used to obtain crude extracts, followed by solid-phase extraction (SPE) for NADES removal and purification. Extracts were analyzed for total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity using ABTS and ORAC assays. Pressurized Liquid Extraction (PLE, 75% ethanol) served as a reference method.

N4 exhibited the highest TPC for *P. anomala* leaves and roots of both species, while PLE yielded the highest TPC for *P. officinalis* leaves. TFC results indicated N2 as the most effective solvent. N4 showed superior ABTS radical scavenging activity across most samples, whereas ORAC trends varied by species. Overall, N4 and N2 provided the most selective antioxidant-rich extracts, supporting the predictive reliability of the HSP model. These findings demonstrate the potential of NADES as sustainable, selective alternatives to conventional solvents and advanced extraction techniques such as PLE.

Keywords: Hansen solubility parameters, *Paeonia officinalis*, *Paeonia anomala*, antioxidant activity, NADES.

Sustainable Bioprocessing of Microalgal Phycocyanin via Fermentation and Freeze-Drying Encapsulation: In *Vitro* Digestion and Storage Stability for Functional Food Applications

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Phycocyanin, a bioactive phycobiliprotein obtained from *Arthrospira platensis*, offers strong potential as a natural colouring agent and antioxidant, yet its susceptibility to degradation during processing and storage restricts wider application. This work examines the fermentation of a phycocyanin-rich extract using *Lactiplantibacillus plantarum* and its subsequent encapsulation with whey protein isolate (WPI) and starch sodium octenyl succinate (OSA-S) through freeze-drying. The resulting lyophilisates were assessed for storage stability and *in vitro* digestibility, focusing on probiotic viability, amino acid bioaccessibility, and antioxidant capacity during digestion.

The WPI-encapsulated sample exhibited higher probiotic survivability during the intestinal phase, reaching 6.2 log CFU/g. Amino acid release was observed during the intestinal phase, accompanied by increased antioxidant capacity, which may be attributed to the release of bioactive peptides. During 50 days of storage, phycocyanin in the WPI-formulated sample remained highly stable (~95% retention). Refrigerated and frozen storage conditions were the most effective for maintaining probiotic viability (98% retention). Overall, WPI encapsulation proved to be an effective approach for improving probiotic viability, bioactive functionality during digestion, and phycocyanin stability during storage, supporting its potential application in functional foods.

Keywords: Phycocyanin, Fermentation, Encapsulation, *In vitro* digestion

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Production of food waste derived - graphitic porous carbon as anode electrode for supercapacitors

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Turkey is one of the largest grape producers worldwide, with a significant portion of the grapes being consumed as table dry grapes. Dry grapes are often at risk of aflatoxin formation, which results in severe toxic and carcinogenic threat to human and animal health. Aflatoxin-containing dry grapes needs to directly be disposed, mostly by burning. Alternatively, dry grapes wastes can be converted into valuable products through thermochemical conversion processes. In this work, we aimed to produce graphitized porous carbon(GPC) through hydrothermal carbonization (HTC) of dried grape wastes, followed by one-step chemical activation-graphitization. For this purpose, DPW was hydrothermally carbonized at different temperatures (200-250 °C) and duration(1-8h). The best HTC performance was achieved at 200 °C for 6 hours, producing a high-yield, uniform hydrochar. Microscopic analysis revealed that the high sugar content in the grape waste promoted secondary char formation through polymerization reactions. Subsequent activation and graphitization with K_2CO_3 and $FeCl_3$ at 700–900 °C improved the porosity as well as graphitic order of the carbon material. When tested in supercapacitor cells, GPC produced at 700 °C exhibited the highest specific capacitance of 120 F g^{-1} at a scan rate of 10 mV s^{-1}in 1 M $EMIMBF_4$ electrolyte. Overall, this work presents a bio-circular approach to valorize grape waste into high-performance carbon materials for energy storage applications.

Keywords: Aflatoxin-containing dry grapes, hydrochar, graphitized porous carbon, supercapacitor

Magnetically responsive cereal byproducts: Preparation and application

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Cereal byproducts are the secondary materials left after processing corresponding grains. Common examples include straw, bran, germ, hulls, brewers' spent grains or distillers' grains. They are often used in animal feed, as food ingredients, and for various industrial applications due to their fiber, protein, and nutrient content.

Appropriate modification of cereal byproducts can substantially increase their application potential. Magnetic modification of diamagnetic cereal byproducts enables their easy recovery from complex systems using external magnetic field. Magnetic modification is usually based on the attachment of ferrimagnetic iron oxides nano- and microparticles on the surface or within the pores of the treated material. Magnetic modification can be performed using different procedures, e.g., by magnetic fluid treatment, mechanochemical synthesis and by direct or indirect microwave assisted synthesis. Magnetically responsive cereal byproducts have been efficiently used as biosorbents for the removal of wide variety of pollutants (e.g., organic dyes, heavy metal ions, radionuclides or bacterial signal molecules) from contaminated water resources. In addition, magnetically modified cereal byproducts can be used as biocompatible, low-cost carriers for the immobilization of enzymes and other catalysts.

Keywords: cereal byproducts; magnetic modification; magnetic biosorbents; magnetic carriers

Valorization of Mandarin Juice Byproducts through Freeze-Dried Encapsulation of Phenolic Compounds

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This study investigated the use of maltodextrin (MD), gum arabic (GA), and carboxymethylcellulose (CMC), applied in various ratios, as coating materials for the encapsulation of phenolic compounds derived from mandarin juice byproduct (citrus pomace). Phenolic-rich extracts were obtained using ultrasound-assisted extraction and subsequently encapsulated via freeze drying. The resulting microcapsules were evaluated in terms of encapsulation efficiency and their physical and chemical properties. The choice of wall materials significantly influenced encapsulation efficiency, retention of phenolic constituents, and reconstitution behavior. Encapsulation efficiencies ranged from 50.909% to 84.000%, with CMC addition playing a key role in improving performance. Reconstitution parameters, particularly the water absorption index (WAI) and water solubility index (WSI), exhibited a broad range, suggesting potential differences in release mechanisms among formulations. HPLC analysis confirmed the presence of three major phenolic compounds: hesperidin, naringin, and rutin. A wall material mixture containing MD, GA, and CMC in equal proportions proved optimal for freeze drying, yielding microcapsules with low moisture content (1.936 ± 0.012%) and low water activity (0.110 ± 0.001), indicative of extended stability. Overall, the findings demonstrate that freeze drying is a promising encapsulation technique for recovering valuable compounds from citrus byproducts while protecting them from environmental stressors and gastrointestinal degradation.

Keywords: citrus pomace, citrus, encapsulation

Biocompatible Ionic Liquids for Green Valorization of Raspberry Pomace

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Raspberry is a high-value berry fruit characterized by an intense flavor and notable nutritional and health-promoting properties, largely due to its high content of bioactive compounds (polyphenols, flavonoids, anthocyanins). These bioactives are associated with anti-inflammatory, antioxidant, and anti-diabetic effects. However, the fragile nature and short shelf life of raspberries often necessitate their processing into products like juices, wines, jams, and syrups, generating large quantities of raspberry pomace (mainly seeds and residual pulp) that are typically treated as low-value agricultural waste. In this work, raspberry pomace is investigated as a renewable source of valuable bioactive compounds using an environmentally benign extraction strategy. A series of hydrophilic and hydrophobic choline-based ionic liquids were synthesized and evaluated as alternative, low-toxicity solvents. Direct extraction from the solid matrix was performed under ultrasound-assisted conditions. Quantification of bioactive compounds were performed spectrophotometrically or HPLC analysis. The results demonstrate that choline-based ionic liquids enable efficient and green extraction of bioactives from raspberry pomace, confirming their suitability as alternative solvents for the valorization of berry-processing residues. Overall, this study highlights the potential of converting an underutilized agro-industrial by-product into a valuable source of health-relevant compounds, thereby supporting more sustainable and circular practices in the berry processing sector.

Acknowledgment

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Keywords: Ionic liquids, Raspberry pomace, Valorization

Synergistic Phenolic Transfer from EVOOs and Upcycled Pomace Flour Improves Oxidative Stability and Sensory Quality in Air-Fried Foods

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Olive oil production generates substantial by-products, with pomace remaining underutilised despite its high phenolic content. Sustainable strategies to incorporate this matrix into food systems are still limited. For the first time, this study evaluated the combined effect of pomace flour and extra virgin olive oils (EVOOs) on the oxidative stability, nutritional quality, and sensory perception of air-fried foods. Fresh olive pomace was dried and milled into fine powder. Chicken and hake were breaded using either commercial whole-wheat flour or pomace-enriched flour (EF, 10% w/w), and air-fried with ordinary olive oil (OOO) or EVOOs from *cvs*. Arbequina (AR) and Picual (PI), following a 2 × 2 × 3 factorial design. LC-MS/MS analysis of cooked samples revealed foods contained 93.23–133.67 mg/kg of total phenolic compounds with predominance in hydroxytyrosol and its derivatives. Lipid oxidation decreased in EF-breaded chicken (↓56%), from 1.252 mg MDA/kg (OOO-control) to 0.544 mg MDA/kg (PI-EF), with similar reductions in hake (↓31%). Sensory evaluation (9-point hedonic scale) showed improved aroma, taste, texture, and overall acceptability in EF samples prepared with EVOOs, particularly PI. These findings show that combining EVOOs with pomace flour improves nutritional quality and consumer liking while reducing waste, supporting sustainable strategies in food innovation.

Keywords: Extra Virgin Olive Oil; Phenolic Compounds; Olive Pomace; Lipid Oxidation; Consumer Acceptance

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Designing PVA-CNF-MOF Composite Films for Active Packaging: Improving Mechanical Strength, Barrier Properties, and Stability in Fresh Produce Preservation

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Food waste is a significant global issue, with nearly 40% of food discarded annually, contributing to economic losses, food insecurity, and environmental damage. The primary factors behind food spoilage include microbial contamination, enzymatic activity, oxidation, and excessive ethylene production. Active packaging has emerged as a promising approach to prolong shelf life by selectively absorbing or releasing specific substances. In this study, polyvinyl alcohol (PVA) films containing metal-organic frameworks (MOFs) were synthesized via solvent casting to improve their mechanical and barrier properties. Five different MOFs—HKUST-1, MIL-88A, BASF-A520, UiO-66, and MOF-801—were incorporated into the PVA matrix and analyzed for their physical, mechanical, and optical properties. The addition of TEMPO-oxidized cellulose nanofibers (CNF) enhanced the dispersion of MOFs within the matrix, significantly boosting film performance. Among the different formulations, the PVA-CNF-MOF-801 composite demonstrated the best performance, showing a 130% increase in tensile strength, a 50% decrease in water vapor permeability, and a 168% improvement in UV protection compared to neat PVA films. Ethylene adsorption tests with climacteric fruits showed that CNF-containing films effectively retained ethylene, although differences among the MOFs were minimal. These findings suggest that PVA-CNF-MOF composite films hold great potential as sustainable active packaging materials, offering an effective strategy to reduce food waste and mitigate its environmental impact.

Keywords: metal-organic frameworks; cellulose nanofibers; flexible films; active packaging

Optimization of Reusable NADES formulations to enhance the Recovery, Stability and Bioactive Properties of Anthocyanins from Vegetal Biomass

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The sustainable valorization of agri-food residues represents a crucial step toward circular bioeconomy. In this context, grape pomace (GP)—a rich but underutilized source of anthocyanins and phenolics—was used to explore Natural Deep Eutectic Solvents (NADES) as greener extraction systems. This study systematically evaluated 27 NADES combinations, designed by pairing choline chloride (HBA) with citric, oxalic, and lactic acids (HBDs), against conventional ethanolic solvents. The optimal formulation, OxA(1:1)25, yielded up to twice the total phenolic content and five times higher anthocyanin recovery compared to EtOH-based extracts. Furthermore, NADES-derived extracts exhibited remarkable antioxidant potential and a clear bactericidal effect against foodborne pathogens—an outcome not observed in ethanolic counterparts—significantly reducing MIC values as well.

Beyond extraction efficiency, NADES provided outstanding stabilization of anthocyanins under degrading conditions of light and temperature, maintaining color and integrity where organic solvents failed. Importantly, OxA(1:1)25 could be reused in four consecutive extraction cycles without loss of performance, reinforcing its eco-efficient character. The halochromic response of NADES-extracted pigments further demonstrated their potential as pH-sensitive freshness indicators for potential inclusion in smart (active and intelligent) packaging. Altogether, this work highlights NADES as a transformative, recyclable, and multifunctional platform for sustainable recovery and stabilization of natural colorants.

Keywords: Valorization, NADES, Anthocyanins, Food packaging

Tailoring Curcumin Bioaccessibility through Wheat-Straw (Ligno)Cellulose Nanofiber-Stabilized Pickering Emulsion

(Times New Roman 14 font; Bold, centered)

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To improve the administration of lipophilic bioactives such as curcumin, stabilization strategies are required that improve both physical stability and gastrointestinal solubility. This work explores oil-in-water Pickering emulsions (PEs) stabilized by cellulose and lignocellulose nanofibers derived from wheat straw (CNF and LCNF), evaluating how the composition, morphology, and surface charge of the fibers influence emulsion performance and curcumin bioaccessibility. Nanofibers produced by chemical pretreatment (TO) showed higher surface charge and specific surface area, enabling efficient droplet coverage and long-term stability at concentrations as low as 0.25% w/w. CNF-TO-stabilized emulsions exhibited the smallest droplet sizes (<5 μm), lowest creaming index (<1%), and highest viscosity, reflecting the formation of a dense interfacial network. The addition of curcumin further reduced droplet size, improving structuring and delaying separation. Both CNF-TO and LCNF-TO systems achieved encapsulation efficiencies greater than 90% and effectively protected curcumin from light-induced degradation.

In vitro digestion demonstrated a substantial increase in curcumin bioaccessibility compared to the free compound, reaching 45.5% for CNF-TO and 22.3% for LCNF-TO, highlighting the superior interfacial organization of lignin-free fibers. Although the moderate polydispersity of the droplets limited long-term stability, these nanofiber-stabilized PEs provide a surfactant-free, renewable, and highly effective platform for enhancing the functionality of lipophilic bioactives in food applications.

Keywords: Curcumin; Pickering emulsion; Encapsulation; Lignocellulose nanofibers; Bioaccessibility

Valorization of prickly pear seeds in the formulation of biscuits: modelling of consumer acceptability by regression analysis and artificial neural networks

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Abstract

Biscuit consumption reflects a blend of tradition, health-conscious choices, and modern snacking habits. This study aims to explore the ability of prickly pear seeds (PPS) to partially replace wheat flour in the biscuit formulations at different percentages. The incorporation of PPS (considered as a waste) into biscuit diminishes the fiber intake deficiency and considerably increases the level of proteins and polyphenol contents. A decrease in both the diameter and spread ratio and an increase in the thickness were noted with the increase of the incorporation percentage of PPS in biscuits. Biscuits of acceptable quality could be prepared by substituting wheat flour by 15% PPS.

The overall acceptability of the biscuit was evaluated by panelists. A mathematical model was used to analyze the biscuit acceptability by multiple linear regression analysis (MLR) and artificial neural networks (ANN). Principal component analysis of data indicated that color and seed percentage represent more than 57% of the totality of variability. The prediction of consumer overall acceptability by ANN technique (R^2=99.16%) was more accurate in comparison with MLR (R^2=67%).

Keywords:

Prickly pear seeds; biscuits; sensory evaluation, multiple linear regression, artificial neural networks

From Waste to Value: Mandarin Peel Powder in Cookies

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Abstract

Food waste valorization offers innovative opportunities to transform discarded by-products into valuable food ingredients. This study investigates the incorporation of mandarin peel powder into cookie formulations, assessing its impact on nutritional composition, physicochemical stability, and sensory acceptance. Results demonstrated that cookies enriched with mandarin peel powder contained higher levels of energy, proteins, fats, fiber, and vitamin C compared to control samples. Physicochemical parameters such as moisture content, water activity, acidity, and pH showed improved stabilization, supporting extended shelf life. Sensory evaluation revealed positive consumer acceptance, confirming the feasibility of integrating citrus by-products into baked goods. By converting mandarin peels from waste into functional components, this research highlights the dual benefits of enhancing dietary quality and reducing environmental burdens. This research highlights the potential of mandarin peel as a valuable resource for improving the quality of baked products, combining nutritional benefits with the reduction of food waste.

Keywords: Food waste valorization; Mandarin peel powder; Cookies; Nutritional enhancement; Physicochemical stability; Sustainability

Mustard by-products as a source of selenium and bioactive compounds (glucosinolates and isothiocyanates)

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Brassica carinata (Ethiopian mustard) and *Sinapis alba* (white mustard) are two cruciferous varieties widely cultivated for seed production. They are a dietary source of isothiocyanates (ITCs), a group of bioactive compounds, present almost exclusively in plants of the *Cruciferae* family, to which they belong. These ITCs are produced from other precursors, which are the glucosinolates (GLS). Nevertheless, their green parts (leaves and stems) are also rich in three GLS: sinigrin (18.42 μmol/g); glucotropaeolin (12.41 μmol/g); and sinalbin (21.34 μmol/g) which are the precursors of allyl-ITC; benzyl-ITC; 4-hydroxi-benzyl-ITC, respectively. These compounds have been extensively studied, particularly due to their antioxidant, anti-inflammatory, and anti-cancer properties.

These by-products have also shown to be an excellent dietary source of selenium (0.22 and 2.12 μg/g). These trace element plays a significant role in human nutrition, forming part of the active site of glutathione peroxidase, one of the main antioxidant enzymes. Besides, these cruciferous vegetables are among the few vegetables that have the ability to methylate Se organic forms, which have shown to have higher bioactivity

The potential for valorising the green tissues of mustard seeds production (typically considered waste) makes them suitable ingredients for use in the formulation of new functional foods

Keywords: Cruciferous, Antioxidant, Anti-cancer, Bioaccessibility

Upcycling Fish Side Streams into Protein Hydrolysates Using Nanofiltration Technology

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The world fisheries and fish farming industries generate huge amounts of side-streams, which could account for up to 75% of total fisheries production. This includes heads, backbones and viscera after the filleting process. If treated appropriately, these can be upcycled into ingredients for food applications. One promising route is the use of commercial enzymes to produce fish protein hydrolysates (FPH). However, one of the major challenges in the adoption of FPH is the often associated unpalatable and unpleasant tastes and flavours, and the presence of unwanted compounds such as NaCl (saltiness) and trimethylamine (TMA) (fishy smell). In recent years, refining and purification of hydrolysates by membrane filtration has gained increasing interest. By applying filters with specific molecular weight cut-offs (MWCO), products of different properties may be produced.

The aim of the project was to produce protein hydrolysates from salmon heads and cod backbones, and to refine the hydrolysates using membrane filtration technology to reduce flavour intensity while retaining nutritional and bioactive properties. Two nanofiltration cut-offs were used with MWCO of 1000 and 200 Da. The obtained hydrolysates and nanofiltration retentates were analysed for chemical composition and sensory properties (by a trained panel of 10 assessors) to find the optimal process.

Nanofiltration significantly reduced NaCl and TMA contents, as well as the overall flavour and salty taste intensities. The 200 Da filter was more effective at reducing salt and free amino acids than the 1000 Da filter, indicating that nanofiltration of protein hydrolysates is a complex process.

A simple digital tool for tracking grape pomace flows in small wineries of Herzegovina

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Grape pomace is a key agro-food by-product in wine-producing regions and a relevant hotspot of food loss and waste (FLW). Small and medium wineries in Herzegovina often handle pomace in a traditional way, with limited and non-standardised recording of quantities and destinations. This contribution presents a light, easy-to-implement digital framework for basic monitoring of grape-pomace flows that can be adopted by wineries and research institutions without additional hardware or sensors. The approach is based on a standardised Excel/Google Sheets template that captures essential data fields: processed grape quantity, estimated pomace quantity, process step, date and batch, current use (e.g. discard, animal feed, compost, other) and final destination. The template is co-designed with winery staff to fit existing workflows and to minimise extra workload. Built-in formulas and charts automatically generate simple indicators (e.g. total pomace per harvest, share of each destination, seasonal patterns). Expected outcomes include a replicable data structure for grape-pomace FLW, user-friendly guidelines for wineries, and practical examples of basic dashboards for internal decision-making and communication with stakeholders. The case study supports WG5 on cross-cutting strategies and smart systems and interfaces with WG3 (quantification) and WG4 (valorisation), while remaining accessible for small operators with limited digital capacity.

Keywords: grape pomace; food loss and waste; digital template; Excel; wineries; circular bio-economy

The Multidimensional Impacts of Tourism on Quality of Life: A Food Waste–Oriented Perspective

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Abstract

The tourism sector, while generating significant economic and socio-cultural benefits, is also responsible for substantial levels of food loss and waste, particularly within accommodation and food service operations. Tourism-related food waste contributes to inefficient resource use, increased environmental pressures, and rising operational costs, thereby exerting multidimensional impacts on quality of life, encompassing economic, social, cultural, and environmental dimensions. Service formats such as open buffets, demand uncertainty, portion sizes, and tourist consumption behaviors are among the key drivers intensifying food waste generation in tourism settings.

This study aims to examine the multidimensional impacts of tourism on quality of life through a food waste–oriented perspective. Adopting a conceptual and literature-based approach, the study synthesizes empirical findings from hotel, restaurant, and destination-level research to identify the main sources, drivers, and consequences of tourism-related food waste. Particular attention is given to the role of tourist behavior and operational practices in shaping waste generation patterns.

The findings indicate that food waste significantly undermines the positive contributions of tourism to quality of life. Conversely, targeted prevention strategies, food recovery practices, and circular economy–based solutions have the potential to reduce environmental impacts, lower operational costs, and enhance social acceptance of tourism among host communities. In this regard, tourism emerges as a **critical intervention sector** for food waste reduction.

Aligned with the objectives of COST Action FoodWaStop, this study highlights the importance of integrating food waste prevention into tourism planning and management processes to support sustainable destinations, improved community well-being, and long-term tourism resilience.

Keywords:

Tourism; Quality of Life; Food Waste; Sustainability; FoodWaStop; COST Action

A Circular Bioeconomy Network for Agrifood Waste Management and Valorisation in Italy

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Agrifood waste management and valorisation are central challenges for advancing sustainability and circularity in European food systems. Building practice-oriented networks is essential to promote knowledge exchange, support innovation uptake, and empower local actors. In line with the objectives of COST Action CA22134 FoodWaStop, the thERBN project contributes to this mission by establishing a circular bioeconomy network in Italy, focusing on agrifood waste prevention, management, and valorisation.

thERBN operates as a multi-actor platform facilitating knowledge transfer and collaboration among farmers, foresters, practitioners, scientists, and rural stakeholders. Activities in Italy include: (i) mapping urgent needs, existing practices and baseline conditions for agricultural residues and agrifood waste; (ii) organising targeted training sessions and demonstration activities on sustainable waste handling and circular bioeconomy solutions; (iii) expanding the ERBN community through engagement with national Operational Groups, EU initiatives, and regional networks; and (iv) disseminating results and good practices through events and outreach actions.

By strengthening cooperation, enhancing practical knowledge, and promoting adoption of circular bioeconomy solutions, thERBN contributes to a sustainable, inclusive, and practice-driven network for agrifood waste management in Italy, offering insights that can complement the goals of FoodWaStop and other European initiatives.

Keywords: circular bioeconomy, agrifood waste management, waste valorisation, multi-stakeholder network