GreenNutriFood 2025

April 7th - 9th

BOOK OF ABSTRACTS

1ST INTERNATIONAL CONGRESS ON SUSTAINABLE FOOD, GREEN CHEMISTRY AND HUMAN NUTRITION

Dubrovnik riviera, Croatia

faculty of food technology and biotechnology
University of Zagreb

GreenNutriFood

Universitat de València
Facultat de Farmàcia

faculty of food technology and biotechnology
University of Zagreb

VNIVERSITAT DE VALÈNCIA
Facultat de Farmàcia i Ciències de l'Alimentació

University of Zagreb, Faculty of Food Technology and Biotechnology

Universitat De València, Faculty of Pharmacy and Food Sciences

1st International Congress on Sustainable Food, Green Chemistry and Human Nutrition

GREENNUTRIFOOD2025

Book of Abstracts

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07. – 09.04.2025.

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Introductory word

Dear colleagues and friends,

On behalf of Mladen Brncic, Full Prof. from the Faculty of Food Technology and Biotechnology, University of Zagreb, (Croatia) and Francisco J. Barba, Full Prof. from the Faculty of Pharmacy and Food Sciences, Universitat de València (Spain), we are delighted to invite scientists from academia and industry to join **the 1st International Congress on Sustainable Food, Green Chemistry and Human Nutrition (GreenNutriFood 2025)** which will take place on the stunning Dubrovnik Riviera, the beautiful surroundings of the UNESCO-protected city of Dubrovnik, Croatia. We are so excited to meet all of you and to share the new research advances and latest scientific knowledge in food science and technology, human nutrition, and green chemistry.

In light of the push towards a circular economy, particularly in the food sector due to the growing food waste problem, various efforts have been made to align company strategies with the European Green Deal and the Sustainable Development Goals. Developing green, innovative, and sustainable processes to accelerate the transition to sustainable food systems that ensure food security, proper nutrition, and adherence to green chemistry principles is more relevant than ever. **GreenNutriFood 2025** will showcase the latest scientific discoveries, technologies, and methodologies for creating new ingredients and foods.

We're excited to welcome you to Dubrovnik, a vibrant, sun-soaked city renowned for its rich historical and cultural heritage! We look forward to meeting you in person!

Yours sincerely,

Chairs of the Conference

Prof. Dr. Mladen Brnčić

Prof. Dr. Francisco José Barba

Congress Program

Sunday, April 6th 2025

18:00 – 20:00	**Registration**
20:00	**Welcome cocktail party**

Monday, April 7th 2025

8:00 – 9:00	**Registration**
9:00 – 9:30	**Opening of the GreenNutriFood 2025 Conference**
9:30	**Session I**
Topic	**Consumer behavior and sustainable eating** **Chair: Barba Francisco J.** **Brnčić Mladen**
9:30 – 10:05 **Plenary Lecture**	**Da-Wen Sun, Ireland** **GREEN HYPERSPECTRAL IMAGING TECHNOLOGY FOR EFFICIENT NONDESTRUCTIVE EVALUATION OF FOOD QUALITY AND SAFETY**
10:05 – 10:40 **Plenary Lecture**	**Vodnar Dan, Romania** **MOLECULAR GASTRONOMY AND MODERN BIOTECHNOLOGICAL PROCESSES INVOLVED IN THE DEVELOPMENT OF VALUABLE COMPOUNDS**
10:40 – 10:55	**Jönsson Madeleine, Sweden** Historical grains in modern gastronomy: a case study of artisan breads
10:55 – 11:10	**Kušar Anita, Slovenia** Enhancing consumer awareness of sustainable food choices: integrating the eu organic logo into the VKJ mobile app
11:10 – 11:25 **Sponsor Lecture**	**Anton Paar - Valenčak Branimir** **Supercritical CO_2 - green extraction on industrial scale**
11:25 – 12:00	**Coffee break**

Topic	**Innovative Food Technologies for Sustainability** **Chair: Da-Wen Sun** **Ninčević Grassino Antonela**
12:00 – 12:35 **Plenary Lecture**	**Meléndez-Martínez, Antonio J., Spain** **SUSTAINABLE PRACTICES FOR THE OBTAINING OF CAROTENOID-RICH PRODUCTS**
12:35 – 12:55 **Invited Lecture**	**Elez Garofulić Ivona, Croatia** **Innovative waste utilization in berry processing: focus on aronia berries**
12:55 – 13:10	**Franca Adriana Silva, Brazil** Renewable biopolymers for food packaging: improving hidrophobicity, mechanical and barrier properties
13:10 – 13:25	**Oliveira Leandro, Brazil** Agricultural residues as a source of renewable biopolymers for food packaging: combining waste-based protein and pectin
13:25 – 13:40 **Sponsor Lecture**	**Ru-Ve – Runje Hrvoje** **Your Lab Partner**
13:40 – 15:00	**Lunch Break** (Lunch not included in registration fee)

15:00	**Session II**
Topic	**Innovative Food Technologies for Sustainability** **Chair: Vodnar Dan** **Badanjak Sabolović Marija**
15:00 – 15:35 **Plenary Lecture**	**Barba Francisco J., Spain** **ENHANCING THE NUTRITIONAL AND FUNCTIONAL PROPERTIES OF WHEAT-BASED BEVERAGES THROUGH INNOVATIVE PRETREATMENTS AND LACTIC ACID BACTERIA FERMENTATION**
15:35 – 15:55 **Invited Lecture**	**Milčić Nevena, Croatia** **Application of reaction engineering principles for the improvement of synthetic biocatalytic processes**
15:55 – 16:10	**McMackin Amy, Switzerland** From bitter to better: towards enhanced plant proteins using natural deep eutectic solvents
16:10 – 16:25 **Sponsor Lecture**	**KOBIS - Ivan Bilić** **Reducing Waste in Food Formulation: Predicting Instability Early with Turbiscan**

16:25 – 17:00	**Coffee break**
Topic	**Functional food and nutraceuticals in human nutrition** **Chair: Castagnini Juan Manuel** **Hadnađev Miroslav**
17:00 – 17:15	**Silva Luís R., Portugal** Functional and nutraceutical potential of plants from serra da estrela natural park: insights into antidiabetic, antioxidant, and anti-inflammatory activities
17:15 – 17:30	**Mnayer Dima, Lebanon** Development of healthy gluten-free double-layer pita bread: nutritional, technological and sensorial properties
17:30 – 17:45	**Silva Luís R., Portugal** Phytochemical profiling and anti-inflammatory potential of unexplored vegetal parts of sweet cherry
17:45 – 18:00	**Arjun Muthu, Hungary** Biosynthesis of selenium and tellurium nanoparticles and their alloys using Lactobacillus casei: a sustainable approach to functional nutraceuticals
18:00 – 18:15	**Degenek Jovana, Serbia** Wild thyme (Thymus Serpyllum l.): its impact on composition and texture in an innovative fresh cheese formulation
18:15 – 19:00	**Poster Session 1**

Tuesday, April 8th 2025

9:00	**Session III** **Under Auspices of Platinum sponsor BÜCHI**
Topic	**Food waste reduction and circular economy** **Chair: Meléndez-Martínez Antonio J.** **Elez Garofulić Ivona**
9:00 – 9:35 **Plenary Lecture**	**Cravotto Giancarlo, Italy** **SMART PROCESSES AND TECHNOLOGIES FOR THE INDUSTRIAL UPCYCLING OF AGRI-FOOD BY-PRODUCTS**
9:35 – 10:10 **Plenary Lecture**	**Dapčević Hadnađev Tamara, Serbia** **FROM MACRO TO NANO: SHIFTING PERSPECTIVES ON FOOD WASTE**
10:10 – 10:30 **Invited Lecture**	**Ćurko Natka, Croatia** **Effect of ultrasound pretreatment on the concentration of lipophilic and hydrophilic antioxidants in cold pressed grape seed oil produced from wine waste**
10:30 – 10:45	**Doğan Yağmur Nil, Turkey** Biofilm formation power of escherichia coli in dairy farms
10:45 – 11:00	**Poklar Ulrih Nataša, Slovenia** Utilizing food waste for bioactive compound recovery
11:00 – 11:30	**Coffee break**
Topic	**Food waste reduction and circular economy** **Chair: Calvo Lerma Joaquim** **Gai Francesco**
11:30 – 11:50 **Invited Lecture**	**Montarop Yamabhai, Thailand** **Valorization of chitinous waste from marine bioresources into functional oligosaccharides by green technology**
11:50 – 12:05	**Moral Raúl, CIAGRO-UMH, AGROALNEXT, Spain** **What AGROALNEXT is?**
12:05 – 12:25 **Invited Lecture**	**Salgado-Ramos Manuel – AGROALNEXT, Spain** **Supercritical CO_2 ($SCCO_2$) enabling sustainable food systems based on discarded tiger nuts (tn): from lab – to pilot scale**
12:25 – 12:40	**López Maria J. – AGROALNEXT, Spain** Characterisation and potential application of olive oil mil wastewater sludge for sustainable agriculture
12:40 – 12:55	**Suárez-Estrella Francisca – AGROALNEXT, Spain** Phytostimulation and phytoprotection strategies based on the application of the microbiota from olive oil mill wastewater sludges

12:55 – 13:10	**Levizou Efi, Greece** Circular economy in agricultural production: a tri-trophic system incorporating plants, fish, and insects turns waste into resource
13:10 – 13:25	**Cabrera-Barjas Gustavo, Chile** Suillus luteus (L. Fries) mushrooms as a source of chitin nanofibers for active food packaging applications
13:25 – 14:30	**Lunch Break** (Lunch not included in registration fee)
14:30	**Session IV** **Under Auspices of Platinum sponsor BÜCHI**
Topic	**Food waste reduction and circular economy** **Chair: Cravotto Giancarlo** **Milčić Nevena**
14:30 – 15:00 **Sponsor Lecture**	**BÜCHI - Lejla Juranić / Zvonimir Kodba** **What are We Throwing Away Today?** 1. Valorization of Food Residues: Sustainable Extraction of Bioactive Molecules 2. The New Approach to Chemical Oxygen Demand Monitoring 3. Water Activity: A Key Parameter for Sustainable Food Stability
15:00 – 15:15	**Martin Diana, Spain** Use of insects for the bioconversion of agri-food waste into products with high added value rich in bioactive compounds for human and animal health
15:15 – 15:30	**Jurado Macarena M., Spain** Valorization of agri-food waste through the production of compost extracts as a sustainable tool for protection against airborne pathogenic fungi
15:30 – 15:45	**D'Agostino Giulia, Italy** Antimicrobial effect of polyphenols extract from artichokes roots
15:45 – 16:00	**Aimone Clelia, Italy** Sustainable valorization of blueberry by-products: exploring the bioactive potential of anthocyanins and polyphenols
16:00 – 16:15	**Duyen H.H. Nguyen, Hungary** Upcycling food waste into carbon dots: a sustainable approach for green nanotechnology
16:15 – 16:30	**Pantić Jovana, Serbia** Influence of satureja montana l. essential oil addition on plum-oil cake based biofilms properties
16:30 – 17:30	**Poster Session 2**
21:00	**Gala Dinner** (dinner not included in registration fee)

Wednesday, April 9th 2025

9:00	**Session V**
Topic	**Plant-based and alternative proteins** **Chair: Dapčević Hadnađev Tamara** **Rimac Brnčić Suzana**
9:00 – 9:35 **Plenary Lecture**	**Gai Francesco, Italy** **ALTERNATIVE PROTEINS: LIGHTS AND SHADOWS OF THE PROTEIN TRANSITION**
9:35 – 9:50	**Pavlić Martina, Croatia** Evaluating the public health impact of plant based alternatives: a risk-benefit assessment to guide the protein transition
Topic	**Microbiome and gut health in sustainable nutrition** **Chair: Dapčević Hadnađev Tamara** **Rimac Brnčić Suzana**
09:50 – 10:10 **Invited Lecture**	**Calvo-Lerma Joaquim, Spain** **Assessing the impact of food and biotics on gut microbiome through in vitro fermentation models**
10:10 – 10:25	**Kušar Anita, Slovenia** Functional foods for constipation management: eu legislative and scientific challenges
10:25 – 10:40	**Martău Gheorghe-Adrian, Romania** In vitro and extended colonic digestion of sea buckthorn: assessing the bioaccessibility and bioavailability of bioactive compounds
10:40 – 10:55	**Chrysanthi Mitsagga, Greece** Beneficial effects of natural feed additives from olive fruit, pomegranate peels and grape pomace on growth, gut microbiome and meat quality of broilers
10:55 – 11:30	**Coffee break**
Topic	**Sustainable seafood and marine resource management** **Chair: Salgado-Ramos Manuel** **Radosević Kristina**
11:30 – 11:45	**Martins Valter, Portugal** Biodegradable films with polysaccharides and bioactives from lobosphaera
11:45 – 12:00	**Turrini Federica, Italy** Effective strategies for the sustainable valorization of fishery by-products: insights from the H2020 ecoefishent project

Topic	**Green chemistry in the food industry** **Green chemistry in food additives and preservatives** **Chair: Salgado-Ramos Manuel** **Radosević Kristina**
12:00 – 12:20 **Invited Lecture**	**Kučić Grgić Dajana, Croatia** **Sustainable bioplastics: producing phas from agro-industrial waste via solid-state fermentation**
12:20 – 12:35	**Kostelac Anja, Austria** Green chemistry from an enzymologist´s point of view: a study of pyranose oxidase and β-galactosidases
12:35 – 12:50	**Biočić Maja, Croatia** Sequential injection analysis: a reliable method for penicillamine quantification in pharmaceutical preparations
12:50 – 13:05	**Tardugno Roberta, Italy** Exploring sea asparagus antioxidant nades-uae extracts
13:05 – 13:20	**Calinoiu Lavinia Florina, Romania** Phytobiotic essential oils as antibiotic alternatives in aquaculture: antimicrobial and antioxidant properties of garlic, thyme, rosemary, and eucalyptus
13:20 – 13:50	**Coffee break**

Topic	**Green chemistry in the food industry** **Green chemistry in food additives and preservatives** **Policies and regulations for sustainable nutrition** **Chair: Montoya Patricia Roig** **Ćurko Natka**
13:50 – 14:10 **Invited Lecture**	**Radošević Kristina, Croatia** **Deep eutectic solvents and their applicability in food protein utilization**
14:10 – 14:25	**Jesenko Erika, Slovenia** Apples as a natural biosynthetic tool for aroma production
14:25 – 14:40	**Giavasis Ioannis, Greece** Characterization of indigenous microflora and quality parameters of natural Greek red wine, produced with natural antioxidants, without use of sulphites and starter cultures
14:40 – 14:55	**Pavlinović Silvana, Croatia** Marketing and ethics of food labeling: case study
14:55 – 15:10	**Ouaddane Alami Mohammed, Morocco** Marketing and ethics of food labeling: case study
15:10 – 15:40	**Awards and Closing Ceremony**

Contents

PLENARY LECTURE

PL - 1

SUSTAINABLE PRACTICES FOR THE OBTAINING OF CAROTENOID-RICH PRODUCTS

Meléndez-Martínez Antonio J

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Abstract

Carotenoids are widespread and versatile isoprenoid compounds with applications in different industries, including agri-food, pharma and cosmetics. They are key for food production given their essential roles in photosynthesis, pollination and seed dispersal, not to mention the many actions of their derivatives (usually termed apocarotenoids), some of which are phytohormones (abscisic acid, strigolactones) regulating many processes in plants contributing to resilience and development. In this revision, studies on sustainable practices for the production of carotenoid-products in which our team has participated are summarized. Some dealt with the influence of hydro-sustainable practices for the production of several tomato cultivars. Others with the application of high-pressure homogenization for the obtaining of citrus juices with markedly enhanced carotenoid bioaccessibility. More recently, attention is paid in our team to the production of carotenoid-rich insect powders from agri-food residues. Last, studies on ultrasound-assisted extraction of microalgal carotenoids with emerging biosolvents are commented, as well as more sustainable cooking practices to enhance carotenoid bioavailability.

Keywords: Deficit irrigation, high pressure homogenization, insects, ultrasounds

PL - 2

SMART PROCESSES AND TECHNOLOGIES FOR THE INDUSTRIAL UPCYCLING OF AGRI-FOOD BY-PRODUCTS

Cravotto Giancarlo

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Abstract

The valorisation of by-products from the agri-food industry has become a key strategy for advancing the circular economy, reduce environmental impact and improve resource efficiency in the food industry. Smart processes and technologies offer innovative solutions for converting these by-products into high-value products such as bioactive compounds, biopolymers, functional ingredients and biofuels. The integration of cutting-edge approaches, including new extraction and processing technologies, green solvents, enzymatic hydrolysis and membrane separation, may lead to a sustainable industrial upcycling. Emphasis is placed on smart control systems, real-time monitoring and data-driven optimisation that enable higher process efficiency and product quality. In addition, the potential of emerging techniques such as subcritical water and supercritical fluid extraction, continuous-flow ultrasound, hydrodynamic cavitation and pulsed electric field treatments may dramatically promote extraction processes. The challenges related to scalability, regulatory frameworks and economic feasibility will also be discussed, and an outlook on future innovations to promote sustainable development will be provided. By utilising enabling technologies, the agri-food sector can significantly reduce waste, diversify revenue streams and contribute to the global transition toward bio-based and circular industries. Relevant case studies on the upcycling of industrial by-products from the agricultural and food industry report on cocoa bean shells [1], hazelnut skins [2], chestnut peels [3], pomegranate peels [4], hemp stalks [5], prickly pears peels and cladodes [6] and grape seeds [7].

[1] Process intensification technologies for the recovery of valuable compounds from cocoa by-products. Innov. Food Sci. Emerg. Technol. 2021, 68, 102601. doi.org/10.1016/j.ifset.2021.102601
[2] Upgrading hazelnut skins: green extraction of polyphenols from lab to semi-industrial scale. Food Chem. 2025, 463, 1, 140999. doi.org/10.1016/j.foodchem.2024.140999
[3] Bioactive Antioxidant Compounds from Chestnut Peels through Semi-Industrial Subcritical Water Extraction. Antioxidants 2022, 11, 988. doi.org/10.3390/antiox11050988
[4] Unlocking the Bioactive Potential of Pomegranate Peels: A Green Extraction Approach. Antioxidants 2023, 12, 1796. doi.org/10.3390/antiox12101796
[5] Preparation of hemp-based biocomposites and their potential industrial application. Polymer Composites 2024, DOI: 10.1002/pc.29206
[6] Mechanochemical preparation of new biocomposites starting from polymers and plant-derived fibres. J. Compos. Sci. 2024, 8, 452. doi.org/10.3390/jcs8110452
[7] Semi-industrial ultrasound-assisted extraction of grape-seed proteins. J. Sci. Food Agric. 2024, 104 (10), 5689-5697. doi.org/10.1002/jsfa.13395

Keywords: enabling technologies, process intensification, subcritical water, flow-ultrasound, pulsed electric field, enzymatic hydrolysis

PL - 3

GREEN HYPERSPECTRAL IMAGING TECHNOLOGY FOR EFFICIENT NONDESTRUCTIVE EVALUATION OF FOOD QUALITY AND SAFETY

Da-Wen Sun

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Abstract

Traditional methods for evaluating food quality and safety, such as chemical analysis, microbiological testing, and physical measurements, often require destructive sampling, are time-consuming, and generate waste. These conventional techniques, while effective, are not sustainable and may not be suitable for large-scale or real-time monitoring.

Hyperspectral imaging is a nondestructive technology that merges the well-established tools of optical sensing—both imaging and spectroscopy. It not only captures spatial details but also reveals the spectral signature for each pixel in an image, enabling advanced food quality and safety assessment beyond the capabilities of conventional colour imaging systems. Hyperspectral imaging represents a greener, faster, and more efficient alternative to conventional destructive testing, paving the way for its broader adoption in the food industry for real-time monitoring and quality assurance.

The fusion of spatial and spectral data has propelled hyperspectral imaging to the forefront of technological exploration across various fields. In the food industry, hyperspectral imaging has emerged as a valuable tool, unveiling not just the physical attributes such as colour, size, shape, and texture but also intrinsic chemical and molecular compositions like water, fat, and protein in food products.

This presentation highlights the advantages of hyperspectral imaging over traditional destructive methods in ensuring food safety and quality. The fundamental principles and theoretical foundations of hyperspectral imaging will be presented first, followed by a discussion of representative application examples from our own work and international researchers. These examples range from the detection and evaluation of the quality and safety of muscle foods such as salmon fillets, chicken fillets, pork, ham, minced lamb, and poultry carcasses to the detection, analysis, and grading of fruits like banana, lychee, kiwifruit, pear, citrus, strawberry, and cucumber. Additionally, the visualization of kiwi sugar distribution, the tracking of tomato ripening, and the critical detection of melamine contamination in flour will also be explored.

References

[1] Da-Wen Sun (editor), Computer Vision Technology in the Food and Beverage Industries, Woodhead Publishing Limited, Cambridge, UK, 528 pp., ISBN 978 0 85709 036 2 (2012).
[2] Da-Wen Sun (editor), Hyperspectral Imaging for Food Quality Analysis and Control, Academic Press / Elsevier, San Diego, California, USA, 528pp., ISBN 978-0123747532 (2010).
[3] Da-Wen Sun (editor), Infrared Spectroscopy for Food Quality Analysis and Control, Academic Press / Elsevier, San Diego, California, USA, 424 pp., ISBN 978-0-12-374136-3 (2009).
[4] Da-Wen Sun (editor), Computer Vision Technology for Food Quality Evaluation, Academic Press / Elsevier, San Diego, California, USA, 583 pp., ISBN 978-0-12-373642-0 (2008).34, 276-285.

Keywords: hyperspectral imaging, fruit quality, food safety, nondestructive detection

PL - 4

MOLECULAR GASTRONOMY AND MODERN BIOTECHNOLOGICAL PROCESSES INVOLVED IN THE DEVELOPMENT OF VALUABLE COMPOUNDS

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Abstract

Molecular gastronomy is an interdisciplinary domain that integrates principles of physics, chemistry, and culinary arts to modify the structural and textural properties of food. This avant-garde discipline, formally defined in 1988 by physicists Nicholas Kurti and Hervé This, investigates the biochemical and physicochemical transformations occurring during food preparation. Utilizing advanced techniques such as spherification, emulsification, vacuum cooking, freezing, and lyophilization, molecular gastronomy employs natural polymers, including alginates, celluloses, and gums, to engineer novel food structures and sensory experiences. Over time, this field has evolved into various sub-disciplines, such as molecular cooking, culinary constructivism, and abstract cooking, contributing to the scientific understanding of gastronomy.

A significant advancement within this domain is Note-by-Note (NbN) cooking, conceptualized in 1994, which employs purified chemical compounds rather than conventional food matrices to construct culinary compositions. Inspired by the principles of electroacoustic music synthesis, NbN cooking involves sophisticated extraction methodologies, such as cryoconcentration and gas chromatography, to isolate and reassemble flavor molecules into structured food products. Pioneered by Pierre Gagnaire in collaboration with Hervé This in 2008, NbN cooking enhances food sustainability by optimizing resource utilization and reducing agricultural waste.

Parallel to molecular gastronomy, modern biotechnological interventions facilitate the production of value-added food compounds. Fermentative bioconversion enables the transformation of industrial by-products into bioactive molecules, including bio-vanillin, omega-3 fatty acids, and organic acids. Fermentation techniques further optimize probiotic bacterial cultures for incorporation into functional foods, with microencapsulation technologies enhancing bacterial viability under adverse physiological conditions. Additionally, the antimicrobial and antimutagenic properties of plant-derived extracts have been investigated for their potential applications in food preservation and safety.

The valorization of crude glycerol, a biodiesel industry by-product, represents an environmentally sustainable approach for synthesizing biochemicals such as lactic acid, citric acid, and bioactive metabolites. Advances in fermentation technology have facilitated the extraction and utilization of bioactive compounds from agro-industrial waste, thereby promoting circular economy principles in food production. Furthermore, the development of functional probiotic beverages incorporating encapsulated bacterial strains has demonstrated efficacy in improving gastrointestinal health, as evidenced by clinical trials.

Recent innovations in molecular gastronomy extend to edible biofilms, 3D-printed food products, and nutritionally enhanced confectionery, such as Sweet Burgers and deconstructed Caprese Salad formulations. These advancements integrate bioactive compounds and probiotics, augmenting the nutritional profile of food products. A notable invention in this field, the edible molecular lipstick, combines food-grade biopolymers and probiotic microcapsules, illustrating the convergence of gastronomy and functional food science.

Molecular gastronomy, in conjunction with biotechnological innovations, presents transformative opportunities for sustainable food systems. By optimizing food formulations, minimizing waste, and enhancing bioactive compound bioavailability, these interdisciplinary approaches contribute to the advancement of food science and human nutrition.

Keywords: molecular gastronomy, bioconversion, probiotics, edible films, food waste

PL - 5

ALTERNATIVE PROTEINS: LIGHTS AND SHADOWS OF THE PROTEIN TRANSITION

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Abstract

Global demand for food is expected to nearly double by 2050. Alternative proteins (AP) have been proposed as a sustainable solution to provide food security as natural resources become more depleted. More specifically, four main AP categories such as plant-based, insect-based, microbe-derived, and cultured meat and seafood are investigated and compared in terms of environmental impacts, technological challenges, nutritional profile and food safety. All these aspects are crucial for the success of APs in the food market because although APs have gained substantial interest amongst the scientific community as well as the food industry, they are still considered a small sector and are not widely appealing to many consumers. In fact, the development of alternative products with nutritional and sensory profiles similar to their conventional counterparts remains highly challenging in particular for insect-based and microbe-derived products. Furthermore, incomplete safety assessments and a lack of clear regulatory guidelines confuse the food industry and hamper progress. An overview on the recent advancements obtained in the framework of research and innovation projects focused on AP and carried out in the European Union are reported. Future trends and opportunities for new protein sources as well as technological innovations are explored considering also their possible impact in terms of economics. Financial support for this research has been provided by PRIMA, a program supported by the European Union, under grant agreement No 2231, project CIPROMED (PRIMA Call 2022 Section 1 Agri-food IA).

Keywords: Consumer acceptance, environmental benefits, health claims, nutritional profile, sensory traits

PL - 6

ENHANCING THE NUTRITIONAL AND FUNCTIONAL PROPERTIES OF WHEAT-BASED BEVERAGES THROUGH INNOVATIVE PRETREATMENTS AND LACTIC ACID BACTERIA FERMENTATION

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Abstract

Wheat (*Triticum* spp.) is a staple cereal crop with high nutritional value, rich in carbohydrates, proteins, essential vitamins, minerals, and bioactive compounds that contribute to health benefits such as reduced risks of chronic diseases. The development of wheat-based functional beverages offers an opportunity to enhance the bioavailability of these compounds while improving sensory and functional properties. Pulsed Electric Field (PEF) technology, a non-thermal processing method, has demonstrated potential in enhancing the extraction efficiency of bioactive compounds and improving fermentation processes.

In this study, lactic acid bacteria (LAB) were isolated from wheat, and their fermentation ability in wheat-based beverages was investigated. The strains were identified using Random Amplified Polymorphic DNA (RAPD) and 16S rDNA sequencing, revealing six species, including *Enterococcus durans, Enterococcus faecium, Lactobacillus coryniformis, Lactobacillus casei, Pediococcus acidilactici, and Pediococcus pentosaceus*. After that, the impact of PEF pretreatment on the fermentation of two selected LAB species (*P. acidilactici* and *P. pentosaceus*) together with the strain of *Lactobacillus plantarum* CECT 748, which is a well-known probiotic strain, was assessed at an incubation temperature of 37 °C for 24 hours. The results indicated that PEF treatment allowed improvements in microbial growth and acidification rates leading to an overall improvement in the quality of fermented wheat beverages. Additionally, Principal Component Analysis (PCA) of phenolic compound composition indicated that PEF had a greater impact than microbial fermentation on phenolic profile modifications. Post-PEF fermentation, bioactive phenolic compounds such as sinapoyl glucose, coumaric acid, 4-vinylphenol, apigenin, and carvacrol increased, particularly in beverages fermented with *L. plantarum*. These compounds possess antioxidant, anti-inflammatory, and antimicrobial properties, highlighting the potential of PEF-treated, LAB-fermented wheat beverages in functional food applications.

This study underscores the potential of integrating PEF with LAB fermentation to enhance the nutritional and bioactive profiles of wheat-based functional beverages. Future research should further explore optimization strategies to maximize the health benefits and industrial viability of these innovative products.

Keywords: Wheat fermentation, Pulsed Electric Field (PEF), Lactic acid bacteria (LAB), Phenolic compounds, Functional beverages

PL - 7

FROM MACRO TO NANO: SHIFTING PERSPECTIVES ON FOOD WASTE

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Abstract

The emergence of nanotechnology in the food industry has brought significant advancements in food processing, packaging, and functionality; however, it also introduces an often-overlooked form of waste - nanowaste (NW). Nanowaste poses unique challenges for environmental and social sustainability due to its minute size, complex interactions, and difficulty in detection. Pathways of engineered nanomaterials (ENMs) entering the environment and food chain as NW are numerous and will be discussed in the present study. Once in nature, NW undergoes complex transformations, potentially altering its toxicity and interactions with biological systems. This lecture addresses the critical need for understanding, identifying, and managing NW as an emerging category of waste. Drawing upon recent research, including work on the definition, detection, and tracking of NW in foods, this study explores presence and distribution of ENMs in waste and advanced analytical techniques for NW detection, while also addressing the analytical challenges associated with NW detection. Moreover, the paradox of nanotechnology in food systems is discussed - while it can enhance sustainability by reducing waste and improving food preservation, it may simultaneously introduce new environmental and health risks that counteract its benefits. Additionally, the study evaluates nano-risk assessment in nano-products and highlights the necessity of a multi-actor approach for effective NW management, ensuring sustainable development. Traceability remains a key issue, with implications for regulatory policies and human health and environmental risks within food systems.

Keywords: nanowaste management, food waste, nanotechnology, advanced analytical techniques, nano-risk

INVITED LECTURE

I - 1

INNOVATIVE WASTE UTILIZATION IN BERRY PROCESSING: FOCUS ON ARONIA BERRIES

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Abstract

Berry fruit processing generates substantial waste, primarily consisting of peels, skins, pulp residues, seeds, stems, and leaves. In Europe, where berry production is significant—reaching 700,000 tonnes in 2023 and projected to grow to 1,020,000 tonnes by 2028—waste management remains a challenge, traditionally relying on composting or disposal. Processing methods such as freezing, juicing, canning, and jam production contribute to waste generation, with losses reaching 30–40% of total berry weight, amounting to approximately 280,000 tonnes annually. However, this waste contains valuable bioactive compounds, including antioxidants, vitamins, fibers, and pigments, with potential applications in the food, cosmetic, and pharmaceutical industries. Among berry species, aronia stands out, as it is predominantly processed rather than consumed fresh due to its astringent taste. Extracting bioactives from aronia processing waste presents opportunities for developing high-value-added products across multiple industries. In line with green chemistry principles, modern sustainable extraction techniques such as ultrasound-assisted, microwave-assisted, and pressurized liquid extraction are preferred for isolating bioactive compounds. Optimal extraction methods and processing conditions differ for pomace and leaves due to variations in their structure and polyphenolic profile. Obtained aronia pomace and leaf extracts exhibit strong antioxidant properties, with pomace extracts demonstrating higher antioxidant activity, attributed to their rich anthocyanin content. In contrast, aronia leaf extracts show protective effects against oxidative stress and DNA damage, along with moderate antimicrobial activity against S. aureus and B. subtilis. To further enhance the stability and usability of these bioactive extracts, encapsulation techniques such as spray drying are employed. This method ensures the production of stable, high-quality products with improved solubility, emulsification, and controlled bioactive release. By integrating sustainable extraction and encapsulation strategies, aronia processing waste can be effectively valorized, supporting the development of functional ingredients with significant biological potential.

Keywords: aronia, pomace, leaves, extraction, encapsulation

I - 2

DEEP EUTECTIC SOLVENTS AND THEIR APPLICABILITY IN FOOD PROTEIN UTILIZATION

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Abstract

Since the advent of green chemistry and its 12 principles, one of which emphasizes the need for safer solvents, intensive research has been conducted to identify alternative solvents for various processes and applications. Among those, deep eutectic solvents (DESs) have emerged as innovative materials in food science, particularly for stabilizing, processing, and delivering food proteins. Their unique properties, including biocompatibility, tunability, and green credentials, make them valuable for applications in the food industry. DESs are labelled as environmentally friendly solvents which can be used for the extraction of proteins from various food sources, such as plant seeds, grains, and animal tissues. Beyond their extraction efficiency DESs can help preserve the functionality and structure of food proteins, which are often sensitive to environmental stressors like heat, pH changes, or enzymatic activity. There are also several examples that DESs facilitate the functionalization of food proteins, enhancing their solubility, emulsification, and gelation properties, therefore broadening their application in food formulations. Furthermore, protein-DES systems could be used to encapsulate and deliver bioactive compounds, such as vitamins, antioxidants, and probiotics, and in that way protect sensitive bioactive compounds during food processing and storage. Since it was shown that DESs could prevent protein denaturation during processes like drying, pasteurization, or freeze-thaw cycles, they can be integrated into food production processes to improve the quality, stability, and nutritional value of protein-based foods. One of well-known advantages of DESs is improvement of enzyme stability and activity, therefore they can also act as solvents for enzymatic reactions involving food proteins, facilitating their hydrolysis or modifications. Although challenges exist in applying DESs to food proteins, the growing demand for sustainable and green technologies in the food industry highlights their significant potential. Surely, DESs should be used in the future to develop innovative, functional, and eco-friendly protein-based food products.

Keywords: DES, protein, extraction, stabilization, delivery

APPLICATION OF REACTION ENGINEERING PRINCIPLES FOR THE IMPROVEMENT OF SYNTHETIC BIOCATALYTIC PROCESSES

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Abstract

Biocatalysis is a transformative tool for sustainable and efficient chemical production, with widespread applications in industries such as food technology, pharmaceuticals, and specialty chemicals. When developing novel biocatalytic synthetic process, the complexity of enzymatic systems can pose substantial challenges, particularly when working on higher concentration scales which are often necessary to achieve industrial feasibility. Through a series of case studies and practical examples, this lecture will illustrate how reaction engineering approach can be applied to characterize novel systems and identify bottlenecks in early phases of the process development. When investigating a novel process for enzymatic synthesis of desired compounds, the first task is to identify the optimal environment for enzymes to exhibit high activity and stability while ensuring the substrate is bioavailable. This involves a characterization of the performance of the enzyme in different conditions, including pH, temperature, and reaction media. Depending on the system of choice, various aqueous buffers and solvents may be tested. Then, enzyme kinetic modelling can be employed, as through kinetic mathematical models, relationship between an enzyme and a substrate can be understood better, with insights into enzyme affinities, reaction rates, existence of different inhibitions, etc. These models guide the optimization of process conditions and enable the informed selection of the most suitable reactor setup. At this stage of process development, the operational stability of enzymes becomes critical. If it is insufficient, the immobilization techniques may be explored to enhance the stability and reusability of an enzyme while retaining satisfactory activity. The lecture will illustrate described challenges and ways of addressing them systematically through examples including different types of enzymes.

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Keywords: biocatalysis, enzyme kinetics, mathematical modelling, reaction engineering

ASSESSING THE IMPACT OF FOOD AND BIOTICS ON GUT MICROBIOME THROUGH *IN VITRO* FERMENTATION MODELS

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Abstract

The gut microbiome is essential for human health, influencing metabolism, immunity, and neurological functions. Diet plays a crucial role in shaping gut microbiota, with certain foods exerting prebiotic or probiotic effects. Sustainable nutrition integrates health-promoting dietary strategies with environmental responsibility, necessitating the identification of functional foods and biotics that support a resilient microbiome while reducing ecological impact.

This presentation explores how food-derived bioactive compounds, prebiotics, and probiotics modulate gut microbiota and their metabolic outputs. Examples include dietary fibers such as beta-glucans, fructooligosaccharides, and resistant starches, which selectively promote beneficial bacteria, leading to increased production of short-chain fatty acids (SCFAs) like butyrate, acetate, and propionate. These metabolites contribute to gut homeostasis, immune regulation, and systemic metabolic health.

A major challenge in microbiome research is the effective screening of prebiotic and probiotic potential in novel foods and microbial strains. Various in vitro fermentation models simulate colonic conditions, enabling controlled assessments of microbial shifts and metabolite production in response to dietary interventions. These models range from batch fermentations, providing rapid microbiota insights, to dynamic multi-stage systems that replicate human colonic complexity.

Our research applies these methodologies to evaluate plant-based proteins, fermented food matrices, and probiotic strains for gut microbiota modulation. Results highlight the ability of specific dietary components to enhance microbiome diversity and functionality, influencing personalized nutrition and sustainable diets. Also, screening strategies allow for identifying possible collateral and undesirable effects. Additionally, we discuss emerging trends in microbiome-targeted interventions, including precision nutrition strategies leveraging microbiota signatures for dietary recommendations.

The future of gut microbiome research requires a multidisciplinary approach integrating microbiology, food science, and nutrition to develop optimized dietary strategies benefiting both human and planetary health. Refining in vitro methodologies and expanding translational studies will advance microbiome-friendly dietary solutions aligned with sustainable nutrition principles. This talk provides an overview of methodologies, findings, and future prospects in microbiome research within sustainable dietary strategies, emphasizing the crucial role of functional foods and biotics in shaping a healthier future.

Keywords: Gut microbiota, in vitro colonic fermentation, probiotics, prebiotics, dysbiosis

SUSTAINABLE BIOPLASTICS: PRODUCING PHAs FROM AGRO-INDUSTRIAL WASTE VIA SOLID-STATE FERMENTATION

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Abstract

Bio-based plastics, also known as bioplastics, are derived wholly or partially from biological sources. Unlike conventional plastics, they are not inherently biodegradable or compostable. However, their environmental impact can be favorable if a comprehensive life cycle analysis demonstrates such benefits. Bioplastics can be produced from first-generation feedstocks such as corn and sugar beet and second-generation feedstocks derived from inedible by-products such as waste starch, cellulose, fatty acids and organic waste from agricultural residues, etc. Second-generation feedstocks are more sustainable, cost-effective, and support the circular bioeconomy. One of the newer types of bioplastics are polyhydroxyalkanoates (PHAs), fully biodegradable bio-based polyesters that are a valuable alternative to conventional non-degradable fossil-based polyesters. PHAs are produced by bacteria as intracellular granules, serving as carbon and energy reserves under stress conditions (e.g., excess carbon or a shortage of phosphorus, nitrogen, or oxygen). The type of PHA synthesized depends on the bacterial strain, available substrates, and environmental conditions. The cost of PHA production is mainly related to processing costs, such as sterilization of the production equipment, substrate and polymer extraction from the cell biomass. The most common fermentation processes for PHA production are submerged fermentation (SMF) and solid-state fermentation (SSF). The development of sustainable technologies such as SSF allows for greater flexibility in feedstock selection and can lead to higher process productivity and a reduction in energy and wastewater costs. After fermentation, the subsequent steps of extraction and purification are pivotal in acquiring pure PHA. Various extraction methods are employed, such as solvent extraction, digestion, extraction using supercritical fluids, and aqueous two-phase extraction. Analytical techniques like thermogravimetric analysis, gas chromatography coupled with mass spectrometry, Fourier-transform infrared spectroscopy with attenuated total reflectance, and nuclear magnetic resonance spectroscopy are commonly utilized to determine the PHA content in biomass and assess polymer purity. Ultimately, to optimize PHA production, it is crucial to predict system behavior and develop mechanistic models, often achieved through design of experiments (DoE) and response surface methods (RSM). This study aimed to explore agroindustrial waste as a feedstock for PHA production using Cupriavidus necator and to optimize the production process.

Acknowledgment:
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Keywords: bioplastics, PHA, solid state fermentation, optimization of process

VALORIZATION OF CHITINOUS WASTE FROM MARINE BIORESOURCES INTO FUNCTIONAL OLIGOSACCHARIDES BY GREEN TECHNOLOGY

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Abstract

Chitinous wastes from marine bioresources, especially shrimp and prawn, are highly recalcitrant, posing a threat to the environment if not managed properly. Chitin, a polymer of beta-1,4 linked N-acetylglucosamine (GlcNAc) residues, can be extract from these wastes and further deacetylated into chitosan, which is a heterogenous polymer with various degree of acetylation (DA), polymerization (DP), and sequence of Glc and GlcNAc. While chitin is only soluble in hot acid, chitosan is soluble under mild acidic conditions. Chito-oligosaccharides (COS) or chitosan-oligosaccharides (CHOS), shorter versions of chitin and chitosan, respectively, have been shown to have numerous biological activities such as antimicrobial, anticancer, or antioxidant properties. COS or CHOS can be prepared by using harsh physicochemical methods such as hot acids, radiation and microwave treatment, or green technology using specific enzymes. In the past decade, our laboratory has been working on cloning and expression of various *Bacillus* chitinolytic enzymes, i.e., chitinase (*Bs*Chi18A) and chitosanase (*Bs*Csn46A). An efficient system for secretory production of these enzymes from *E. coli* have been established. Both enzymes possess properties that are suitable for industrial application. Since chitosan is soluble in mild acid, it is a more suitable substrate for bioconversion into CHOS for nutraceutical or cosmeceutical purposes. Therefore, a food-grade method based on a *Lactobacillus plantarum* quorum sensing system has been established to produce the enzyme. Using *Bs*Csn46A, a soluble CHOS mixture of the size ranging from DP2 to DP5 could be generated. We showed that these CHOS mixtures have a potent anti-inflammatory activity in a U-shape dose-dependent manner, using human mature monocytes (THP-1). This property makes CHOS highly promising for food or cosmetic applications. Notably, we also found batch-to-batch variations of anti-inflammatory activity due to the source of chitosan, bioconversion condition, and downstream processes. Most importantly, certain CHOS preparations at the dosage higher than optimal could induce inflammation. Therefore, careful quality assurance of CHOS preparation is highly essential.

Keywords: Valorization, Chitosanase, Chito-oligosaccharides; marine; anti-inflammatory

EFFECT OF ULTRASOUND PRETREATMENT ON THE CONCENTRATION OF LIPOPHILIC AND HYDROPHILIC ANTIOXIDANTS IN COLD PRESSED GRAPE SEED OIL PRODUCED FROM WINE WASTE

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Abstract

Rising global environmental challenges have intensified the need for innovative technologies and practices to significantly reduce waste in the food and agriculture sectors. The winemaking industry is also actively implementing sustainable strategies by embracing eco-friendly production methods and efficient waste management practices. Wine waste is generated at various stages of winemaking, with the largest amounts obtained after wine pressing. This waste, known as grape pomace, accounts for approximately 20–25% of the weight of processed grapes. To minimize this waste, various valorization strategies can be employed. In addition to being a rich source of hydrophilic polyphenolic antioxidants, grape pomace also contains valuable lipophilic antioxidants, making it a valuable raw material for producing grape seed oil. To preserve the bioactive properties of grape seed oil, as well as its neutral taste and vinous aromas, cold pressing is preferred over other conventional extraction methods. However, the extraction yield of cold pressing is generally limited to 65–70%. This limitation can be successfully addressed by employing alternative extraction techniques such as supercritical CO_2 extraction or process techniques like pulsed electric fields and high-voltage electrical discharges prior to cold pressing. The aim of this research was to study the effect of ultrasound pretreatment of grape seeds prior to cold pressing on the extraction yield and concentrations of lipophilic and hydrophilic antioxidants in grape seed oil, that have not been earlier explored. The ultrasound pretreatments involved the application of two frequencies, 37 Hz and 80 Hz, each for durations of 30 and 90 minutes. Results showed that ultrasound pretreatments significantly increased oil yield when applied for a longer duration, leading to increases of 7.6% and 8.3% for 37 Hz and 80 Hz, respectively. Pretreatments at 37 Hz resulted in significantly higher concentrations of total tocochromanols and antioxidant capacity (L-ORAC) compared to 80 Hz, with the highest values observed at 37 Hz for 30 minutes ($p < 0.05$). A similar trend was noted for phenolic compounds, as the 37 Hz frequency proved more effective, yielding the highest concentrations of total flavonoids, non-flavonoids, and most individual phenolic antioxidants, but at 37 Hz and 90 minutes ($p < 0.05$). In contrast, total sterol concentrations were significantly higher in samples pretreated at 80 Hz ($p < 0.05$), suggesting greater susceptibility of these compounds to lower-frequency pretreatments. Finally, the fatty acid composition of grape seed oils remained largely unaffected by ultrasound pretreatments.

Keywords: grape seed oil, ultrasound, cold pressing, chemical composition, antioxidants

SUPERCRITICAL CO_2 ($SCCO_2$) ENABLING SUSTAINABLE FOOD SYSTEMS BASED ON DISCARDED TIGER NUTS (TN): FROM LAB- TO PILOT SCALE

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Abstract

Chemical Process Intensification (CPI) has represented a noted advance for boosting process efficiency and sustainability through the application of non-conventional technologies, in line with Green Chemistry principles. Supercritical fluids, particularly supercritical CO_2 ($scCO_2$), play a key role in green extraction processes for producing valuable chemicals from discarded food materials, so that its contribution to chemical sector is worthy of recognition. This work encompasses a sustainable upcycling of discarded tiger nuts (TN) co-products, of particular relevance in Comunitat Valenciana (Spain), via CPI with $scCO_2$. This methodology afforded a noted degree of defatting in TN when it was executed at lab- and pilot scale, pointing out the quality of the oil recovered. Moreover, a quantitative assessment at both levels evidenced the low environmental footprint enclosed in these processes. The post-extraction remaining solid, which showed an enhanced fibre content, has served to develop alternative foods as TN-modified burgers, aligning with the progress in sustainable food systems.

ACKNOWLEDGEMENTS

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Keywords: Supercritical CO_2, tiger nuts co-products, sustainable food, scaling-up, chemical process intensification

ORAL PRESENTATIONS

O - 1

HISTORICAL GRAINS IN MODERN GASTRONOMY: A CASE STUDY OF ARTISAN BREADS

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Abstract

There is a current and growing interest in food based on heritage grains. While modern wheat has been bred for improved yields, harvest index and baking properties, heritage varieties have recently gained increased recognition for their nutritional profiles, contribution to biodiversity, and resilience towards adverse climate change effects. Today, heritage cereals can be regarded as trendy, however they are in comparison to conventional cereals more of a niche product and often sold from the producer directly to consumers, or to artisanal bakeries, but show great potential for expanded consumer acceptance and usage. Previous consumer studies indicate high purchase intention towards products based on heritage cereals, with bread and pasta being the products with greatest market potential. This increased interest in heritage cereals calls for deepened understanding of their sensory attributes and consumer acceptance. Hence, this study evaluated bread based on two heritage wheats (Öland and Källunda) and a modern wheat mix (Modern) by the means of quantitative descriptive sensory analysis (n=8) and consumer liking (n=47) using a 9-point hedonic scale. The sensory profiles of the three breads were similar, with differences mainly in the crust's brownness, roasted odor, chewiness, and hardness. These differences were not linked to whether the wheat was heritage or modern. Overall, consumers gave positive scores for the crumb and crust of all three bread types: Öland (6.38 and 6.87), Källunda (6.53 and 6.19), and Modern (6.26 and 6.49). Among all participants, 68.1%–85.1% gave positive scores for the breads. Öland wheat crust was better liked than crust from Källunda wheat, which related to less roasted odor, brown appearance, chewy and hard textures. The study's implications for gastronomy includes that heritage wheat can be used like modern varieties without impeding sensory quality, making them versatile for various foods and cuisines.

Keywords: Heritage, Grains, Cereals, Bread, Descriptive sensory profile, Consumer acceptance

O - 2

ENHANCING CONSUMER AWARENESS OF SUSTAINABLE FOOD CHOICES: INTEGRATING THE EU ORGANIC LOGO INTO THE VKJ MOBILE APP

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Abstract

Mobile applications are becoming essential tools in shaping consumer purchasing behavior, helping individuals make healthier and more sustainable choices. Despite the increasing number sustainability labels on food products, consumer understanding remains limited. Mobile applications can help bridge this gap by providing easily accessible information. In Slovenia, the widely used free mobile app VKJ (Veš, Kaj Ješ - Know What You Eat, 30,000 users) enables consumers to scan the barcode of branded food products and receive feedback on their nutritional composition through a traffic light profiling system, supporting healthier food choices. In 2025, the app will be upgraded with sustainability information, including the EU organic logo, to provide accessible sustainability insights.

The upcoming mobile app upgrade will integrate data from NutriBase, a centralized database management system that contains comprehensive details on 28,296 branded food products. This includes data on nutritional value, allergens, ingredients, nutrition and health claims, and symbols. NuriBase information sistem is supported by data from the Composition and Labelling Information System (CLAS). The CLAS tool was developed to efficiently conduct food monitoring studies and generate branded food datasets. Today, it is used by research and governmental organisations in different European countries. It simplifies the collection of food packaging photographs in retail stores. The CLAS cloud-based web platform enables efficient and systematic data extraction and data processing. Currently, CLAS datasets contain information on approximately 28,000 food products, 13% of which bear the EU organic logo. To assess consumer knowledge and perceptions of sustainability-related information, specifically the EU organic logo, a survey was conducted among all VKJ app users in January 2025 before the app upgrade. Participants were invited to the survey via VKJ app push notifications. Data analysis included only fully completed surveys (N = 287). Results showed that while 72% (N = 207) of respondents had previously seen the EU organic logo on food products, only 50% (N = 104) correctly identified (open-ended question) its meaning as indicating organic certification. These findings highlight the need for interventions to improve awareness of sustainable food labelling. Our future research will examine the effects of repeated exposure to the EU organic logo and related content (an explanation of its meaning) within the app. The upgraded application featuring the EU organic logo is expected to support informed purchasing decisions and foster sustainable consumer behavior.

Keywords: mobile applications, food labelling, consumer awareness, EU organic logo, sustainability

O - 3

FUNCTIONAL FOODS FOR CONSTIPATION MANAGEMENT: EU LEGISLATIVE AND SCIENTIFIC CHALLENGES

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Abstract

Constipation is one of the most prevalent health issues, affecting up to 20% of the global population, with higher incidence in women and older adults. Only about one-third of constipated population seek medical care, while many individuals self-manage symptoms through dietary modifications such as increasing fibres, polyols and pectin intake. In European cultures, foods like plum (Prunus domestica), flaxseeds (Linum usitatissimum), chicory root (Cichorium intybus), and fermented products (e.g. kefir, sauerkraut) have been traditionally used for their beneficial effects for constipation relief. This contribution presents the challenges in communicating these benefits to consumers through food labelling and promotion due to strict European legislation. While some health claims for foods have passed the authorisation process by European Food Safety Authority (EFSA) and European commission (EC), many have been rejected due to insufficient supportive clinical trials or lack of conclusive evidence under EFSA's rigorous standards. Our investigation showed that health claims related to normal bowel function are authorised for wheat, oat, barley, sugar beet and rye fibre. However, as the decision on botanical health claims on foods in the EU is still pending, non-authorised health claims can be used for botanicals from the 'on hold' list, either with supportive scientific evidence, or based on traditional use. In this context, the health claim for flaxseeds (Linum usitatissimum) can be applied. However, the question about promotion of fermented foods remains open. Since the adoption of health claims regulation in 2006, only one fresh fruit received a positive assessment by the EFSA - green kiwifruit - for normal bowel function. This precedent has supported our interest in substantiating health claims, based on new evidence. A randomized controlled parallel four-arm intervention study with 120 subjects with functional constipation has been started this year (Project NutriPlant, ARIS L7-50154). Study is conducted with four foods with potential to effectively support normal bowel function: active control product (Psyllium), and three test products (one of them is sauerkraut). Our findings highlight the complexity of gaining health claim approvals for foods with traditional laxative effects under the current European regulatory framework. While some fibre-based claims are authorised, the pending status of botanical claims and the lack of approved claims for fermented foods create significant challenges in consumer communication. Ongoing clinical trials, such as the study in Slovenia, may provide new evidence to support future health claims, potentially expanding the range of food-based solutions for constipation management.

Keywords: functional foods, bowel function, constipation, health claims, legislation

O - 4

RENEWABLE BIOPOLYMERS FOR FOOD PACKAGING: IMPROVING HIDROPHOBICITY, MECHANICAL AND BARRIER PROPERTIES

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Abstract

Many polymeric food packaging materials are still derived from petroleum and thus non-biodegradable, so recent studies have concentrated on developing polymeric films based on biodegradable materials, including polysaccharides. However, due to the hydrophilic nature of these molecules, high moisture absorption limits their use, and chemical modifications are needed to improve film properties. Therefore, this study aimed to develop biopolymeric films based on galactomannans from locust bean and verify the effect of acetylation on film properties including mechanical, barrier and water repellence. The films were prepared by casting, using glycerol as a plasticizer. A comparison of films prepared with and without the acetylation step indicated a significant increase in the water contact angle, from ~ 73° to 101°, confirming the desired improvement in hydrophobicity. Acetylation also led to improvements in mechanical properties, especially film resistance, with an increase of approximately 60% in tensile strength, without affecting film elasticity. Also, there was a significant reduction (25%) in water vapor permeability under a controlled atmosphere (25°C and 53% RH). These results indicate that the developed methodology is a viable method for improving hydrophobicity and barrier/mechanical film properties, making them suitable for sustainable food packaging applications.

Keywords: carbohydrates, galactomannans, polymeric films, hydrophobic

O - 5

AGRICULTURAL RESIDUES AS A SOURCE OF RENEWABLE BIOPOLYMERS FOR FOOD PACKAGING: COMBINING WASTE-BASED PROTEIN AND PECTIN

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Abstract

The need for sustainability and food waste reduction has prompted several studies on the development of food packaging materials based on agricultural and food processing by-products. Such by-products are rich in proteins and polysaccharides, biopolymers that have been demonstrated suitable for developing films for biodegradable packaging. In this study, we developed polymeric films by combining protein from sunflower seed oil press-cake (sunflower oil by-product) and pectin. The films were prepared by casting and the influence of pectin amount on film properties was evaluated. Addition of pectin led to a significant increase in tensile strength (up to 193%) but decreased elongation at break (down to 82%). Nonetheless, there was also a significant increase in thermal stability. Thermal gravimetric analysis curves indicated two significant thermal events for all the prepared films. The first event was associated with the evaporation of water and the second one was due to decomposition of glycerol and the polymeric molecules. Addition of pectin led to an increase in the peak temperature of the main event, from 129oC (pure protein film) to 220-230oC (films with added pectin). The results indicated that, the higher the amount of pectin in the blend, the more intensified are the interactions between the protein and polysaccharide molecules. The developed biopolymeric films present potential for applications for food packaging as alternatives to films based on petroleum-derived polymers.

Keywords: pectin, protein, polymeric films, food packaging

O - 6

FROM BITTER TO BETTER: TOWARDS ENHANCED PLANT PROTEINS USING NATURAL DEEP EUTECTIC SOLVENTS

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Abstract

As world food systems trend towards environmentally sustainable and ethically produced foods, there is growing demand for novel plant-based protein sources and processing technologies. The past decades have seen extensive exploration of proteins from legumes and grains. Still, these extracted proteins frequently elicit poor consumer acceptance due to pungent flavors, off-color, and poor texture. Other protein-rich crops, such as rapeseed, have been restricted to vegetable oil production because of similar concerns.

This project explores an innovative processing strategy for peas (Pisum sativum L.) and rapeseed (Brassica napus L.) using food-grade natural deep eutectic solvents (NADES) based on betaine or choline chloride with 1,2-propanediol. This work established the optimal processing window for this solid-liquid extraction process, ensuring maximal removal of antinutritive and acrid plant polyphenols using NADES while minimizing protein loss. Experiments looked at the effects of particle size (size fractions of 0.25-0.5, 0.5-1, 1-2, and 2-3.15 mm), solvent temperature (35, 45, 55, 65, 75 °C), and NADES hydration levels (0-40% water), demonstrating these parameters' effects on protein and polyphenol extraction over time. Results were compared to those of extractions using 1,2-propanediol containing 0-40% water, aiding in understanding the role of the individual compounds in NADES. Extraction experiments using 60% aqueous ethanol or pure water were conducted for reference. Kinetic modeling parameters for the extraction process were derived from analytical data.

The results demonstrate NADES' remarkable efficacy at extracting phytochemicals from plants, leaving behind refined plant material. Extraction kinetics follow a pseudo-first order model, clearly revealing a correlation between solvent viscosity and extraction efficacy. Diluting NADES enhances solvent diffusion into plant tissues, accelerating polyphenol extraction rates and improving overall yield. Meanwhile, the overlap in extraction rate models between NADES and 1,2-propanediol highlights the importance of eutectic systems' components. NADES or 1,2-propanediol-refined peas and rapeseed are considerably whiter and odorless, indicating high total phenolic compound extraction (over 80% of total, ~30 mg L-1), while protein co-extraction remains low (below 15% of total, ~275 mg L-1). While reference solvents (60% ethanol and water) remove similar quantities of phenolic compounds (~35-45 mg L-1), protein losses increase (~805-4295 mg L-1). These findings underscore NADES' potential as a sustainable and efficient means for purifying plant-based proteins while enhancing their sensory attributes. Models of the condition-specific kinetics of this approach will facilitate up-scaling and potential extension of the technology to other seeds, enabling researchers to effectively develop a new generation of functional and neutral-tasting plant protein ingredients.

Keywords: Plant-based proteins, green chemistry, kinetic modeling, natural deep eutectic solvents

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EXPLORING SEA ASPARAGUS ANTIOXIDANT NADES-UAE EXTRACTS

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Abstract

Nowadays the extraction of plant secondary metabolites as polyphenols is commonly employed to develop promising pharmaceutical, nutraceutical, and cosmeceutical products beneficial for both human and animal health. Halophyte plant cultivations such as the genus Salicornia can be seen as a non-conventional crop to enhance the productivity of coastal lands with high salinity not suitable for conventional crops. Salicornia europaea L. commonly known as glasswort or sea asparagus is widely spread on coastal sites of Europe, and worldwide. The succulent stems of S. europaea are rich in polyphenols with recognized antioxidant properties. This study aimed to select and optimise the most promising natural deep eutectic solvent (NaDES) for sustainable polyphenolic extraction from non-conventional halophytic S. europaea plants present in the Apulian region of Italy. A software-based prediction approach (BIOVIA COSMOtherm) was applied to select the best couples in terms of the acceptor of hydrogen bond (HBA) and donator of hydrogen bond (HBD) solvents. Six different NaDES were synthesized with subsequent S. europaea polyphenol extractions conducted in an ultrasonic bath with a power of 100 W and frequency of 38 Hz at 30°C for 30 minutes. The results presented in this study demonstrated the ability of NaDES to extract antioxidant compounds from S. europaea. The most effective extraction in terms of total polyphenol content (TPC) was achieved using proline as the HBA and choline chloride as the HBD green solvents. The results from the FRAP antioxidant assay and the DPPH antiradical assay, along with the total phenolic content (TPC) stability over time, confirmed that the proline: choline chloride NaDES-UAE S. europaea extract was the most promising among the six NaDES tested, as well as compared to the conventional hydroalcoholic extract. The NaDES-UAE approach to extract antioxidant compounds from a non-conventional crop such as S. europaea may have various green and sustainable applications for pharmaceutical, nutraceutical, and cosmeceutical fields.

Keywords: Sea asparagus, antioxidant, NaDES, UAE, extraction

O - 8

DEVELOPMENT OF HEALTHY GLUTEN-FREE DOUBLE-LAYER PITA BREAD: NUTRITIONAL, TECHNOLOGICAL AND SENSORIAL PROPERTIES

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Abstract

Bread is a commodity consumed by people all around the world. However, the prevalence of celiac disease and other gluten related disorders, such as gluten intolerance, prevented these people from the consumption of bread and other gluten-containing foods. In this project, two gluten-free double layer pita breads were formulated containing tapioca flour and chickpea flour respectively. Both of these breads are made of a base, free from allergens and synthetic additives, consisting of rice flour, corn starch, guar gum, psyllium husk, yeast, sugar and salt. The physicochemical properties, nutritional content, shelf-life and acceptability of the formulated breads in addition to that of an industrial GF mix, used as control, were determined. The chickpea-based bread showed to have the highest moisture content but had a low rollability score and was the fastest to spoil. However, it showed more acceptability compared to the tapioca-based bread and also had the lowest fat content and highest values for protein and fiber content. The tapioca-based bread had higher rollability scores than the control bread. All of the tested samples showed decrease in moisture after five days of baking and a slight increase in yeast and molds, emphasizing the need for the gluten-free breads to be consumed fresh or frozen for later consumption. All samples were free from gluten free contamination. Chickpea and tapioca GF breads show a lower caloric content compared to control. Moreover, the formulated gluten-free double-layer breads, made from natural raw material, present a potential substitute option for individuals seeking products without wheat or other gluten-containing cereals and creates avenues for the development of various gluten free products.

Keywords: Gluten-free double layer pita bread, tapioca flour, chickpea flour, Gluten intolerance, Celiac disease.

O - 9

SEQUENTIAL INJECTION ANALYSIS: A RELIABLE METHOD FOR PENICILLAMINE QUANTIFICATION IN PHARMACEUTICAL PREPARATIONS

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Abstract

A new, sensitive, rapid, and precise spectrophotometric method was developed and validated for determining penicillamine (PEN) in pharmaceutical formulations using sequential injection. Sequential injection analysis (SIA), a second generation of flow analysis introduced by Ruzicka and Marshall in 1990, allows full computerization of the analysis process. SIA is an environmentally friendly technique, requiring smaller quantities of both reagents and samples, which reduces chemical waste and lowers analysis costs. Penicillamine, a synthetic amino acid with an additional SH group, forms non-toxic, water-soluble chelates with heavy metals that are excreted through urine. Originally used as a treatment for Wilson's disease, PEN is also effective for treating lead, mercury, and arsenic poisoning. The method utilizes a rapid redox reaction in which PEN reduces the Cu(II)-bathocuproine complex to Cu(I)-bathocuproine with absorption maximum at 483 nm. The flow cell's internal volume was minimized to 30 µL, allowing for the further miniaturization of other components in the system. Experimental conditions and manifold parameters were optimized using the univariate method. A reagent solution (150 µL) prepared in acetic buffer (pH 5) and a sample solution (200 µL) were aspirated into the holding coil (500 µL), forming adjacent zones. These zones were than propelled through the reaction coil (30 cm length, 0.8 mm inner diameter) at a flow rate of 5000 µL min-1 with distilled water as carrier stream. A linear calibration curve for PEN was established with a concentration range from $2.0 \times 10^{-}6$ to $6.0 \times 10^{-}5$ mol L-1 resulting in the equation $y = 7182x + 0.0073$ ($R2 = 0.9992$). This sensitive method achieves an LOD of 6.0 × 10-7 mol L-1 and a throughput of 72 analyses per hour without the need for expensive equipment. In addition, it has demonstrated very good precision (RSD 3.53%, n = 50) and accuracy (recovery between 88.24% and 99.07%). The proposed method is suitable for PEN analysis in pharmaceutical formulations, as common excipients and other active ingredients do not interfere. Beyond pharmaceutical applications, this method contributes to sustainable food and nutrition science by providing a reliable analytical approach that can be adapted for the quantification of other essential compounds in food and dietary supplements.

Keywords: Sequential Injection Analysis, Penicillamine, Green Chemistry, Sustainable Analysis, Pharmaceutical Quality Control

O - 10

FUNCTIONAL AND NUTRACEUTICAL POTENTIAL OF PLANTS FROM SERRA DA ESTRELA NATURAL PARK: INSIGHTS INTO ANTIDIABETIC, ANTIOXIDANT, AND ANTI-INFLAMMATORY ACTIVITIES

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Abstract

Serra da Estrela Natural Park (SENP), a UNESCO Global Geopark in Portugal, is renowned for its biodiversity and the traditional medicinal practices of its local populations. This region hosts unique native flora, traditionally used to treat various illnesses. Ethnobotanical surveys in the park have identified plants with potential bioactive compounds, positioning the region as a key resource for developing functional foods and nutraceuticals. This study investigates the local flora, including Sanguisorba minor, Cistus ladanifer, Cistus salviifolius, Rhus coriaria, and Pterospartum tridentatum abundant in natural bioactive molecules that may be found in various foods and have been demonstrated to affect health positively. To evaluate the biological potential of these plants, infusions were prepared from leaves, flowers and berries, and their extraction yields, polyphenol content were evaluated. Antioxidant activity was analyzed using 1,1-diphenyl-2-picrylhydrazyl (DPPH), superoxide (O2●-), and nitric oxide (●NO) assays, while antidiabetic activity was assessed via α-glucosidase inhibition. For cell viability evaluation, 3-(4,5-Dimethylthiazol-2-yl)-2,5-Diphenyltetrazolium Bromide (MTT) and Lactate Dehydrogenase (LDH) tests were performed against NHDF (Normal Human Dermal Fibroblasts), and HepG2 (Hepatoblastoma cell line). The anti-inflammatory activity was investigated in lipopolysaccharide (LPS)-induced RAW 264.7 macrophages. Extraction yields were highest for C. ladanifer flowers (15.1 ± 0.265%), while S. minor leaves exhibited the highest polyphenol content (336.393 ± 10.222 mg GAE/g DW extract). The strongest α-glucosidase inhibition was observed with C. salviifolius (IC50 = 2.156 ± 0.118 µg/mL), outperforming acarbose (IC50 = 148.876 ± 21.501 µg/mL). P. tridentatum demonstrated significant DPPH• scavenging activity (IC50 = 21.180 ± 0.770 µg/mL), while C. ladanifer exhibited the strongest superoxide radical scavenging (IC50 = 44.703 ± 2.184 µg/mL). Cellular studies revealed the anticancer potential of the infusions. In HepG2 hepatocytes, infusions from C. ladanifer and S. minor exhibited time- and dose-dependent cytotoxic effects, with significant reductions in cell viability observed at higher concentrations. These findings suggest promising antiproliferative activity, particularly at prolonged exposure durations and elevated doses. NHDF fibroblasts exposed

to concentrations up to 200 µg/mL-maintained viability above 90%, while higher doses induced mild cytotoxicity. Anti-inflammatory activity was prominent in RAW 264.7 macrophages, with C. ladanifer and S. minor achieving up to 80% •NO reduction at 800 µg/mL. R. coriaria demonstrated consistent •NO inhibition across all concentrations, highlighting its broad-spectrum activity. These findings emphasize the potential of medicinal plants from SENP as sustainable sources of bioactive compounds make them promising candidates for functional foods and nutraceuticals. This research also supports biodiversity preservation and the valorization of traditional knowledge.

Keywords: Serra da Estrela Natural Park; Medicinal plants, Functional foods and nutraceuticals, Biological potential; Bioactive compounds.

O - 11

PHYTOCHEMICAL PROFILING AND ANTI-INFLAMMATORY POTENTIAL OF UNEXPLORED VEGETAL PARTS OF SWEET CHERRY

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Abstract

Prunus avium L., commonly known as sweet cherry, is widely consumed and recognized for its medicinal and health benefits. In Fundão region (Portugal), large amounts of cherries are produced annually. However, significant amounts of by-products are generated after flowering and fruit processing, without commercial or biological value. Despite their traditional use in folk medicine, these by-products remain underexplored regarding their phytochemical composition and bioactivity. This work aimed to explore the phenolic, mineral, and volatile profiles of sweet cherry vegetal parts, such as stems, leaves, and flowers from the Saco cultivar. Additionally, the antioxidant and anti-inflammatory activites of aqueous infusion and hydroethanolic extracts were evaluated. Phenolic compounds were identified by HPLC-DAD-ESI/MSn and the results obtained revealed that hydroxycinnamic acids as the predominant. Phosphorus was the major essential mineral quantified by ICP-MS. Volatile compound profiling using HS-SPME/GC-MS identified 117 compounds, primarily aldehydes, alcohols, ketones, and esters. Regarding antioxidant activity, both stems extracts exhibited strong activity against diphenyl-1-picrylhydrazil radical (DPPH•), while aqueous infusions demonstrated notable scavenging effects on nitric oxide radicals. Anti-inflammatory activity was assessed by testing the extracts on lipopolysaccharide (LPS)-stimulated RAW 264.7 mouse macrophages, where the extracts showed no cytotoxic effects and effectively inhibited nitrite production in a dose-dependent manner. These findings provide the first comprehensive knowledge about the phytochemical and biological properties of Portuguese sweet cherry by-products, highlighting their promising biological properties.

Keywords: Prunus avium L.; By-products; Anti-inflammatory activity; Bioactive compounds

O - 12

WILD THYME (THYMUS SERPYLLUM L.): ITS IMPACT ON COMPOSITION AND TEXTURE IN AN INNOVATIVE FRESH CHEESE FORMULATION

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Abstract

The use of nonconventional starter cultures, such as kombucha inoculum, represents a significant innovation in fresh cheese production. However, the use of wild thyme (Thymus serpyllum L.) and its extracts (obtained by valorization of a by-product from the filter tea industry) in addition to improving antioxidant activity and microbiological profile, may show a favorable impact on the technological characteristics of this type of cheese. The aim of this study was to monitor the fermentation process of milk initiated by kombucha and investigate the influence of wild thyme addition (in forms of ground, supercritical fluid extract and dry extract) on the physico-chemical composition, fatty acid composition and textural properties of fresh kombucha cheese during 30 days of storage.

Fermentation flow exhibited a parabolic shape, during a process that lasted 13h 49 min and 48s until the pH value reached 4.5. The dry matter content ranged from 52.33% to 54.04% after production. However, by the end of the storage an increase in dry matter content was observed in all samples (from 53.34% to 54.04%). The fat content did not differ much between the samples after production and after 30 days (in intervals between 25.25% and 27%). A slight decrease in protein content was noted, from 23.21%-24.21% after production to 23.08%-24.05% after 30 days of storage. After 30 days, there was a slight increase in the ash content. During the 30-day storage, a drop in pH with a simultaneous increase in acidity was recorded in all samples, while Aw value did not differ between samples. After production, no differences were observed in the energy values of samples of fresh kombucha cheese with the addition of wild thyme. The most pronounced change in hardness was observed in the control sample, where was recorded a decrease from 5114.60 g to 1955.27 g. A similar trend was observed in terms of work of shear. After 30 days stickiness increased in all samples except for the one to which the wild thyme ground was added. The control sample showed the most pronounced change in the adhesiveness value, where it increased from -273.89 gsec to -188.41 gsec. Overall, the addition of wild thyme showed a positive influence on the desired changes, which can lead to the potentially good consumer acceptance of this innovative type of fresh cheese.

Keywords: fresh cheese, kombucha, wild thyme, fermentation flow, physico-chemical composition, textural properties

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GREEN CHEMISTRY FROM AN ENZYMOLOGIST´S POINT OF VIEW: A STUDY OF PYRANOSE OXIDASES AND β-GALACTOSIDASES

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Abstract

The Carbohydrate-Active enZYme (CAZy) database contains catalytic modules and domains of enzymes that degrade, modify, or create glycosidic bonds. In conjunction to the CAZy enzymes, auxiliary activity enzymes provide a helping hand to the main CAZy enzymes.
In our laboratory, we have been engineering the CAZy enzymes, e.g., pyranose oxidases and β-galactosidases, using rational design and ancestral reconstruction to achieve specifically desired properties. By characterizing not only putative enzymes but also their variants, we are able to explore their biochemical and structural characteristics. Pyranose oxidases are enzymes that oxidise monosaccharidic sugars/*C*-glycosides, while β-galactosidases hydrolyse lactose and catalyze the transgalactosylation of lactose yielding various galacto-oligosccharides. Both enzymes could be used for biotechnological purposes however their biochemical properties are still insufficient for most industrial purposes. In this presentation, not only the work on these enzymes at molecular level but also our recent results to engineer them to be more applicable in the food industry will be discussed.

Keywords: Enzymes, protein engineering, pyranose oxidase, β-galactosidase

O - 14

CHARACTERIZATION OF INDIGENOUS MICROFLORA AND QUALITY PARAMETERS OF NATURAL GREEK RED WINE, PRODUCED WITH NATURAL ANTIOXIDANTS, WITHOUT USE OF SULPHITES AND STARTER CULTURES

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Abstract

Industrial winemaking involves usually the use of preservatives (sulphites), which prevent spoilage and oxidation of color and flavor compounds, as well as starter cultures which help control the alcoholic fermentation and lead to standardized, stable products. However, sulphite are allergiogenic synthetic chemical that may also leave a non natural, chemical taste to wines, while the addition of Saccharomyces starter cultures leaves little room for the indigenous microflora of grapes and wine must to develop. In the last years, a new trend for natural wines without sulphites and starters has grown among consumers who seek more unique, authentic flavors, without compromising wine stability. This study describes the main indigenous microflora of natural Greek red wine "Limniona", which was produced without sulfites by incorporating natural antioxidants from pomegranate peels, grape skins and olive fruit extracts rich in polyphenols/tannins. These green antioxidants not only serve as natural preservatives, but may also enhance the sensory or microbiological properties of the wine.

Microbiological, molecular, chemical and sensory analyses of the natural red wine "Limniona" were carried out in order to describe the main quality attributes of this wine (or similar natural wines). Alcohol and sugar content, acidity, taste, aroma and color were measured and different species of alcohol-producing yeasts and few species of beneficial lactic acid bacteria were isolated and characterized. Ripe grapes, must and wine microflora included yeasts like Candida, Saccharomyces, and several bacterial species (Bacillus, Staphylococcus, Serratia, Klebsiella, etc), some of which are probably the result of cross-contamination by humans or the equipment used during harvest and processing.

All natural antioxidants from plant processing byproducts that were used as a replacement for sulphites offered antioxidant protection and affected the quality parameters. Encapsulated olive extracts had high antioxidant activity, as well as distinct effect on flavor and color and enhanced malolactic fermentation, while pomegranate peels and grape skins had milder effects on sensory attributes, but required higher dosages for antioxidant effect. All natural additives could help avoid oxidations and spoilage, while the fermentation by only indigenous yeasts allowed the development of distinctive aroma and taste. This study highlights the microbiological, chemical and sensory characteristics of high-quality, sulfite-free natural red wines, produced with natural alternatives to synthetic additives, which are in line with the modern consumer trend for green, sustainable, nutritious foods.

Keywords: natural wine, natural antioxidants, sulphites, microbiota, alcohol fermentation, sensory analysis

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BIOSYNTHESIS OF SELENIUM AND TELLURIUM NANOPARTICLES AND THEIR ALLOYS USING LACTOBACILLUS CASEI: A SUSTAINABLE APPROACH TO FUNCTIONAL NUTRACEUTICALS

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Abstract

Due to their potential antioxidant, anticancer, and antimicrobial effects, Selenium (Se) and Tellurium (Te) nanoparticles (NPs) have gained more attention as promising sustainable materials for functional foods and nutraceutical applications. Selenium is a vital micronutrient crucial for immune system function, thyroid metabolism, and hormone regulation, while tellurium is an antimicrobial agent. Nevertheless, Conventional synthesising methods utilise toxic precursors and hazardous substances, constraining their use in food and healthcare industries. This study explores an eco-friendly, probiotic bacterial assisted synthesis of Selenium and Tellurium nanoparticles and their nanoalloys using Lactobacillus casei. Scanning electron microscopy and Atomic Fluorescence spectroscopy were used to characterise synthesised nanomaterials. Our results show that L. casei can effectively reduce selenite and tellurite to produce red amorphous selenium nanospheres (206 ± 33 nm) and black tellurium nanorods (176 ± 32 nm in length, 62 ± 13 nm in cross section), respectively. If the precursor of the selenium-tellurium solution is mixed, the bacteria produce Selenium-Tellurium nanoalloys with an elemental composition similar to that of the initial medium. The bacteria synthesised nanomaterials show the high stability, bioavailability and potential biocompatibility, making them suitable candidates for nutraceutical formulations.

This research highlights the promise of microbial transformation of producing functional food ingredients. Including selenium and tellurium nanoparticles into probiotic yoghurt, dairy items, and nutraceuticals could offer an innovative approach to improving human health with sustainable food elements. Furthermore, Investigations related to long-term safety, toxicity and potential regulatory aspects of incorporating these new technologies into food systems.

Keywords: Functional foods, Probiotic biosynthesis, Green nanotechnology, Microbial transformation, Green synthesis

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APPLES AS A NATURAL BIOSYNTHETIC TOOL FOR AROMA PRODUCTION

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Abstract

The demand for natural flavors in the food industry is steadily increasing, driven by consumer preference for clean-label products. Natural aromas can command significantly higher prices than their synthetic alternatives. Traditionally, volatile organic compounds responsible for fruit aroma are extracted through distillation or steam distillation processes and subsequently reintroduced to clarified juices to enhance sensory quality. Apple-derived hydrolates are widely utilized for this purpose, offering a significant natural alternative to synthetic additives.

Esters are the main compounds responsible for apple aroma due to their high concentration in apples and their low odor threshold. The biosynthesis of esters in apples involves metabolic pathways where the main precursors include fatty acids and amino acids, while the key intermediates and final products are aldehydes, alcohols, and esters. The final step in ester biosynthesis is catalyzed by enzyme alcohol acyltransferase, which transfers an acyl group from coenzyme A to an alcohol acceptor. The quantity and diversity of aroma compounds in apples largely depend on the availability of enzymes and precursors.

It is known that apple fruit is able to convert the added precursor into the responsible ester. Therefore, aldehydes and alcohols, as aroma precursors, could play a crucial role in the aroma production by apple. Hexanal and ethanol, both compounds occur naturally in fruits and hold GRAS (Generally Recognized as Safe) status, rendering them suitable for use in food applications. Our study demonstrates that supplementing apples with relatively low concentrations of ethanol and hexanal significantly enhances the natural ability of apples to produce key volatile compounds that are responsible for apple aroma. By adjusting natural aroma precursors and selecting specific apple varieties, it is possible to create a wide range of aroma profiles tailored to different product requirements. This method could present an efficient and environmentally favourable alternative to traditional chemical and enzymatic production of natural aromas. Furthermore, the use of natural compounds as precursors in this process ensures regulatory compliance and consumer acceptance, making it an attractive solution for manufacturers seeking to meet the growing demand for clean-label products.

Keywords: Nautral aromas, apple hydrolates, aroma production, apple fruit, esters

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EVALUATING THE PUBLIC HEALTH IMPACT OF PLANT BASED ALTERNATIVES: A RISK-BENEFIT ASSESSMENT TO GUIDE THE PROTEIN TRANSITION

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Abstract

A growing concern about the environmental impact of red meat production has intensified debates in Western countries over reducing red meat consumption, notably due to its significant carbon footprint and ethical issues surrounding animal welfare. Research has also highlighted public health risks associated with red meat consumption, particularly its processed forms, linked to an increased prevalence of chronic diseases such as type 2 diabetes, cardiovascular diseases and colorectal cancer. Consequently, reducing red meat intake, especially its processed varieties, is seen as a crucial step in public health strategies aimed at reducing the incidence of these diseases. However, there is a need to assess the viability and health implications of alternative protein sources. To find alternatives for red meat consumption, we proposed the following scenarios: a reference scenario reflecting the current consumption of beef burger and alternative scenarios utilising different plant-based options. To identify the most environmentally sustainable and nutritious food alternatives, food items from the Ciqual table were ranked using ECO and NUTRI scores. A probabilistic exposure assessment evaluated nutrient content, microbiological and toxicological components, and food consumption data from France, Greece, and Croatia. Individual risks and benefits were assessed by combining dose-response estimates with exposure assessment data. Overall health impacts for each scenario were estimated in Disability-Adjusted Life Years (DALYs). Monte Carlo simulations were applied to integrate uncertainty and variability in model inputs and parameters. Ranking of the food items in Ciqual database showed promising substitutes for beef burger could be red kidney bean-based or green lentil-based burger. Shifting from the reference scenario to any alternative one results in notable changes in the intake of the nutrients present in the analyzed scenarios. The analysis showed that the most impactful domain In terms of shaping the overall health impact is the one of nutrition. Estimating the public health impact through risk-benefit assessment (RBA) provides valuable insights for risk managers, enabling them to make well-informed decisions, and guiding policymakers in creating tailored nutritional recommendations for their populations. The RBA methodology serves as a decision-support tool to evaluate substitution scenarios, and help industry formulate recipes beneficial for consumers with a simultaneous consideration of nutritional, microbiological, and toxicological aspects under a unified framework. This work reveals new insights into the balance between nutritional quality and food safety, offering consumers scientifically-supported reasons to diversify their diets to more sustainable plan-based diets.

Keywords: risk-benefit assessment, plant-based alternative, edible insects, alternative proteins, dietary shift

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PHYTOBIOTIC ESSENTIAL OILS AS ANTIBIOTIC ALTERNATIVES IN AQUACULTURE: ANTIMICROBIAL AND ANTIOXIDANT PROPERTIES OF GARLIC, THYME, ROSEMARY, AND EUCALYPTUS

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Abstract

The goal of this research was to reduce or replace antibiotics in aquaculture by incorporating bioactive phytobiotic compounds that promote fish health. Essential oils from garlic (*Allium sativum*), thyme (*Thymus vulgaris*), eucalyptus (*Eucalyptus globulus*), and rosemary (*Salvia rosmarinus*) were selected for their potent antimicrobial and antioxidant properties. Compounds such as allicin, thymol, carvacrol, and eucalyptol contribute to their efficacy against fish pathogens and their potential as natural preservatives in aquafeed. Hydro-distillation was employed to extract volatile and polar components from plant materials. GC-MS analysis of essential oil samples was conducted. Minimum inhibitory concentration was determined using a resazurin-based microtiter plate antibacterial/antifungal assay. The antioxidant activity (AA) of essential oils was measured in Trolox equivalents (TEAC, µmol/mL). Rosemary essential oil was predominantly composed of eucalyptol (1,4-cineol) at 43.00%, followed by α-pinene (9.06%), camphor (3.85%), and borneol (3.57%). In thyme essential oil, thymol constituted 35.1% of the oil, with p-cymene at 31.6%, and smaller amounts of linalool (2.65%) and borneol (2.50%). Conehead essential oil contained carvacrol as the major component at 19.98%, with p-cymene (4.83%) and linalool (2.22%) presented in lesser amounts. Carvacrol is known for its potent antimicrobial properties, which are enhanced by the presence of p-cymene, a precursor that can synergistically increase carvacrol's efficacy. The primary constituent of garlic essential oil was propyl propane thiosulfonate (PTSO) at 30.3%, along with dipropyl trisulfide (1.72%) and dipropyl disulfide (0.64%). These sulfur-containing compounds are largely responsible for garlic oil's broad-spectrum antimicrobial activity, effectively inhibiting both Gram-positive and Gram-negative bacteria. Eucalyptus essential oil was characterized by a high content of eucalyptol (1,3-cineol) at 68.9%, with limonene-D (5.25%) and p-cymene (1.01%) as minor components. Among the tested essential oils, *Thymus capitatus* (Thyme) exhibited the highest AA, with a TEAC value of 34.7 µmol/mL, indicating its potent antioxidant potential. All the EO shown antibacterial activity, with garlic and both thyme varieties expressing higher activity than the

positive control, Fluconazol, against *E. coli, P. aeruginosa and S. aureus*. According to the results obtained, garlic and conehead thyme followed closely by thyme shown the highest antibacterial effects against the tested strains. All the essential oils shown strong antifungal activity as well.
In summary, the distinct chemical profiles of these essential oils underpin their specific therapeutic properties and potential applications in various industries, including pharmaceuticals, food preservation, and aromatherapy.
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Keywords: natural additives, phytobiotics, essential oils, antimicrobial, aquaculture

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INFLUENCE OF SATUREJA MONTANA L. ESSENTIAL OIL ADDITION ON PLUM-OIL CAKE BASED BIOFILMS PROPERTIES

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Abstract

Plastic materials are widely used for food packaging, but their production relies on non-renewable resources and their improper disposal generates significant amounts of waste. This has prompted scientists to look for more environmentally friendly alternatives. Biopolymers, which are biodegradable and derived from renewable resources, are gaining increasing attention as sustainable materials for food packaging. Modern technologies are also exploring the use of agro-industrial waste, leading to various biomasses being investigated for their potential value. Among food industry, fruit and vegetable industry waste makes up the largest portion of food industry waste. Waste from fruit processing is often thrown away, although it is a promising source for the extraction of value-added compounds. In the Republic of Serbia, the most widely cultivated fruit is plum, so a certain amount of waste remains after its processing. A large part of the plum waste - the fruit seeds - are rich in oil. After cold pressing, the remaining plum oil cake (POC) becomes a nutritious by-product. POC is highly nutritious as it contains proteins, lipids, carbohydrates, fibers, but also micronutrients and thus offers a potentially sustainable solution for packaging materials as an excellent raw material for biofilms production.

Even though POC-based films present good alternative for synthetic materials and naturally contains plum oil, water sensitivity may be improved by addition of hydrophobic components into material formulation. Aromatic plants Satureja montana L. is widely spread in the Balkan region and can be found in Serbia. Both the major components (carvacrol and thymol) of Satureja montana essential oil are highly hydrophobic phenolic monoterpenes, and addition of the mentioned essential oil could improve water sensitivity, but other properties of POC-based materials, as well.

In this work 1, 2 and 3 % (v/v) of Satureja montana essential oil was incorporated into POC-based biopolymer films. The obtained materials were analyzed regarding mechanical, physicochemical and water barrier properties. The most significant influence of essential oil addition is observed in water vapor transmission rate reduction - up to 43.14%. These results are promising in terms of further application of POC-based biofilms for food preservation.

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Keywords: plum oil cake, valorization, biofilms, Satureja montana L. essential oil, biofilm properties

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SUILLUS LUTEUS (L. FRIES) MUSHROOMS AS A SOURCE OF CHITIN NANOFIBERS FOR ACTIVE FOOD PACKAGING APPLICATIONS

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Abstract

Chitin is the second most prevalent polysaccharide in nature, found in the exoskeletons of arthropods and the cell walls of fungus. It is a linear copolymer of N-acetylglucosamine and glucosamine linked by (β-1-4) bonds, with a preponderance of the former units. Fungal chitin chains exhubit branching with glucose units interconnected by β-1-3 and β-1-6 linkages. This offers the benefit of less toxicity compared to chitin derived from crustaceans and exhibits higher structural reproducibility. The presence of these branches reduces the moisture permeability of fungal chitin films. This study aimed to isolate and analyze the chitin found in the stem, hymenium, and cap of the pine mushroom Suillus luteus (L.: Fries) Gray. Furthermore, to investigate various conditions for preparing chitin nanofibers (CNF) by physical methods and carrying out their physicochemical characterization. The CNF could function as a reinforcing and waterproofing additive for biodegradable films designed for active food packaging applications. Fungal chitin was extracted from mushroom components via alkaline extraction and analyzed using several techniques including: FT-IR, TGA, CPMAS 13C-NMR, SEM, and GC-MS for sugar analysis. The isolated material was utilized for NFQ preparation via a sequential treatment comprising high-speed agitation at 12,000 rpm (ultraturax) followed by a high-pressure homogenization process. The number of homogenization cycles (5-40) was examined in this latter scenario. The fiber dimensions were ascertained utilizing a Microtrac. Suspensions of 1% (w/v) chitin in water were produced for nanofibrillation, and the resulting nanofibers were studied using viscometric analysis and transmission electron microscopy (TEM). The fungal chitin from S. luteus is present in greater quantities in the stem compared to other components. The typical acetylation degree of chitin is GA = 93.1%. The chitin/glucan ratio was 60/40, agreeing with the anticipated range for fungal chitin. The microtrac and TEM analyses revealed that NFQ with a width of 10-15

nm and a length of 19-42 µm had been obtained. The findings suggest that these NFQ may serve as an effective reinforcing ingredient in the formulation of smart and active bioplastics for food packaging applications.

Keywords: chitin nanofibers, food packaging, Suillus luteus mushroom, chitin

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BIOFILM FORMATION POWER OF ESCHERICHIA COLI IN DAIRY FARMS

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Abstract

Biofilm formation is considered an important virulence factor of opportunistic and pathogenic bacteria. Bacterial biofilms can grow on many abiotic and biotic surfaces. Biofilm-related diseases caused by gram-positive bacteria can cause many conditions such as gingivitis, endocarditis and prostatitis. The aim of this study was to evaluate the presence of *Escherichia coli*, *Staphylococcus aureus*, and *Listeria monocytogenes* in milking machines, given their potential to contaminate milk during the milking process. Additionally, the study assessed the ability of these bacteria to form biofilms, which can further affect milk quality and safety.

In the present study, samples were collected from a total of ten different dairy farms in Gaziantep, Turkey, and the Campania region of Southern Italy, four hours after the cleaning and sanitation process. Samples were collected through sponges from both the surfaces and internal components of the milking machines. The classical culture method combined with MALDI-TOF mass spectrometry was used to isolate and identify the bacteria. Subsequently, the isolated bacteria were evaluated for their biofilm formation ability using the microtiter plate method.

According to the isolation results, Enterobacteriaceae and *Staphylococcus* spp. counts varied between 2.0 - 6.0 $\log_{10}$ cfu/ml; 2.0 - 6.60 $\log_{10}$ cfu/ml, respectively. Among the 132 isolates for both regions was determined only one *E. coli*. *L. monocytogenes* and *S. aureus* weren't isolated from the samples. It was determined that *E. coli*, with an ODs/ODc value of 13.67, was a strong biofilm former. In light of the results, it is thought that *E. coli*, which has strong biofilm properties, threatens public health by contaminating products in dairy industry.

Keywords: Biofilm, Dairy Farms, Public Health, Escherichia coli

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BENEFICIAL EFFECTS OF NATURAL FEED ADDITIVES FROM OLIVE FRUIT, POMEGRANATE PEELS AND GRAPE POMACE ON GROWTH, GUT MICROBIOME AND MEAT QUALITY OF BROILERS

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Abstract

Much like human nutrition, animal nutrition involves the use of several nutritional supplements that boost health and growth and has direct effects on gut microbiome, which in turn determines to great extend overall health. In recent years, there is a constant search for natural substances that can boost animal health and increase growth rate, or improve meat quality, without relying on administration of antibiotics or hormones. In the present study, natural feed additives rich in polyphenols, derived from plant processing by-products such as olive fruit, pomegranate peels, extract, and grape skins were used to promote health and productivity of broilers and improve quality characteristics of poultry meat.

Four groups of broilers were used : a control group, plus three different treatments with 1% w/w addition of each one of the natural additives in the animal feed (pomegranate peels, olive fruit extract, and grape skins). For all groups of broilers the growth rate, living weight, mortality, occurrence of diarrhea, gut microbiome, antioxidant capacity and chemical composition of meat were studied.

The results indicated that the additions of these natural, bioactive feed supplements improved productivity and health parameters, such as growth rate and net weight at slaughter or occurrence of diarrhea, while they helped improved gut microbiome, either by reducing the population of potentially pathogenic bacteria (such as Campylobacter, Clostridium), or by increasing the level of probiotic bacteria (Lactobacillus, Bifidobacterium species), thus serving as alternative prebiotics. Also, the addition of some of these natural antioxidants in animal feed, not only increased antioxidant properties of meat and prevented lipid oxidation, but also altered the composition of lipids, leading to increased levels ω-3 fatty acids of meat. Meat color was also affected, compared to the control meat samples.

These results show that readily available agricultural by-products rich in polyphenols, organic acids and other bioactive compounds can serve as functional ingredients that contribute to improved animal health (especially gut health) and performance, as well as better nutritional characteristics of poultry meat.

Keywords: Natural antioxidants, prebiotic, polyphenols, feed supplements, gut health, poultry meat quality

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CHARACTERIZATION AND POTENTIAL APPLICATION OF OLIVE OIL MILL WASTEWATER SLUDGE FOR SUSTAINABLE AGRICULTURE

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Abstract

Olive oil mill wastewater (OMW), a byproduct of olive oil extraction, generates significant environmental challenges due to its toxicity, heterogeneity, and high content of recalcitrant organic compounds. This waste is typically disposed of in evaporation ponds across the Mediterranean Basin, where water evaporation leaves concentrated olive oil mill wastewater sludge (OMWs) which accumulate in the ponds. While most research has focused on the study of OMW composition, there is limited understanding of the functional potential and practical applications of OMWs from an agri-food and sustainability perspective. This study aimed to characterize the physicochemical, toxicological, and microbiological properties of OMWs from evaporation ponds in different geolocations and evaluate their potential for agricultural use. Results revealed variability in pH, organic matter, ecotoxicity, and phytotoxicity, with some sludges exhibiting phytostimulant properties, suggesting their suitability for sustainable agriculture. Functional microbial biodiversity analyses identified metabolic activities related to the degradation of complex polymeric compounds and carboxylic acids, consistent with the recalcitrant nature of OMWs. Taxonomic studies highlighted microbial families such as Moraxellaceae, Ruminococcaceae, and Lactobacillaceae, which may play a key role in reducing toxicity and enhancing agronomic value. Samples were classified based on their characteristics, providing insights into their functional potential. These findings underscore the opportunity to develop tailored bioremediation strategies to mitigate environmental risks while leveraging OMWs as a resource for sustainable agriculture. By uncovering valuable properties of this widespread waste product for agricultural use, the study offers a promising solution to address both environmental and agronomic challenges in olive oil-producing regions.

Acknowledgements: This work was supported by the OLIVE_RELIFE project (TED2021-129481B-C3), funded by the Spanish Ministry for Ecological Transition and the Demographic Challenge.

Keywords: OMW sludge, Biolog Ecoplate, phytotoxicity, ecotoxicity, microbiome

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EFFECTIVE STRATEGIES FOR THE SUSTAINABLE VALORIZATION OF FISHERY BY-PRODUCTS: INSIGHTS FROM THE H2020 ECOEFISHENT PROJECT

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Abstract

It is estimated that about 35% of global fish production is lost or wasted annually, leading to significant economic and environmental challenges. As a result, the generation of by-products from the fish supply chain, encompassing fishing, aquaculture, and processing sectors, is also growing. The EcoeFISHent project ("Demonstrable and replicable cluster implementing systemic solutions through multilevel circular value chains for eco-efficient valorisation of fishing and fish industries side-streams"), funded under the Horizon 2020 - Green Deal program, is designed as an Innovation Action to deploy sustainable and efficient use of fishery side streams by obtaining bioactive compounds potentially exploited in the nutraceutical, cosmetic, and bio-packaging field [1]. This study examines both the leftovers from the filleting process of seabass and seabream by an Italian aquaculture company and side streams from the tuna canning industry. Main novelties concern the valorisation of unsorted and non-separated fishery side streams, avoiding the costly sorting step of these side streams (i.e., heads, skins, backs), and the preliminary microbiological stabilization of this highly perishable biomass using a patented mild industrial dehydration technique. Eco-friendly techniques such as Microwave-Assisted Extraction (MAE) combined with green solvents and Enzyme-Assisted Extraction (EAE) have been investigated to extract the oil fraction from aquaculture sidestreams. Moreover, a scalable extraction method, depicted by a single cascade flowchart using EAE, has been implemented to upcycle the protein fraction of canned tuna by-products [2]. This method, which has been scaled up from laboratory scale to semi-pilot scale (30L reactor @ NOFIMA), primarily allows for the separation of proteins and hydrolyzed peptides, including non-collagenous peptides (NCs), gelatin (G), and hydrolyzed collagen peptides (HCPs) [3]. All the extracted bioactives (oils and proteins/ hydrolyzed peptides), after their isolation and purification, were characterized in terms of proximate and ultimate analyses to assess their potential applicability in different fields.

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from Tuna Mixed Byproducts: An Example of Fishery Side Streams Upcycling. Antioxidants. 2024 19;13(8):1011. doi: 10.3390/antiox13081011.

Keywords: fishery sidestreams, circular economy, green extraction, fish oil, hydrolyzed peptides

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UTILIZING FOOD WASTE FOR BIOACTIVE COMPOUND RECOVERY

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Abstract

The market for natural products has experienced significant growth in recent years. Bioactive compounds found in natural products possess remarkable properties, including beneficial nutritional and medicinal possesing antimicrobial, antiinflamations and antioxidant activities. However, these bioactive compounds often exhibit poor solubility, stability, and low bioavailability. Low stability, especially during storage, can result in the loss of the active component, formation of inactive metabolites, and in extreme cases, formation of toxic metabolites.

We will presents new approaches to enhance the stability of bioactive compounds and protect them from adverse environmental conditions using lipids and/or polymeric matrices. Additionally, it discusses low bioavailability in terms of solubility and stability of bioactive compounds, with a focus on quercetin and oleuropein.

Quercetin is a natural plant polyphenol found abundantly in several vegetables and fruits, with the highest content reported in onion skin, and is believed to have beneficial effects on human health. Olive leaves, a by-product of olive tree cultivation, are plentiful in olive oil industries and olive groves. They contain simple phenols, flavonoids, and secoiridoids. Among these, oleuropein is the major secoiridoid compound in olive leaves and has demonstrated interesting biological and pharmacological properties, largely attributed to its antioxidant and anti-inflammatory effects.

The bioavailability of polyphenols is a key factor influencing their health benefits. The current approaches to increase the bioavailability of poorly soluble and stable bioactive components, such as polyphenols, especially for the fortification of beverages and similar liquid foods will be discussed.

Keywords: bioactive compounds, encapsulation, olive tree leaves, onion skin

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CIRCULAR ECONOMY IN AGRICULTURAL PRODUCTION: A TRI-TROPHIC SYSTEM INCORPORATING PLANTS, FISH, AND INSECTS TURNS WASTE INTO RESOURCE

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Abstract

The circular economy concept should be incorporated into primary production to enhance the sustainability and resource use efficiency of crop production systems. A pioneering circular tri-trophic system has been implemented for the cultivation of major greenhouse crops, which includes three types of organisms (plants, fish, and insects) that feed each other. This approach has enabled the reuse of nutrient-rich materials that have previously been regarded as waste. The residues or by-products of one organism's metabolism have been transformed into food for the next, turning them from waste into a resource. Cucumber, lettuce, and tomato crops were cultivated in this circular system, with pruning residues and fruits used to feed the black soldier fly. The latter was reared to produce insect meal which was incorporated into the fish (tilapia) feed. Fish metabolic products, rich in nitrogen and other elements necessary for plant nutrition were driven to crops through the recirculating water system (aquaponics). In this presentation we evaluate the results of implementing this system for crop production in comparison with the widely used linear system. Additionally, we discuss the system's bottlenecks and restrictions and propose mitigation measures to ensure high crop productivity and increased sustainability, while minimizing the ecological footprint.

The project is funded by the Green Fund, under the Programme "Natural Environment & Innovative Actions 2022" / P.A. 3 "RESEARCH AND APPLICATION

Keywords: Aquaponics, crop yield, insect meal, nutrients recovery

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PHYTOSTIMULATION AND PHYTOPROTECTION STRATEGIES BASED ON THE APPLICATION OF THE MICROBIOTA FROM OLIVE OIL MILL WASTEWATER SLUDGE

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Abstract

The olive oil industry produces large quantities of waste, including olive mill wastewater sludge (OMWs), which is highly polluting from an environmental point of view. However, OMWs contain valuable microbiota adapted to very specific extreme conditions. Moreover, this microbiota could have a potent biofertilizing and biopesticidal character, which could help to reduce the use of agrochemicals. The main objective of this work was the physicochemical and microbiological characterization of OMWs samples for the development of new phytostimulation and phytoprotection strategies. In addition, the most interesting microbial candidates were characterized based on their antagonistic spectrum against plant pathogens such as Botrytis cinerea, Fusarium oxysporum f.sp. melonis, Xanthomonas campestris and Clavibacter michiganensis subsp. michiganensis.

Specifically, four strains showed a promising antagonistic spectrum, and three of them were also able to promote tomato and melon seed germination by increasing radicle elongation after applying biopriming techniques. Subsequently, these strains were applied by in vivo assays as a microbial cocktail composed of the bacterium BS1, identified as Bacillus wiedmannii, and the fungi H2 and H6, identified as Aspergillus terreus and Penicillium paneum, respectively. The results showed variability depending on the crop used, but stimulation of root development as well as mitigation of damage caused by phytopathogenic fung were observed.

Acknowledgements: This work was supported by the OLIVE_RELIFE project (TED2021-129481B-C3), funded by the Spanish Ministry for Ecological Transition and the Demographic Challenge.

Keywords: Olive mill wastewater sludge, Phytostimulation, Phytoprotection, Plant pathogens, Biopriming

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VALORIZATION OF AGRI-FOOD WASTE THROUGH THE PRODUCTION OF COMPOST EXTRACTS AS A SUSTAINABLE TOOL FOR PROTECTION AGAINST AIRBORNE PATHOGENIC FUNGI

Jurado M M, Jimenez R, Suarez-Estrella F, Lopez-Gonzalez J A, Estrella-Gonzalez M J, Martinez-Gallardo M R, Toribio A, Lerma-Moliz R, Lorente-Escanez D, López M J

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Abstract

Compost extracts are proposed as an alternative application to traditional solid organic compost amendments, with enormous potential for use in intensive agricultural systems that aim to produce enough food to meet market demands, while offering a sustainable alternative to agrochemicals, due to their biopesticidal, biofertilizing, and biostimulant properties. However, establishing quality standards and predicting the mechanisms by which these formulations suppress plant diseases remains a major challenge today. Thus, the objective of this study focused on the microbiological and functional characterization of a collection of aqueous compost extracts, using different extraction protocols, as well as their impact on different pathosystems. Composts derived from agro-food waste, sludge, olive oil mills, and vegetable waste were subjected to different extraction procedures based on temperature and incubation time. Specific microbial groups and enzymatic activities of interest were quantified. The potential of compost extracts to suppress disease caused by Botrytis cinerea in cucumber plants was also evaluated. In this regard, extracts obtained through protocols involving longer extraction times at moderate temperatures showed greater functional diversity and microbial abundance, while those obtained through protocols applying higher temperatures showed lower microbial counts and less bioactivity, which could negatively affect their suppressive potential against plant pathogens. Thus, this work demonstrated that extracts with greater functional diversity were more effective in controlling the damage caused by the pathogenic fungus, although a significant influence of the initial compost was observed. Furthermore, this study demonstrates the efficacy of compost extracts that even when applied through the soil, they act as elicitors, controling aerial pathogens in cucumber plants, achieving a 65-80% reduction in plant damage. Therefore, the development of appropriate extraction protocols could lead to compost extracts with greater phytoprotective capacity. This study lays the foundations for the development of a novel and sustainable solution to manage both the growing amount of agri-food waste and to offer an application of safe products for agriculture and the environment, and therefore for future consumers, based on biotechnological tools.

This work was supported by a “Bridge grant” under the Research and Transfer Plan 2022 of the University of Almeria (Spain) (PID2020-118402RB-I00), and the COMPOBIOTICS project (PID2023-149455OB-I00), supported by Ministry of Science, Innovation and Universities (Spain).

Keywords: Compost extracts, Agrifood waste, Microbiological characterization, Suppression Air-borne fungal pathogen.

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ANTIMICROBIAL EFFECT OF POLYPHENOLS EXTRACT FROM ARTICHOKES ROOTS

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Abstract

Over the years, the problem of food waste has become an increasingly important issue for the countries of the Mediterranean basin. To counter this growing phenomenon, the European Commission through the application of the European Green Deal is focusing research on reducing food wastes and valorizing them by using green solvents in order to reduce their environmental impact. Among the most widely produced by-products in Italy are those deriving from artichokes cultivation. In particular, among the various byproducts, artichokes roots can be used as a valuable source of high-value compounds, including polysaccharides such as inulin and antioxidant compounds as polyphenols. This research work focused on optimizing the extraction of polyphenols from artichokes roots and the subsequent study of antimicrobial activity of polyphenols-rich extract against Escherichia coli.

The optimization of polyphenols extraction from artichokes roots was made using a high pressure and temperature extractor (HPTE). The experimental plan included analysis of the effect of the solvent composition (hydroalcoholic solution with different volume fraction of ethanol), time and temperature on the extraction yield using Box-Behnken Design for response surface modeling. In detail, percentages of ethanol between 0 and 100%, extraction temperature between 120 and 180 °C and extraction time between 30 and 120 minutes were tested. The results were expressed in terms of total polyphenols yield (TPY) and antiradical power (ARP) using Folin-Ciocalteu colorimetric assay and ABTS assay respectively. After defining the best operational conditions to recover antioxidants, the polyphenols-rich extract was tested on selected microorganism, E. coli, using agar diffusion method.

Two quadratic equations were defined from the experimental study for the determination of the variables of interest, and the optimum point was defined by the following parameters: for the solvent it would be necessary to use a 31% hydroalcoholic solution for an extraction time of 30 minutes, operating at the maximum tested temperature, 180 °C, to obtain a TPY equal to 46.66 mgCAE/gDB and ARP equal to 152.56 mgTE/gDB.The optimum point was evaluated experimentally, and it has been shown, by preliminary results, interesting antimicrobial effects against E. coli.

The HPTE process has resulted in a polyphenol-rich extract from artichoke roots, with an extraction yield higher than that obtained by other non-conventional techniques. In addition, it is interesting to observe how the extract obtained from a byproduct can be used against Gram positive bacteria such as E. coli.

Keywords: Food waste, antioxidant recovery, unconventional extraction

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SUSTAINABLE VALORIZATION OF BLUEBERRY BY-PRODUCTS: EXPLORING THE BIOACTIVE POTENTIAL OF ANTHOCYANINS AND POLYPHENOLS

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Abstract

In the framework of circular economy and green extraction, this work aims to valorise Blueberry Pomace (BP) as a source of bioactive compounds, by exploring innovative extraction technologies, for a sustainable upgrading of this agri-food byproduct. Specifically, Microwave-Assisted Extraction (MAE) and Microwave-Assisted Subcritical Water Extraction (MASWE) were exploited with a sequential approach on the same biomass, to yield two distinct fractions: MAE 1° and MASWE 2°. The MAE 1°, obtained at 80°C, showed a high content in total anthocyanins (21.96 mgCya-3-glu/gextract) suggesting its potential application as a natural pigment. Conversely, MASWE 2°, recovered at 150°C from the residual biomass of MAE 1°, was characterized by a higher total polyphenolic content (211.73 mgGAE/gextract), reflected in its strong antioxidant activity. Both fractions were tested for their in vitro activity on various enzymes, demonstrating distinct bioactive properties. MAE 1° revealed a significant inhibitory effect against α-amylase and β-glucosidase, suggesting potential application on diabetes management and anti-viral treatments. MASWE 2° showed greater inhibition of acetylcholinesterase and tyrosinase, highlighting its potential use in Alzheimer's treatment, skincare, or in food preservation. Some in vitro cell studies (antiproliferative effect and antioxidant activity in cell with induced oxidative stress) revealed that MASWE 2° exhibited higher cytotoxicity against HeLa cells and effectively mitigated H_2O_2-induced oxidative stress in HaCat cells, while MAE 1° showed similar effects but less pronounced.
To improve the thermal stability of anthocyanins and evaluate the feasibility of developing a natural pigment, a formulation combining the two extracts was tested. The preservative effect of the polyphenol-rich fraction resulted in a promising heat-stable pigment.
To further assess the sustainability of the overall process, various green metric tools - namely RME, E-Factor, PMI, and PME – along with the Green Motion approach, were applied to quantify the "green level", taking into account both the efficiency of the protocol and the environmental impact.
The presented study focuses on the use of enabling technologies to enhance the agri-food residues valorisation, merging the attention toward process intensification supported by chemical/biological evaluation, together with standardized and quantifiable greenness assessment.

Keywords: Green Extraction; Microwave-Assisted Subcritical Water Extraction; Secondary Metabolites; Bioactivity; Green Metrics.

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BIODEGRADABLE FILMS WITH POLYSACCHARIDES AND BIOACTIVES FROM LOBOSPHAERA

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Abstract

In trying to mitigate environmental hazards caused by the increased consumption of fossil resources and poor disposal of non-biodegradable packaging waste, active and edible films from natural sources emerge. These films intend to extend the shelf life of food products. For this reason, other natural compounds with antioxidant and antimicrobial properties can be added to the natural edible film, turning it into a functional preservative for food safety. *Lobosphaera* sp. is a source of natural bioactive compounds with antioxidant and antimicrobial activities and other nutritional compounds, such as polysaccharides and proteins.

In this study, bioactive compounds were extracted from *Lobosphaera* sp. through maceration (hydroethanolic solution 90%, 50 °C, 120 rpm, 2 h, repeated twice), and the polysaccharides were extracted through hydrolysis (water, 90 °C, 60 min). The total phenolic content (TPC) and the antioxidant activity (ABTS, DPPH, ORAC) of the bioactive-rich extract were determined. The films were produced using the casting method, and their antioxidant activity (ABTS, DPPH), and physical properties were determined. The TPC of the bioactive-rich extract was 1.07±0.05 mg GAE/100 mg DW, and the ABTS, DPPH, and ORAC were 2.44±0.27, 1.67±0.15, and 11.90±1.22 µmol TE/100 mg DW, respectively. The edible film with 2% alginate, 0.5% polysaccharides extract, and 0.25% bioactive-rich extract presented an ABTS of 394.61±35.69 and a DPPH of 153.15±20.07 µM TE/mg film. The colour parameters of this film were L*=70.43±8.64, hue=88.5±0.4 °, and chroma=12.98±1.72; its thickness was 0.072±0.008 mm; its solubility was 100% in water; and its water vapour permeability (WVP) was 20.99±2.17 ($g \cdot mm \cdot m^{-2} \cdot day^{-1} \cdot kPa^{-1}$). Incorporating the bioactive-rich extract into the film formulation resulted in significantly higher ABTS and DPPH values and in a lower WVP when compared with films without the bioactive-rich extract.

Lobosphaera sp. is, therefore, a good source of polysaccharides and bioactive compounds, allowing to produce edible films with a high potential to be used in food applications.

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Keywords: Lobosphaera sp., biodegradable films, polysaccharides-rich extract, bioactive-rich extract, antioxidant activity

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USE OF INSECTS FOR THE BIOCONVERSION OF AGRI-FOOD WASTE INTO PRODUCTS WITH HIGH ADDED VALUE RICH IN BIOACTIVE COMPOUNDS FOR HUMAN AND ANIMAL HEALTH

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Abstract

Edible insects are excellent candidates for feeding agri-food by-products, achieving their upcycling into value-added products. Simultaneously, some of these wastes are particularly rich in bioactive compounds, which can bioaccumulate in the insects or cause interesting metabolic effects. Based on these premises, the objective of the presented ENTOMOTIVE project is to explore the potential of edible insects as a novel source of health ingredients, demonstrating that such properties can be enhanced in a circular economy context by feeding insects with agri-food by-products rich in bioactive compounds.

Two popular edible insect species, Tenebrio molitor and Hermetia illucens, were fed with three agri-food by-products at different levels. Both classic by-products from the olive oil industry (olive leaves, olive pomace) and a more emerging one (quinoa husk) were tested. A total of 11 diets were assayed for both species. The main products, protein meals and insect oils were fractionated by supercritical CO_2, and bioactive extracts from defatted meals were generated by ultrasound-assisted extraction. Proximal composition, lipid profile, digestibility and dietary bioaccumulated compounds were characterized. The in vitro antioxidant, anti-inflammatory, antimicrobial and hypolipidemic activities of the insect products have been tested. The efficacy of selected protein meals and bioactive extracts for nutrition and health will be further validated through in vivo trials in aquaculture.

The project has shown that both insect species tolerate the by-products used, but with impacts on productive parameters and nutritional composition at the highest inclusion levels. At the low-medium levels in diets (15-50%, depending on the by-product and species), the by-products were suitable, with productive yields, bioconversion values, and nutritional composition comparable to those from standard substrate. No differences in the in vitro digestibility of meals were observed. However, lipid profiles improved with experimental diets, enhancing unsaturated profiles. The accumulation of dietary bioactive compounds has been evidenced in insect products after feeding on olive oil by-products. In vitro bioactivity studies are demonstrating higher added value of the insect products when fed specific levels of by-products.

Therefore, the ENTOMOTIVE project shows that insect-based bioconversion of agri-food by-products is possible, but conversion efficiency dependent on the species, by-product, and inclusion level in diets. Simultaneously, this bioconversion can yield products such as protein meals, oils, and innovative bioactive extracts, but enhanced through bioactive improvement, and achieved within a circular economy framework when using bioactive-rich by-products.

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Keywords: edible insects, by-products, circular economy, bioactive compounds, functional foods

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IN VITRO AND EXTENDED COLONIC DIGESTION OF SEA BUCKTHORN: ASSESSING THE BIOACCESSIBILITY AND BIOAVAILABILITY OF BIOACTIVE COMPOUNDS

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Abstract

Sea buckthorn (*Hippophae rhamnoides*) is a valuable functional food source rich in bioactive compounds such as polyphenols, carotenoids, flavonoids, and essential fatty acids. However, their bioaccessibility and bioavailability remain key factors influencing their health benefits. This study explored the gastrointestinal fate of bioactive compounds from sea buckthorn fruits and leaves using an *in vitro* digestion model.

The digestion simulation was conducted in two main phases. First, the oral, gastric, and intestinal digestion stages were replicated using the INFOGEST 2.0 protocol, which provides a physiologically relevant assessment of nutrient release and transformation. In the second phase, the digested material was subjected to an extended colonic fermentation model, adapted from Nature-reported methodologies, to simulate microbial metabolism in the large intestine. This step is crucial, as colonic microbiota play a significant role in the biotransformation and absorption of polyphenols and other dietary compounds.

Samples were analyzed at each digestive stage to evaluate changes in total polyphenol content, antioxidant activity, and specific bioactive compounds using HPLC-DAD/RID, spectrophotometric assays, and targeted metabolomics. Comparisons were made between fruit and leaf extracts to determine compound stability and potential bioavailability differences.

Preliminary results suggest that while gastric and intestinal digestion reduce certain bioactive concentrations due to enzymatic and pH-driven degradation, colonic fermentation enhances the bioavailability of specific polyphenolic metabolites. The findings provide valuable insights into the metabolic route of sea buckthorn bioactives and their potential functional benefits in human health.

This research contributes to the growing field of functional foods and nutraceuticals, emphasizing the importance of digestion modelling in understanding the true impact of bioactive compounds. Further studies integrating gut microbiota profiling could refine these insights and support the development of optimized sea buckthorn-based products with enhanced bioavailability.

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Keywords: in vitro digestion, colonic fermentation, sea buckthorn, bioaccessibility, bioavailability

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MARKETING AND ETHICS OF FOOD LABELING: CASE STUDY

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Abstract

The importance of nutrition in human life is already found in religious scriptures such as the Bible, Torah, and Quran. In the Bible, we find Dietary Laws in the Old Testament, advice related to moderation in eating and the importance of fasting, Mindful Eating and Awareness, the Importance of Balanced Meals, and gratitude. The right to food is one of the fundamental human rights. Article 25 of the Universal Declaration of Human Rights states, "Everyone has the right to a standard of living adequate for the health and well-being of himself and his family, including food..." The right to food defined in the above-mentioned declaration is not only about food as a condition for mere survival but is linked to the right to health, dignity, equality, and justice for all people. The International Covenant on Economic, Social and Cultural Rights of the United Nations views the right to food as a right to an adequate standard of living. Food safety is extremely important, which is highlighted by the existence of special. The right to food is incorporated with other rights such as the right to health, education, and housing. Viewing food through an ethical dimension helps us understand nutritional ethics in a narrower sense and food ethics in a broader sense.

In this paper, we will focus on the Marketing and Ethics of Food Labeling within nutritional ethics. The question arises as to whether food labels provide clear information about the product's origin, ingredients, nutritional content, whether the packaging states that it is a higher-quality product (low fat, organic farming, or similar), and how visible the text on the label is, etc. Ethical implications of food labeling have become a significant concern of 21st century. The labels and “marketing outfit” of product may influence consumer choices and public health on the end.

The content and appearance of labels, and thus the quality of food, depend on the legal regulations of each country. Illegible, incomplete, or fragmented, and unclear information in food labeling in some way limits the right to autonomy of the individual consumer.

We will present the results of a study that have been conducted by google questionnaire related to knowledge and attitudes towards food product labeling.

The goal of proper food labeling is benefit both consumers and public health, ensuring ethical, informed, and sustainable food choices.

Keywords: nutritional ethics, food, labeling

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UPCYCLING FOOD WASTE INTO CARBON DOTS: A SUSTAINABLE APPROACH FOR GREEN NANOTECHNOLOGY

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Abstract

Food waste represents a significant environmental and economic challenge, yet it also serves as a valuable resource for innovative applications. This study explores the production of carbon dots (CDs) from food waste as a sustainable nanomaterial for potential applications in food safety and sensing. We investigated the synthesis of CDs from various food waste sources, including fruit peels, coffee grounds, and vegetable scraps, optimizing conditions such as pyrolysis temperature, precursor concentration, and reaction time to enhance CD yield and fluorescence properties. The resulting CDs, characterized by TEM, fluorescence spectrophotometry, and UV-Vis spectroscopy, exhibited an average size of 2.8 ± 0.7 nm with strong fluorescence emission.

Further analysis revealed that the composition of food waste precursors significantly influenced the physicochemical properties of CDs, particularly their quantum yield and surface functionalization. The produced CDs demonstrated excellent stability across a wide pH range (3.0–11.0) and resistance to photobleaching, making them viable for various applications. Notably, these food waste-derived CDs exhibited strong fluorescence quenching in the presence of certain analytes, highlighting their potential use in food safety monitoring. This study underscores the feasibility of converting food waste into high-value nanomaterials, promoting circular economy principles while advancing green nanotechnology for sustainable food systems.

Keywords: Carbon dots, food waste valorization, green nanotechnology, circular economy, fluorescence sensing, sustainable food industry.

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ASSESSMENT OF ALTERNATIVE PROTEIN SOURCES IN AQUAFEED FOR NILE TILAPIA (OREOCHROMIS NILOTICUS) AND THEIR IMPACT ON SOYBEAN (GLYCINE MAX) GROWTH IN A CLOSED-LOOP AQUAPONIC SYSTEM

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Abstract

Aquaponics represents a promising solution for sustainable food production by integrating aquaculture and hydroponics in a closed-loop system. This study investigates the potential of alternative protein sources, specifically black soldier fly larvae (BSFL) and spirulina, in aquafeed formulations for Nile tilapia (Oreochromis niloticus), while simultaneously cultivating soybean (Glycine max) in the hydroponic component. Four experimental diets were formulated by replacing fishmeal with BSFL and spirulina at varying levels: 0% (control), 33%, 66%, and 100%. The impact of these diets was evaluated based on multiple parameters, including fish growth performance, feed conversion ratio (FCR), fish health, blood parameters, protein and lipid content in both fish and soybean, as well as plant productivity in terms of pod number and overall health. The results revealed that the lowest FCR was achieved with the third aquafeed formulation (66% fishmeal substitution), followed by the second (33% substitution) and the control (0% substitution), with the fourth diet (100% substitution) yielding the highest FCR. In terms of soybean productivity, the best harvest was observed in the third formulation, followed by the fourth, second, and control diets. These findings highlight the potential of BSFL and spirulina as sustainable protein sources in aquafeeds, with positive effects on both fish performance and plant productivity. This work demonstrates the viability of an integrated approach to sustainable aquaculture and crop production, contributing to the development of resource-efficient food systems.

Keywords: Tilapia nil, Soybean

POSTER PRESENTATIONS

P - 1

TRENDS IN THE NUTRITIONAL STATUS OF THE STUDENT POPULATION AT THE ŠIBENIK UNIVERSITY OF APPLIED SCIENCES: A COMPARISON BETWEEN 2014 AND 2023

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Abstract

Overweight and obesity are acknowledged as significant global health issues, particularly within the student population. This study aimed to evaluate the nutritional status of students at Šibenik University of Applied Sciences from 2014 to 2023. Various anthropometric indicators were employed, including body mass index (BMI), waist-hip ratio (WHR), and waist circumference (W). Additionally, the study examined the impact of dietary habits, physical activity, and sleep on students' nutritional status.

Fifty-two students (33 females and 19 males) participated in the study conducted in 2014, while the analysis in 2023 included 65 students (47 females and 18 males). The average BMI for female students remained relatively stable, with 21.31 in 2014 and 21.53 in 2023. In contrast, the average BMI for male students increased from 23.26 to 24.05. Additionally, the Waist-to-Hip Ratio (WHR) and weight showed consistent values over the years.

The findings indicate that BMI continues to be the primary indicator for categorizing men into risk groups, whereas WHR is more effective in identifying central obesity among women. In 2023, 44% of students were classified as at risk based on BMI, a significant increase from 26.3% in 2014. The percentage classified as at risk for female students, according to WHR, decreased from 15.15% in 2014 to 12.77% in 2023.

The differences in anthropometric indicators related to dietary habits, physical activity, and sleep did not show statistical significance in either 2014 or 2023. Physically active students exhibited a slightly higher average BMI, attributed to increased muscle mass, while central fat distribution and waist-to-hip ratio indicated traits associated with risk groups.

In conclusion, while the differences between 2014 and 2023 are minimal, the data suggest a rise in the proportion of men classified in risk categories according to BMI. One limitation of this study is the small sample size, which diminishes the power of the statistical analyses. Future research should aim to incorporate larger samples and additional variables, such as socioeconomic status, to gain a more comprehensive understanding of the causes and effects of overweight within the student population.

Keywords: Nutritional status trends, student population, Body Mass Index (BMI), Waist-Hip Ratio (WHR) Overweight and obesity

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PERCEPTION AND KNOWLEDGE OF FOOD ADDITIVES: A CASE STUDY OF SLOVENIAN CONSUMERS

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Abstract

Background: Consumer attitudes toward food additives (FAs) remain a contentious issue, despite strict European Union regulations ensuring their safety. Public skepticism and misinformation about FAs persist, contributing to avoidance behaviors and mistrust in food regulatory authorities.
Existing literature highlights that consumer concerns about FAs often stem from a lack of understanding of their purpose and safety, as well as a preference for "natural" and minimally processed foods. Despite comprehensive risk assessments conducted by the European Food Safety Authority, distrust in regulatory bodies remains a major barrier to consumer acceptance of FAs. Studies from various countries suggest that older and less educated individuals tend to express more skepticism toward FAs, while younger and more educated consumers are generally more accepting. However, such research has been scarce in Slovenia, where food traditions and cultural preferences may further shape attitudes toward FAs.
Objectives: This study aims to explore the perception, knowledge, and concerns of Slovenian consumers regarding FAs, with a particular focus on how socio-demographic factors such as age, education, and sex influence these attitudes.
Study design: We conducted a nationwide survey that included 705 respondents. The survey was divided into content-specific sections, focusing on factors influencing consumer decisions and levels of concern about FAs. Statistical analysis was performed to determine whether attitudes varied significantly based on socio-demographic factors.
Results: The results revealed that 65.1% of respondents expressed concern about the use of FAs, and nearly 90% believed that FAs pose a health risk. Attitudes toward different FA categories varied significantly, with antioxidants receiving the lowest concern (mean score: 3.27 on a 5-point scale) and flavor enhancers the highest (mean score: 4.08). Age played a crucial role in FA perception, with younger respondents showing less concern and greater acceptance compared to older individuals. Additionally, education influenced attitudes, as those with higher education levels were less concerned about FAs than those with lower education. Additionally, female respondents expressed higher levels of concern and displayed lower trust in regulatory authorities compared to their male counterparts.
Conclusion: These findings highlight the importance of consumer education in bridging the gap between scientific assessments and public perception. Policymakers and regulatory authorities must develop targeted communication strategies to improve public trust in food safety measures. Likewise, food manufacturers should consider these consumer concerns when developing and marketing products containing FAs.

Keywords: consumer perception, food additives, food safety, regulatory trust, Slovenia

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CONSUMER PERSPECTIVES ON FISH AND SHELLFISH FROM INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEMS

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Abstract

Integrated Multi-Trophic Aquaculture (IMTA) represents an ecological approach to the cultivation of aquatic organisms, where multiple aquatic species from different trophic levels are farmed together. This method allows waste products from one species to become nutrient source for others, reducing environmental pollution and increasing production efficiency. A survey was conducted in January 2025 using a Google Forms questionnaire with 205 respondents from Croatia. The questionnaire consisted of 15 questions assessing general demographic parameters (age group, gender, place of residence, and education level), frequency of fish and shellfish consumption, awareness of aquaculture practice, with focus on IMTA systems and willingness to consume IMTA products, as well as factors influencing their acceptance. Despite low consumer awareness of IMTA practice (78% of respondents were unfamiliar with this type of aquaculture), a significant majority (82.44%) expressed interest in consuming fish and shellfish from such systems. This suggests that, alongside the ecological and economic benefits of IMTA, its introduction to the market would likely be well-received by consumers. Significant differences were observed in the consumer awareness and willingness to consume the IMTA products, depending on their age group, area of residence (continental vs. coastal part of Croatia) and highest education level, giving perspective for expanding the consumer base through precisely targeted education and awareness initiatives.

Keywords: Integrated Multitrophic Aquaculture, Shellfish, Fish, Consumer Behavior

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ECOLOGICAL AND ECONOMIC OPTIMIZATION OF THE TECHNOLOGICAL PROCESS OF EXTRUSION OF FILLINGS FOR CROISSANTS

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Abstract

Extrusion of fillings is performed by pressing creamy, pasty and gelatinous preparations based on chocolate, vanilla, various fruits and similar raw materials. The piston pushes the filler through the cylinder, which at the end has a nozzle of a certain diameter. Depending on the diameter of the nozzle and the texture of the extrusion filler, resistance to extrusion occurs during extrusion, which is interpreted as extrusion force. This force on the path of movement of the piston in the cylinder defines the work of extrusion, and the work of extrusion, depending on the speed of movement of the piston in the cylinder, defines the power required for extrusion.
The more inhomogeneous and viscous the filler, the smaller the diameter of the nozzle, and the higher the piston movement speed, the higher the compression force required.
From an economic and ecological point of view, it is essential to achieve results with less energy consumption. This requires less extrusion force, which can be achieved by increasing the diameter of the nozzle, by reducing the extrusion speed, and above all, by using fillings that have extremely homogenous smooth textures without excessive viscosity.

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Keywords: texture analysis, extrusion, firmness, fillings

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THE INFLUENCE OF THE TREATMENT OF CULINARY METHODS ON THE CHARACTERISTICS OF CELERY AND POTATOES IN GASTRONOMY

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Abstract

The treatment of vegetables in gastronomy with different culinary methods has a significant impact on their characteristics, such as texture, nutritional value, organoleptic properties (taste, smell, color), as well as on the loss or preservation of nutrients. Each culinary method, be it boiling, baking, frying, steaming, grilling or drying, can change these characteristics in different ways. In this work, two types of vegetables, celery and potatoes, were used for analysis. The results after 3 and 7 chews at the moment of swallowing as well as treatment times of 15, 30 and 45 minutes were analyzed. The number of vegetable bolus donors (amount of food swallowed in one gulp or meal) is one and can be seen as a limitation of this part of the study. As part of the analysis of the number and size of bolus particles, 363 boluses were analyzed considering that some of the potato bolus in this research were pasty and unsuitable for particle analysis. Analysis of the results of potato and celery vegetables are presented in tabular and graphical form. A detailed comparative analysis of celery and potatoes was made using different culinary treatments of vegetable processing. Knowing that celery and potatoes are brittle materials in their raw state, it is interesting to compare these two types of vegetables in the discussion. In the case of the treatment of thermal processing of potatoes and celery vegetables, they showed significant results, and therefore their application in gastronomy. There were significant differences between the different boiling times in water, with the 45-minute treatments being the most different from the 15- and 30-minute treatments. On the other hand, grilling treatments did not differ. Steaming gave better differentiation between processing times than grilling and sous-vide, and had similar effects to boiling. In conclusion, with a careful choice of culinary methods, both in terms of technique and in relation to the goals of preserving nutrients and achieving the desired taste, celery and potatoes can be transformed into various gastronomic delights, adaptable to all kinds of culinary traditions and consumer needs.

Keywords: culinary methods, vegetables, gastronomy, food processing.

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RENEWABLE BIOPOLYMERS FOR FOOD PACKAGING: CAN ULTRASOUND AND THERMAL TREATMENTS IMPROVE FILM PROPERTIES?

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Abstract

Proteins and polysaccharides are the main types of biopolymers used for developing renewable and biodegradable food packaging materials. Although both polysaccharides and proteins have been shown to be suitable for developing films for biodegradable packaging, some studies have focused on enhancing film performance by employing blend systems and green technologies, given that the structural modification of mixtures of proteins and polysaccharides could provide a more cohesive polymeric network. In this study, biopolymeric films based on sunflower seed proteins with added galactomannans from locust bean were prepared, and the effect of different processing treatments such as heating (HT, 75°C, 20 min), ultrasound (US, 425W, 2min) and a combination of both (HTUS) was studied. HT led to a decrease in film resistance, probably due to a decrease in protein intramolecular hydrogen bonds. US had the opposite effect, increasing the number of exposed hydrophobic groups and hydrogen bonds, improving protein reticulation. Consequently, both film strength and flexibility were improved. The combination of treatments led to films like the ones obtained without any treatment. These results indicate that employing US is an efficient strategy for improving mechanical properties of films that combine proteins and galactomannans, making them more appropriate for sustainable food packaging applications.

Keywords: proteins, galactomannans, polymeric films, heat treatment, ultrasound

APPLICATION OF SOUS VIDE TECHNIQUE IN GASTRONOMY

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Abstract

Sous vide is a cooking technique that involves cooking food in vacuum-sealed bags at low temperatures over an extended period of time. This method allows precise temperature control, resulting in even cooking and the preservation of the food's nutritional values. In gastronomy, sous vide is used to prepare meat, fish, vegetables, and even desserts, achieving superior textures and flavours. The goal of this paper is to explore the applications of the sous vide technique in professional kitchens, as well as its advantages and challenges compared to traditional cooking methods. Sous vide, which means "under vacuum" in French, has become popular in gastronomy in recent decades, especially in high-end restaurants. This technique enables cooking with a high degree of precision, contributing to consistent quality and taste. With the help of special temperature control devices, sous vide cooking allows chefs to achieve consistently perfect results, even with complex and delicate ingredients. The objectives of this paper were to investigate how the sous vide technique is applied across different segments of gastronomy, discuss the advantages of sous vide over traditional cooking methods, and examine the challenges and limitations associated with its use in professional kitchens. Based on the results, it can be concluded that the sous vide technique represents a revolution in gastronomy by allowing exceptional precision in food preparation. With its help, chefs can create dishes with enhanced flavours and textures, making it highly valuable in the restaurant industry. Although there are certain challenges, such as preparation time and the need for specialized equipment, the advantages it offers outweigh these difficulties, making sous vide a key tool in modern culinary practice.

Keywords: molecular gastronomy, culinary techniques, sous vide, spherification, liquid nitrogen

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MOISTURE-ACTIVATED PLANT-BASED OXYGEN SCAVENGER FOR SUSTAINABLE FOOD PACKAGING

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Abstract

Introduction

The occurrence of oxygen (O2) in food packages primarily arise from faults or failures in the packaging process. Consequently, substantial research and development efforts have been directed toward addressing these issues to minimize residual O2 in food packages. In our present study, we have developed a moisture-activated bio-based oxygen-scavenging mixture (SM) comprising Acacia catechu (AC) and sodium carbonate (NC). It is reported that 1g of catechu powder contains approx. 74.76 mg of catechin, the polyphenol responsible for oxygen scavenging. This study investigates the combination effects of varying relative humidity, concentrations, and accelerated storage temperatures on the oxygen scavenging activity of the materials for practical food packaging applications.

Methods

For the preparation of the oxygen absorption system, catechu powder was mixed with sodium carbonate (w/w) in 1:1, 2:1, 3:1, and 1:0. The total mass (2g) remained constant for all the samples. Only the component's mass varied in defined ratios. The control sample was one without sodium carbonate (1:0). The samples were labelled as control; AC1/NC1, AC2/NC1, AC3/NC1. All the samples were prepared in triplicates for accuracy and exposed to different temperatures (5°C, 25°C, and 45°C) and humidity conditions (55%, 75%, and 95%). Further, Mixtures were placed in sealed glass vials with specific humidity conditions (55%, 75%, and 95% RH) established using sodium bromide, sodium chloride, and water solutions. The vials were exposed to three temperatures (5 °C, 25 °C, and 45 °C), and oxygen concentration was monitored over 10 days to assess the oxygen scavenging rate under varying conditions.

Results & Conclusions.

Herein, a plant-based oxygen scavenging system utilizing ball-milled Acacia catechu powder and sodium carbonate with moisture activation was developed. Ball milling enhanced the surface area for the oxygen-scavenging reaction sites, which was confirmed through BET analysis. Among the developed SM, AC1/NC1 exhibited a noteworthy oxygen absorption rate of 2.13 ± 0.13 cm3/g.day and 0.56 ± 0.09 cm3/g.day at 25 °C and 45 °C respectively, and at 95% RH conditions. The developed SM demonstrated scavenging performance based on concentration, humidity, and temperature. However, samples achieved stability at different time intervals, indicating their practical suitability. The thermal characteristics analysis demonstrated that the mixtures were suitable for use at the different temperatures typically encountered in food processing. The ability of this plant-based material in sachet forms to be ready for utilization in food applications has to be explored.

Keywords: Acacia Catechu, Oxygen Scavenger, Shelf Life; Food Packaging; Active Packaging

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EFFECT OF DIFFERENT DRYING METHODS ON MICROBIOLOGICAL QUALITY OF AVOCADO (PERSEA AMERICANA) PEEL

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Abstract

Over the years, hot air drying has remained a staple technology in the food industry. However, the past decade has seen a growing interest in microwave drying methods. Operating at a frequency of 2450 MHz, microwaves are long-wavelength electromagnetic waves that cause polar molecules, like water and salts, to vibrate, generating heat within the material. Unlike conventional drying, which transfers heat from the surface inward, microwave drying produces heat directly within the food's tissue. This method enhances drying efficiency while reducing surface damage.
The objective of this study was to investigate the effects of different drying methods, including conduction, convection, microwaves, and a combination of microwaves and convection, on the microbiological safety of avocado peel by monitoring microbiological growth during 9 months of storage at room temperature. Classical microbiological cultivation methods on selective media were used to determine the presence of microorganisms. The results showed that the shelf life of all avocado peel samples was within the permissible limits established by law after 9 months. The best results were obtained in samples treated continuously with microwaves and convection, where aliquots taken at all time intervals were negative for the presence of microorganisms.

Keywords: microbiological methods, avocado, shelf life, microwaves

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CRYOGRINDING PRETREATMENT: A SUCCESSFUL APPROACH TO ENHANCE POLYPHENOLS EXTRACTION FROM BLACKCURRANT POMACE

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Abstract

A more sustainable use of resources in the food industry has become an imperative and interest in the potential use of plant by-products such as pomace and leaves has increased significantly. Blackcurrant pomace is considered a by-product of berry processing and is usually disposed of after juice extraction. Recently, it has become the focus of research due to its chemical composition rich in polyphenols, including anthocyanins, and its high antioxidant potential. The aim of this study was to determine the influence of cryogrinding pretreatment on the extraction of polyphenols, including anthocyanins, from blackcurrant pomace. The freeze-dried blackcurrant pomace was cryoground at different time intervals (1, 2, 3, 4 and 5 min), after which the ground material was subjected to ultrasound-assisted extraction under predetermined optimal conditions (amplitude of 75%, extraction time of 5 min and sample:solvent ratio of 1:60 g/mL) using 1% formic acid in 50% aqueous ethanol solution as an extraction solvent. In addition, the efficiency of cryogrinding was also compared with a conventional grinding process (0 min). The particle size distribution in terms of d (0.5) value was measured in all ground samples prior to extraction, while the content of total polyphenols and total anthocyanins was determined in all extracts obtained. The results showed that the particle size d (0.5) was determined in the range of 50.22 to 225.00 µm, with the highest value measured in the sample comminuted by the conventional grinding method and the lowest in the sample obtained after 5 min of cryogrinding. Differences were also found in the content of total polyphenols and total anthocyanins depending on the duration of cryogrinding. The highest total polyphenol content of 43.64 mg GAE/g dw was found in the sample that was cryoground for 3 min and the lowest (35.99 mg GAE/g dw) in the sample cryoground for 4 min. As for the total anthocyanin content, the highest value of 23.65 mg GAE/g dw was recorded in the sample cryoground for 2 min. The observed results suggest that pretreatment by cryogenic grinding for 3 min prior to ultrasound-assisted extraction is very effective in reducing the particle size, thus possibly improving the extraction performance of the polyphenolic compounds.

Keywords: Ribes nigrum L., pomace, cryogenic milling, polyphenols, yield

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UTILIZATION OF BERRY BY-PRODUCTS: ENHANCING BIOACTIVE COMPOUND EXTRACTION THROUGH CRYOGENIC GRINDING

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Abstract

The food processing industry generates significant by-products, including berry pomace from juice, wine, and jam production. Pomace, consisting of skins, seeds, and residual pulp, makes up 15%–30% of processed fruit mass and is often discarded despite its rich bioactive composition. Similarly, berry leaves left after harvest are underutilized. Both pomace and leaves contain high levels of phenols and anthocyanins, known for their antioxidant and anti-inflammatory properties, making them valuable for food, pharmaceutical, and cosmetic applications.

To improve the extraction and bioavailability of these valuable compounds, various pretreatment techniques have been explored. One particularly effective method is cryogenic grinding, which involves pulverizing materials at extremely low temperatures, typically using liquid nitrogen. This process significantly disrupts cellular structures, reducing particle size and enhancing the release of bioactive compounds, thereby facilitating their extraction. Unlike conventional grinding, which can generate heat and lead to compound degradation, cryogenic grinding preserves the integrity and stability of thermosensitive molecules, making it a superior pretreatment strategy.

This study aimed to optimize cryogenic grinding time (1 and 3 minutes) for blueberry and chokeberry pomace and leaves to enhance the yield of phenolic and anthocyanin compounds compared to untreated samples. Microwave-assisted extraction, an advanced and efficient technique, was employed for compound isolation due to its ability to accelerate the extraction process while maintaining compound integrity. The total phenolic content in blueberry leaves ranged from 125.32 to 152.83 mg/g dw, whereas chokeberry leaves contained between 20.20 and 37.97 mg/g dw. In contrast, blueberry pomace exhibited phenolic content ranging from 37.42 to 50.26 mg/g dw, while chokeberry pomace contained between 71.81 and 97.26 mg/g dw. Regarding anthocyanin content, similar values were recorded for both pomace types, with blueberry ranging from 21.55 to 25.82 mg/g dw and chokeberry from 21.49 to 26.32 mg/g dw.

The results demonstrated that cryogenic grinding significantly enhanced the release of bioactive compounds compared to untreated samples. Notably, just one minute of grinding was sufficient to achieve a considerable increase in phenolic and anthocyanin yields, indicating that this technique is not only effective but also time-efficient. These findings underscore cryogenic grinding as a promising pretreatment strategy for the valorization of berry by-products, offering a sustainable approach for maximizing the extraction of valuable bioactive molecules and supporting their potential use in functional food, pharmaceutical, and cosmetic applications.

Keywords: berry by-products, cryogenic grinding, microwave-assisted extraction, phenols, anthocyanins

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EFFECT OF PASTEURIZATION PROCESS ON TECHNO-FUNCTIONAL PROPERTIES AND ALLERGENICITY OF HAZELNUT SLURRY

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Abstract

Plant-based products have gained popularity due to increased awareness about health and environmental sustainability. In the production of plant-based dairy analogues, hazelnuts can be preferred as raw materials due to their rich nutritional composition and plain taste. This study aimed to determine pasteurization parameters for processing of hazelnut slurry towards production of plant-based dairy analogues. Peeled raw and roasted hazelnuts were mixed with water to obtain a slurry and the slurry was pasteurized at 63, 80, 85 and 90 °C for 30 min. The real time rheological measurements were conducted to examine changes on physical properties during heating in linear viscoelastic region and to determine the gelation temperature. Flow point, yield stress and maximum G' values were measured by application of the oscillatory stress sweep test to evaluate the gelation properties. Water holding capacity, soluble protein content and allergenicity of the samples were also measured. WHC of the samples decreased after roasting treatment and improved with increasing pasteurization temperature. Gelation temperature, flow point, yield stress, and the maximum G' values also decreased due to roasting treatment. The pasteurization temperature of 90°C caused lower rheological properties with a weak body than those obtained at other temperatures. There were no significant changes in soluble protein content by roasting treatment but it decreased with increasing pasteurization temperature. While allergenicity increased after roasting process, pasteurization temperature had no effect on it. Therefore, a better protein solubility, lower allergenicity, higher WHC and better gelation properties were obtained with use of raw hazelnuts compared to those of the roasted ones. To obtain better technological functionality, 85°C can be selected as the pasteurization temperature.

This study was financially supported by the Scientific and Technological Research Council of Türkiye (TUBITAK) under Grant Number 123O155.

Keywords: Hazelnut, Water holding capacity, Rheology, Protein solubility, Allergenicity

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EFFECTS OF SOUS-VIDE COOKING ON THE QUALITY AND SAFETY OF WILD RED DEER (CERVUS ELAPHUS) MEAT

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Abstract

This study investigates the effects of sous-vide cooking at different temperatures on the quality characteristics of wild red deer (Cervus elaphus) meat, focusing on drip loss, water holding capacity (WHC), pH, instrumental color, texture, and microbiological properties. Fresh wild red deer meat was sourced from a local processing plant in Hungary. Semimembranosus muscles were cut into similar sizes, vacuum packed, and cooked sous-vide at 60°C, 65°C, and 70°C for 3 hours. A control group of raw, non-treated meat was included for comparison. After sous-vide treatment, samples were stored at 4±1 °C for further quality evaluation. Drip loss increased with cooking temperature, with 60°C showing 20.78%, 65°C 29.06%, and 70°C 29.25%. WHC showed slight variations, with a reduction in sous-vide samples compared to control. The pH values rose with higher cooking temperatures, from 5.87 ± 0.01 in the control to 6.13 ± 0.03, 6.16 ± 0.05, and 6.18 ± 0.05 for the 60°C, 65°C, and 70°C treatments, respectively. The control exhibited the darkest color, while sous-vide treatments resulted in lighter colors, with the highest temperature (70°C) showing the most intense color change. Microbiological evaluation, using aerobic plate count, showed significantly lower microbial loads in sous-vide treated samples compared to the control, indicating enhanced microbial safety. In conclusion, sous-vide cooking at 60°C, 65°C, and 70°C significantly affected the quality attributes of wild red deer meat. These results suggest that sous-vide is an effective technique for improving both the quality and safety of wild game meat, with temperature being a critical factor in determining the final product characteristics. Further studies are needed to assess the long-term effects on quality parameters.

Keywords: Game meat, Organic meat, Food safety, Meat quality, Innovative food technology, Sustainable cooking

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CAN FLAXSEED PROTEIN ISOLATE PROMOTE LIPID ACCUMULATION IN ADIPOCYTES? A CELLULAR AGRICULTURE PERSPECTIVE

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Abstract

Flaxseed oil-cake is a byproduct of flax oil manufacturing and is often treated as a low-value biomaterial with limited applicability, despite its high protein content. Using flaxseed proteins as substrate in novel food technologies, like cellular agriculture, remains largely unexploited although their physiologically beneficial bioactivity has been proven. This study aims to investigate the impact of flaxseed protein isolate (FPI) on lipid accumulation in adipocytes in vitro. Another goal is to evaluate FPI as a potential alternative to animal blood serum, which remains a component in conventional media formulations, contributing to both the high cost and ethical concerns surrounding the technology. Proteins were isolated from flaxseed oil-cake and composition of obtained FPI was determined. The effects of isolate on 3T3-L1 cell viability was assessed by supplementing normal cell culture media with a wide concentration range of FPI. Isolate does not exhibit cytotoxic effects on cells in the preadipocyte phase at concentrations below 1 mg/mL. Its effect on proliferation and differentiation of mouse adipocytes during adipogenesis was examined by quantifying accumulated lipids and cell viability in growth media supplemented with FPI. Cell differentiation was triggered simultaneously with addition of FPI in cultures with reduced amount of serum in media. Given that lipids play a crucial role in the meat flavor, incorporating in vitro obtained animal fats into meat alternatives could mimic the aroma and texture of real meat. In this work, we examined if FPI can be used as a media supplement to boost lipid accumulation in adipocytes, potentially enabling more cost-effective production of meat alternatives.

Keywords: flaxseed protein, adipocytes, lipid accumulation, cellular agriculture, sustainability

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APPLICATION OF RAPID SENSORY METHODS IN NEW PRODUCT DEVELOPMENT: A CASE STUDY ON SOURDOUGH-BASED COOKIES

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Abstract

Driven by consumers' increasing interest in healthier food options, the food industry often faces pressure to deliver rapid solutions without conducting thorough market research. As a result, many newly developed food products fail in the market. Sensory analysis plays a crucial role in new product development by ensuring that products meet consumer expectations in terms of taste, texture, aroma, and appearance. Traditionally time-consuming sensory methods have recently been replaced by numerous rapid techniques that offer comparable reliability.

This study presents a potential approach for developing sourdough-based whole-grain cookies, guided primarily by sensory properties. In alignment with consumer preferences for natural, organic, and nutrient-rich foods, we formulated several sourdough starters using wholegrain wheat, spelt, Khorasan, and emmer flour–water mixtures, evaluating them based on their odor profile. Initially, the dynamic sensory technique Temporal Dominance of Sensations (TDS) was applied with twenty sensory assessors to track how sourdough odor evolves over time. Additionally, Check-All-That-Apply (CATA) and Hedonic tests, conducted with 48 participants, helped identify the most appealing samples for consumers.

Based on the results, spelt and Khorasan sourdough samples were lyophilized and incorporated into cookie formulations. Their sensory profiles, along with consumer hedonic perceptions and attitudes, were further assessed using Rate-All-That-Apply (RATA) with 15 sensory assessors. The developed cookies were also benchmarked against two commercially available cookies of the same type.

Sourdough-enriched cookies demonstrated comparable nutritional, color, and textural properties to commercial cookies while offering higher fiber content and enhanced sensory appeal. Moreover, the presented methodology provides a practical strategy for developing products that support well-being while maintaining taste and consumer satisfaction.

Acknowledgments

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Keywords: ancient wheat sourdough, sensory analysis, Temporal Dominance of Sensations (TDS), Check-All-That-Apply (CATA), Rate-All-That-Apply (RATA)

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ENHANCED DEFATTING PERFORMANCE, OIL AND CAKE QUALITY ON FOUR EDIBLE INSECTS (EIS) WITH SUPERCRITICAL FLUID EXTRACTION (SFE)

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Abstract

This work reports a chemical extraction of four Edible Insects (EIs), namely yellow mealworm (Tenebrio molitor), house cricket (Acheta domesticus), lesser mealworm (Alphitobius diaperinus) and locust (Locusta migratoria) through supercritical CO_2 ($scCO_2$), resulting in a significant degree of defatting (70-94%) at only 45-75 min extraction time. An enhanced protein content was observed in the post-extraction remaining solid after treatment, while a noted oleic and linoleic acid content (up to 50 and 30%, respectively) was detected in the recovered oil. With a perspective of implementation in the food sector, the scalability of the process was tested at bench scale, and evidenced by the positive defatting achieved (73-78% for lesser mealworm).

ACKNOWLEDGMENTS
This study is enclosed on the AGROALNEXT program (AGROALNEXT/2022/060 - Desarrollo y optimización de procesos innovadores y sostenibles de extracción de aceite y proteínas a partir de microalgas, insectos, residuos y subproductos agroalimentarios: Evaluación de propiedades biológicas (EXTRAOLIOPRO)) and was supported by MICIU with funding from European Union NextGenerationEU (PRTR-C17.I1) and by Generalitat Valenciana. Authors acknowledge Generalitat Valenciana (Spain) for the financial support (IDIFEDER/2018/046-Procesos innovadores de extracción y conservación: pulsos eléctricos y fluidos supercríticos), through the European Union ERDF funds (European Regional Development Fund). Manuel Salgado-Ramos thanks GVA for his postdoctoral fellowship by “Subvenciones para la contratación de personal investigador en fase postdoctoral (APOSTD)” modality (CIAPOS/2023/236)” co-financed by European Union.

Keywords: edible insects, supercritical fluids, sustainable food, non-conventional technologies

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EXPLORING THE USE OF SFE TECHNOLOGY TO OBTAIN SPIRULINA DEFATTED CAKES WITH ADDED VALUE

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Abstract

The search for ecological and functional ways to meet human nutritional needs has become critical today. This has highlighted microalgal biomass as a potential ingredient for the food industry (Barros de Medeiros et al., 2022; Sousa et al., 2023). Microalgae are highly nutritious, with lipid values ranging from 20% to 50% of dry weight and protein values ranging from 30% to 70% of dry weight. They also have an interesting carbohydrate, vitamin and mineral profile, together with a significant amount of antioxidant compounds (Dolganyuk et al., 2020). Various conventional extraction techniques such as Soxhlet have traditionally been used to extract lipids from microalgae, but this method has disadvantages such as high consumption of organic reagents and long extraction times (Zhou et al., 2022). Among the various eco-innovative technologies, Supercritical Fluid Extraction (SFE) makes it possible to extract interesting compounds from microalgae without a negative environmental impact, as no organic solvents are used, and less volume is consumed. It also operates at low extraction temperatures and short extraction times, providing a sustainable alternative to traditional extraction methods (Poojary et al., 2016). The aim of this work is to explore SFE to extract the maximum amount of oils, but also to tailor SFE to obtain defatted remaining cakes with potential added value. In addition, the results obtained by SFE were compared with Soxhlet extraction. To this end, the optimum conditions for SFE were optimized in terms of lipid yield using a response surface methodology with extraction time, temperature and pressure as parameters. Protein content was determined by Dumas method and mineral profile by ICP-MS in the remaining cakes. The results showed that SFE was more efficient than Soxhlet in defatting (86% vs 8%). In terms of protein content, SFE spirulina residual cakes had slightly higher yield values (74.4/100 g) compared to raw microalgae (69.2/100 g) and residual cakes obtained by Soxhlet (68.4/100 g). Regarding the mineral content, the major minerals (Ca, P, Mg) were detected without significant differences in the raw samples and the remaining cakes obtained after SFE and Soxhlet, with values ranging from 3.9 to 4.2 mg/g for Mg, 10.5-10.7 mg/g for P and 2.7-2.8 for Ca. K was the mineral quantified at higher levels (SFE defatting cake: 12.83 mg/g). Finally, Fe was detected at an interesting level (838 -861 mg/kg). Thus, SFE has shown the potential to obtain defatted cakes enriched in proteins and with remarkable levels of minerals.

Acknowledgements
This study is part of the AGROALNEXT program (AGROALNEXT/2022/060 - Desarrollo y optimización de procesos innovadores y sostenibles de extracción de aceite y proteínas a partir de microalgas, insectos, residuos y subproductos agroalimentarios: Evaluación de propiedades biológicas (EXTRAOLIOPRO)) and was supported by MCIN with funding from the European Union NextGenerationEU (PRTR-C17.I1) and the Generalitat Valenciana and the BLUEWAYSE "BLUE WAY to a Sustainable Europe" action PCI2024-153460 (Sustainable Blue Economy Partnership,

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Keywords: Spirulina, defatted remaining cakes, SFE, Soxhlet, minerals, proteins

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UNLOCKING BETALAINS' POTENTIAL: GREEN TECHNOLOGIES FOR MAXIMIZED RECOVERY AND BIOACCESSIBILITY FROM PRICKLY PEAR PEEL

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Abstract

Betalains are water-soluble pigments whose intense color varies between red-violet (betacyanins) and yellow (betaxanthins) and exhibit antioxidant properties as well as anti-inflammatory and anti-carcinogenic potential. For this reason, the recovery, preservation and bioaccessibility of betalains from agri-food co-products such as prickly pear (Opuntia ficus-indica) peel is essential, both to contribute to the valorization of industrial by-products and to the development of new products with functional properties. In this sense, the aim of the present study is to evaluate the recovery and bioaccessibility of betalains from prickly pear by applying two sustainable green technologies: pulsed electric fields (PEF) and pressurized solvent extraction (PLE). For this purpose, total betalains were extracted by PEF under optimized conditions for the recovery of antioxidant compounds and polyphenols (2.5 kV/cm, 50 kJ/kg) and by PLE using 1500 psi, 50ºC, pH 7 and 3 treatment cycles. All extracts were compared to those obtained by conventional extraction by 15 min aqueous maceration, with all extractions performed in triplicate. The extracts were then digested using the in vitro INFOGEST method to simulate human digestion. The total content of betalains, betacyanins and betaxanthins in the original extracts of each technology and the corresponding digests was determined by UV/Vis spectrophotometry for quantification and HPLC-Q-TOF for identification. The results show, firstly, that the extractive process with PLE significantly increases the content of each of the betalains in the extracts obtained, by up to 44.22% compared to the conventional extracts and by 66.46% in the case of the digests. In addition, the application of PLE increases the bioaccessibility of both types of betalains with 92.6% for the total betalains. On the other hand, PEF extraction reduces the content of betalains by up to 17.88% compared to conventional extraction and by up to 4.24% in the case of digests. However, it significantly improves the bioaccessibility of all types of betalains compared to aqueous maceration. From the observed results, it can be concluded that the use of green technologies such as PEF and PLE not only contributes to the sustainability and improvement of the extractive process for high-value compounds but also improves the bioaccessibility of compounds such as betalains, which is of great importance for assimilation by our organism.

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Keywords: pigments, bioaccessibility, optimization, PLE, PEF

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LIPID PROFILE OF BLACK TRUFFLE (TUBER MELANOSPORUM) EXTRACTS OBTAINED THROUGH SUSTAINABLE EXTRACTION TECHNIQUES

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Abstract

This study characterizes black truffle (Tuber melanosporum) extracts obtained through supercritical fluid extraction (SFE) and pressurized liquid extraction (PLE). Regarding the lipid profile, both methods effectively extracted essential fatty acids, albeit with differences in composition. The most abundant fatty acids in the PLE extract were arachidic acid (C20:0) (20%), linoleic acid (C18:2n6) (30%), and oleic acid (C18:1n9) (17%), all of which play crucial roles in cellular function, membrane integrity, and metabolic processes. In contrast, the SFE extract exhibited a higher proportion of arachidic acid (37%), whereas PLE yielded a greater concentration of linoleic acid. Other detected fatty acids included α-linolenic acid (C18:3n3), behenic acid (C22:0), palmitic acid (C16:0), and stearic acid (C18:0). This difference in composition may be attributed to variations in ethanol's behavior under supercritical and subcritical conditions during extraction. The observed lipid composition aligns with previous studies on truffle extracts obtained through different methods, although extraction conditions significantly influence the presence and concentration of detected fatty acids. These findings highlight the importance of sustainable extraction techniques for recovering bioactive compounds with functional potential in food and nutraceutical applications.

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Keywords: truffle extracts, SFE, PLE, fatty acids profile

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ULTRASOUND AND HEAT TREATMENT AND ITS POTENTIAL TO REDUCE FENNEL ALLERGENICITY

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Abstract

Fruit and vegetables undergo various preparation processes to improve their digestibility, sensory properties and shelf life. Thermal and ultrasonic treatments are frequently used in the production of fruit and vegetable products that may contain allergenic proteins. Therefore, it is important to investigate the effects of these processes on allergenicity in order to control allergenic risks during production and to explore technologies that reduce the allergenic potential of the final products. The aim of this study was to investigate the effects of ultrasound and heat treatment on the in vitro immunoreactivity of protein extracts from fennel. After sonication and heat treatment, the protein extracts were analyzed by SDS-polyacrylamide gel electrophoresis, Western blot and ELISA methods. The results showed that both treatments altered the allergenicity of fennel. Due to cross-reactivity with peach antigens, treatment of fennel with ultrasound or heat could potentially reduce additional allergic reactions in individuals with peach allergy. A larger sample size is needed to better understand the effects of these treatments and the differences in individual allergic responses.

Keywords: allergens, Western blot, SDS-PAGE, ELISA, fennel

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INFLUENCE OF DIFFERENT DRYING METHODS ON SOME PHYSICAL PROPERTIES OF PUMPKIN POMACE

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Abstract

Pumpkin (*Cucurbita maxima* L.) is widely cultivated and consumed for its high content of biologically active compounds and essential nutrients. Pumpkin pomace is a by-product of industrial juice processing and a valuable source of nutrients such as fiber, antioxidants, especially carotenoids, and minerals. Given the rich nutritional profile of pumpkin pomace, much attention is being paid to its use to enrich and improve the quality of some foods. At the same time, it can contribute to reducing this waste.

This study investigated the effects of different drying methods on the selected physical properties (bulk density, rehydration properties, oil binding capacity) of Hokkaido pumpkin pomace. Four different drying methods were carried out: hot-air convective drying combined with continuous microwaves (60°C, airflow velocity 1,5 m/s, microwave power 90 W), hot-air convective drying (60 °C, airflow velocity 1,5 m/s), conductive vacuum drying (60 °C, 100 mbar) and hot-air convective drying combined with microwaves pretreatment (60 °C, airflow velocity 1,5 m/s, microwave power 600 W/2 min). The lowest bulk density was observed in pumpkin pomace dried with microwave-convective drying. Regarding the results of rehydration properties, pumpkin pomace dried by convective drying with microwave pretreatment showed the best rehydration properties. Furthermore, the results show that microwave energy enables faster and more efficient moisture removal during drying. However, convective drying alone provided the highest oil binding capacity. This work offers an innovative approach for industrial processors of vegetable juice to transform their processing by-products into functional food ingredients with desirable physical properties and to reduce food waste.

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Keywords: pumpkin pomace, microwave, convective and vacuum drying, rehydration properties

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EFFECT OF ULTRASOUND-ASSISTED EXTRACTION ON PHENOLIC COMPOUNDS RECOVERY FROM THE LEAF OF *LAURUS NOBILIS L.*

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Abstract

Laurel, or scientifically known as *Laurus nobilis*, belongs to the *Lauraceae* family and is an aromatic evergreen tree whose natural habitat is the Mediterranean region. This plant is traditionally used in Mediterranean cuisine to flavor various dishes such as soups, stews, sauces, sausages and other dishes. The chemical composition of laurel, especially the leaves, has been studied in detail and some of the metabolites are polyphenolic compounds, alkaloids, sugars, polysaccharides, organic acids, fatty acids, tocopherols, etc. The yield and bioactivity of these compounds and consequently the quality of the laurel end product and its use depend largely on the extraction methods used, which range from traditional methods such as maceration, hydrodistillation, heat reflux extraction, etc. to innovative methods such as supercritical fluid extraction, microwave-assisted extraction, ultrasound-assisted extraction, etc. Besides saving time, the innovative techniques such as ultrasound-assisted extraction (UAE) offer a simple extraction process with lower solvent consumption, which improves the yield and quality of the extract.

Considering the increasing demand for herbal supplements, of which laurel is less utilized, and the advantages of UAE that a range of extracts can be produced in less time, in this work we combined laurel extraction with UAE technology. Thus, the aim of the present work is to demonstrate the effects of amplitude (60, 80 and 100 %), time (3, 6 and 9 min) and solvents (30 and 70 % ethanol) on the extraction of phenolic compounds from laurel using UAE at a frequency of 37 kHz and a power of 400 W and to define the optimal parameters that maximize recovery. The results of ultra-performance liquid chromatography-mass spectrometry analysis of phenolic compounds after UAE extraction of laurel leaf extracts showed that the parameters, i.e. amplitude, time and solvent, have a significant impact on their composition and quantity. For example, in some extracts, certain phenolic compounds were found in very high amounts, while in others they were found only in small amounts or not at all, suggesting that the right choice of extraction parameters influences their yield. The highest total content of phenolic compounds was mainly found in extracts obtained with 70 % ethanol, 100 % amplitude and 9 minutes sonication time, which means that this parameter combination can be further used. Of the compounds identified, rosmarinic acid was found in the highest amounts, followed by kaempferol-3-O-rutinoside, gallic acid and *p*-coumaric acid with amounts up to 216, 125, 87 and 18 mg/L, respectively, depending on the solvents and UAE parameters used.

Overall, the obtained results underline the continuous use of UAE for the short and environmentally friendly extraction of phenolic compounds for further various nutraceutical applications in the food, pharmaceutical and cosmetic industries.

Keywords: laurel, ultrasound-assisted extraction, ultra-performance liquid chromatography-mass spectrometry, phenolic compounds

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A REVIEW ON MYCOSPORINE-LIKE AMINO ACIDS (MAA) CONTENT IN THE RED MACROALGAE FROM THE ADRIATIC SEA

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Abstract

Mycosporine-like amino acids (MAAs) are low-molecular-weight secondary metabolites found in various aquatic organisms, particularly in marine macroalgae. Research has identified MAAs in 572 species of marine macroalgae, predominantly within the Rhodophyta division (red macroalgae). Notably, the highest concentrations (exceeding 2 mg/g dry weight) are found in four orders: Bangiales, Gelidiales, Gigartinales, and Gracilariales. Although MAAs are primarily studied for their UV protective properties and potential cosmetic applications, they also exhibit various biological activities that enhance their appeal as nutraceuticals. While 22 MAAs have been fully characterized, many remain unidentified. The most prevalent MAAs in red macroalgae include shinorine, porphyra-334, palythine, asterina-330, and palythinol. Investigations have confirmed the antioxidant, anti-inflammatory, anti-viral, and anti-adipogenic properties of these compounds, particularly shinorine and mycosporine glycine, highlighting their potential for health applications. In the Adriatic Sea, literature data on species from the orders known for high MAA content (Bangiales, Gelidiales, Gigartinales and Gracilariales) were analyzed, revealing a rich diversity of these compounds. Porphyra umbicalis showcased the greatest variety of MAAs, but should in no case be exploited due to its vulnerable status. All studied algal species were shown to contain shinorine, thus indicating potential for significant biological activities. Continued exploration of MAA diversity in Adriatic Sea macroalgae is essential for unlocking their full potential while ensuring sustainable practices in their utilization.

Keywords: Marine bioactive compounds, Mycosporine-like amino acids (MAAs), Rhodophyta, Adriatic Sea

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CHANGES OF FATTY ACID COMPOSITION AND SENSORY CHARACTERISTICS OF INNOVATIVE FRESH KOMBUCHA CHEESE WITH THE ADDITION OF WILD THYME (THYMUS SERPYLLUM L.)

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Abstract

The dominant presence of saturated fatty acids, according to previous research, is one of the factors associated with the development of cardiovascular diseases, thereby giving cheese a negative nutritional reputation. However, to date, there is still no solid scientific evidence to establish a cause-and-effect relationship between dairy products or milk fat and heart disease. In addition, the short-chain fatty acids that are abundant in cheese are crucial for improving human health. Depending on the type of milk used, the production process and different additions, the composition of fatty acid groups (saturated, monounsaturated and polyunsaturated fatty acids) present in cheese also can vary significantly and also to affect its sensorial characteristics.

This research aimed to determine the fatty acid composition of innovative fresh kombucha cheese with the addition of wild thyme in the forms of ground, supercritical fluid extract and dry extract during 30 days of storage, as well as to perform the sensory evaluation.

The presence of 24 fatty acids was detected in samples of fresh kombucha cheese with added wild thyme. Among them, the largest share belonged to saturated fatty acids, namely myristic (from 6.33% to 9.48%), palmitic (from 29.87% to 33.19%) and stearic (from 8.63% to 11.68%). Among unsaturated fatty acids, oleic acid was dominant (26.78% to 33.64%). During the 30-day storage period, the most pronounced change was observed in the sample enriched with supercritical fluid extract, where by the end of the storage, an increase in the content of all detected fatty acids was evident. Also, by the end of the storage period, all tested samples had equalized values in the contents of total saturated (about 68.00%) and unsaturated fatty acids (about 38.00%). The atherogenic and thrombogenic index values did not show significant variations and maintained desirable low values. Sensory analysis results showed good acceptability by the evaluation panel. Since the evaluations of the examined samples' appearance, color, consistency, smell and taste remained unchanged after 10 days, it is evident that the added forms of thyme showed a good preservative effect and thus influenced the retention of the desired sensory characteristics during storage.

According to the observed results, this product would meet the demands of consumers if introduced to the market as a representative of innovative functional dairy products.

Keywords: fresh cheese, kombucha, wild thyme, fatty acid composition, atherogenic index, thrombogenic index, sensory analysis

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ANTIMICROBIAL ACTIVITY OF LACTIC ACID BACTERIA AND YEAST ISOLATED FROM STRAWBERRY TREE FRUIT (ARBUTUS UNEDO L.)

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Abstract

The strawberry tree fruit (Arbutus unedo L.) is an evergreen plant indigenous to the Mediterranean region, historically valued in traditional medicine for its potential therapeutic properties. This fruit is abundant in bioactive compounds, including polyphenols and tannins, which exhibit antioxidant and antimicrobial activities. These components play a role in mitigating oxidative stress and inhibiting the growth of pathogenic microorganisms.

Despite its potential, the strawberry tree fruit remains an underutilized species in Croatia, with its cultivation and consumption not yet fully explored. Both the fruit and leaves of the strawberry tree hold significant functional value, as numerous studies have highlighted their rich content of minerals, easily digestible sugars, dietary fiber, vitamins (particularly vitamin C), and various bioactive compounds with notable antioxidant properties.

In recent years, the fruit has gained increasing attention for its nutritional and health benefits. Its rich chemical composition contributes to a range of positive effects, including antiseptic, diuretic, laxative, and anti-inflammatory properties, as well as potential roles in diabetes prevention.

The objective of this study was to isolate indigenous microorganisms from the strawberry tree fruit and evaluate their antimicrobial activity. This research aims to further characterize these microorganisms and explore their potential applications in fermentation processes.

Keywords: antimicrobial activity, lactic acid, strawberry tree fruit, pathogens

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EFFECT OF PRETREATMENT AND THERMAL PROCESSING ON ANTIOXIDANT PROPERTIES, PHENOLIC COMPOUNDS AND PHYTIC ACID CONTENT IN GRASS PEA (LATHYRUS SATIVUS L.)

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Abstract

Grass pea is an annual herbaceous plant from the legume family (Fabaceae), traditionally used in human and livestock nutrition. It has survived thousands of years of cultivation and has spread across three continents. This robust legume variety is considered one of the most resistant to climate change and served as a survival food during drought-induced famines. Today, grass pea is regarded as a functional food in most countries worldwide, due to its high polyphenol content and antioxidant properties compared to other legumes. The aim of this study was to examine the impact of culinary processing of grass pea, including pretreatment (soaking for 12 or 24 hours at room temperature) and thermal processing at 100°C for varying time intervals (30, 45, and 60 minutes), on antioxidant activity (DPPH), total phenols and flavonoids content, as well as phytic acid content. Analyses were simultaneously conducted on the fresh sample as well. Using the ANOVA test, it was observed that soaking time, cooking time, and their interaction have a significant impact on the total phenols and flavonoids content in the samples. Statistical analysis revealed that soaking time, cooking time, and their interaction also influence the DPPH activity of methanol extracts of grass pea. Prolonging the cooking time contributed to a significant ($P < 0.05$) reduction in DPPH activity of the cooked samples compared to the raw sample. The sample that was not soaked or cooked showed significantly higher values of phytic acid compared to the samples that underwent pretreatment and thermal processing.

Keywords: grass pea, antioxidant properties, phenolic compounds, phytic acid

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THE IMPACT OF BREWING METHODS ON THE ANTIOXIDANT POTENTIAL OF COFFEE BEVERAGE

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Abstract

Coffee is one of the most popular beverages today, and its consumption has become a regular part of daily life worldwide. Since coffee beverages are rich in bioactive components, they significantly contribute to the daily antioxidant intake. During the growth, maturing, and processing of coffee, significant changes and various reactions occur, leading to alterations in the chemical composition of coffee, which inevitably affects its quality. Consequently, increasing attention is being dedicated to research on the chemical composition of green coffee, the changes that occur during processing, mainly during roasting, and the physicochemical composition and properties of coffee beverage, as the final product. The aim of this study was to determine the antioxidant activity of coffee beverages depending on the brewing method. The starting raw material used in this study was a blend of Cherry AA coffee (Robusta), Minas Gerais (Arabica), and Mogiana Sao Paulo (Arabica) in a 1:1:1 ratio. Coffee beans were medium roast and then ground to varying degrees of fineness, depending on the brewing method: espresso coffee, filter coffee, black "Turkish" coffee, and coffee intended for cold brew extraction. In these samples the content of total phenols and flavonoids were determined, and three tests of antioxidant activity (DPPH, FRAP, ABTS) were applied. The espresso beverage proved to be the sample with the highest content of total phenols and flavonoids, as well as ranking first in terms of antioxidant compounds. On the other hand, filter coffee was found to be the poorest in these compounds in both cases.

Keywords: coffee, brewing method, antioxidant potential

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ANALYSIS OF VITAMIN C CONTENT IN FRUITS OF CORNELIAN CHERRY (CORNUS MAS L) FROM BOSNIA AND HERZEGOVINA

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Abstract

Cornelian cherry (Cornus mas L), known for its pronounced antioxidant activity, is a rich source of vitamin C, phenolic acids, flavonoids, anthocyanins, and iridoids. Its fruits exhibit a wide range of biological and pharmacological properties, such as antimicrobial, anti-inflammatory, anticancer, antidiabetic, and anti-atherosclerotic effects.

Given the significant concentration of vitamin C in cornelian cherry fruits and considering the important role of this vitamin in the normal functioning of the immune system, the aim of this study was to determine the vitamin C content in fresh cornelian cherry fruits from various locations in Bosnia and Herzegovina (Bileća, Sarajevo, Bijeljina, Tuzla and Mostar). The collected fruits were cleaned and stored at -20°C until analysis.

UV-Vis spectrophotometry was used for quantitative analysis of the total concentration of vitamin C in samples. The DNPH (2,4-dinitrophenylhydrazine) is one of the simplest and most reliable methods to determine the vitamin C content in plant material. In this method, vitamin C is oxidized to L-dehydroascorbic acid, which then reacts with DNPH to produce an osazone. The osazone treated with 85% sulfuric acid results in a red-colored complex, the absorbance of which is measured at a wavelength of 521.5 nm.

The concentration of vitamin C in the examined cornelian cherry samples was determined using the calibration curve of a standard vitamin C solution (0.05-0.10 mg/ml) with the linear equation $y=9.9503x-0.0037$; $R^2=0.9761$ and is expressed in mg vitamin C per gram of sample.

The vitamin C content in fresh cornelian cherry fruits varied between 0.031 and 0.105 mg/g. The lowest content of vitamin C was found in samples collected from Bileća, while the highest was found in samples from Sarajevo.

Based on the results obtained, it can be concluded that the analyzed fresh samples of cornelian cherry fruit contain a lower amount of vitamin C than reported in some studies. The reason for these variations may be explained by the fact that ascorbic acid concentration varies with conditions such as temperature and storage period of preservation. The vitamin C content gradually decreases with the temperature and storage period of the fruit.

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Keywords: Cornus mas, vitamin C, DNPH, UV-Vis

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ELECTROANALYTIC APPLICATION OF THE COORDINATION COMPOUND CO(II) FOR DETERMINATION OF ADRENALINE

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Abstract

Adrenaline, or epinephrine, is a hormone and neurotransmitter secreted by the adrenal gland. It plays an important role as a mediator in stressful situations, such as anxiety and depression, and is used as a medication for conditions like anaphylaxis, bleeding, and cardiac arrest. In the blood, it regulates blood pressure, heart rate, and glycogen metabolism. Its presence can indicate health issues, with elevated levels observed during physical and emotional trauma, as well as in cases of cancer and Parkinson's disease. Electrochemical detection is used to monitor neurotransmitters associated with diseases due to its fast response, ease of use, and high sensitivity. A newly developed electrochemical sensor was used for the sensitive and selective determination of adrenaline, based on a glassy carbon electrode (GCE) modified with a cobalt(II) complex. When analyzing a real sample, the modified electrode demonstrated good electroanalytical performance (in terms of adrenaline oxidation), good interference resistance, stability, reproducibility, and potential applicability in commercial pharmaceutical samples. The good selectivity towards adrenmaline was also demonstrated by analysing potential interferences, where no changes in response were observed on the prepared electrode, except for vitamin C.

Keywords: Adrenaline, electrochemical sensor, cobalt(II) complex, electrochemistry

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STABILITY OF CAROTENOIDS IN ENCAPSULATED CARROT POWDERS: INFLUENCE OF COMPOSITION, PARTICLE SIZE AND HEAT TREATMENT OVER STORAGE

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Abstract

Carotenoids are bioactive compounds with significant health benefits, but their stability in food supplements is a major challenge. This study evaluated the stability of carotenoids in freeze-dried carrots encapsulated under different treatments and particle sizes. Fresh carrots (Daucus carota cultivar 'Nantesa') of Spanish origin and size 20/35 mm were cut into 1 cm thick slices. A heat treatment was applied in boiling water for five minutes, followed by rapid cooling in ice water to simulate blanching. Both untreated and heat-treated samples were freeze-dried, ground and sieved into two particle size groups >355 µm and 90-355 µm. Calcium sulphate was used as excipient (67:33 v/v) and the mixtures were encapsulated in either gelatine or hydroxypropyl methylcellulose (HPMC) capsules, then blister-packed for storage. The carotenoid content was analysed according with the validated method published by Stinco et al. (2019) and the stability of the carotenoids was monitored at 0, 7, 15, 15, 30, 60, 90, 90, 180, 270 and 365 days. One-way ANOVA and Tukey's test were used to identify significant differences ($p<0.05$). The results revealed that carotenoid degradation was observed in all conditions, with colourless carotenoids showing greater stability in percentage terms compared to the coloured ones. In not-heat-treated samples, after 365 days, colourless carotenoid degradation reached 81% in gelatine capsules and 85% in HPMC, while coloured carotenoids degradation reached 97% and 98%, respectively. Heat treatment accelerated degradation in gelatine capsules (93% and 99% for colourless and coloured carotenoids, respectively). However, in HPMC capsules containing heat-treated particles of 90-355 µm, degradation was significantly reduced, with only 39% loss for colourless carotenoids and 61% for coloured ones. These findings highlight the relevance of optimizing particle size, selecting encapsulation material, and heat treatment conditions in enhancing carotenoid retention in storage. The combination of HPMC capsules with a controlled particle size of 90-355 µm provided higher stability. Heat treatment exhibited a dual impact: while it initially accelerated degradation in gelatine capsules, it substantially enhanced carotenoid stability in HPMC capsules when combined with the appropriate particle size.

Keywords: capsules, carotenoids, carrots, phytoene

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THE ANALYSIS OF MICRO AND MACRO ELEMENTS IN BLACK ELDERBERRY (SAMBUCUS NIGRA L) FROM DIFFERENT REGIONS OF BOSNIA AND HERZEGOVINA

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Abstract

Within the elderberry family there are about thirty species, with black elderberry (Sambucus nigra L) being the most commonly used in Bosnia and Herzegovina. This plant is a rich source of phytochemicals and bioactive compounds, including flavonoids, phenolic acids, triterpenoids, anthocyanins, vitamins, and other antioxidants. Numerous studies have underscored its protective effects on human health, including antiviral, anticancer, and anti-inflammatory properties.

The analysis of the macro- and microelements present in the leaves, bark, fruit, and flowers of black elderberry provides key information about the nutritional profile of this plant. Since plants are an important source of mineral nutrients for humans, these analyses can significantly impact the safety and use of elderberry in nutrition. If the plant is used for pharmacological purposes or human nutrition, an increased content of certain elements can reduce its therapeutic efficacy or even be toxic to human health, which may limit its use.

In this study, the content of micro and macroelements in samples of black elderberry collected from the Tuzla and Sarajevo regions was determined using the ICP-OES method (Inductively Coupled Plasma Optical Emission Spectrometry). The samples were prepared by microwave digestion with H2O2 and HNO3 (70%). Concentrations of 23 elements were determined, including Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, S, Se, Si, Sr, and Zn in the dry leaves and flowers of black elderberry.

Results indicated that potassium (K) was the most abundant macroelement, followed by calcium (Ca) and phosphorus (P), while magnesium (Mg), sulphur (S), and sodium (Na) ware present in lower concentrations. Iron (Fe) was the most represented essential microelement, followed by manganese (Mn), zinc (Zn), copper (Cu), selenium (Se), and cobalt (Co). Among the trace elements, aluminium (Al) was the most abundant, followed by nickel (Ni) and chromium (Cr). Among the toxic metals, lead (Pb) was the most prevalent, followed by cadmium (Cd) and arsenic (As).

Differences in the concentrations of micro- and macroelements in the analysed black elderberry samples depend on the region from which they were collected, as natural geology and geochemistry influence the content of these elements. The results suggest that the analysed black elderberry samples can be considered a good source of essential elements.

Acknowledgments:
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Keywords: Micro- and macroelements, ICP-OES, Black Elderberry

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RAPESEED AND SUNFLOWER FIBRES AS CARRIERS OF POLYPHENOLS OF TART CHERRY JUICE

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Abstract

Rapeseed and sunflower meals are by-products of oil production. Often it is used for extraction of proteins, however there are still considerable amount of fibres left after protein extraction, containing over 60% of fibres mostly insoluble fraction. The aim of this research was to explore possibility of utilisation of rapeseed and sunflower fibres as carriers for polyphenols of tart cherry juice with the goal of preparation of functional food additives. Functional food additives were prepared by complexation of selected fibres and tart cherry juice. After complexation, freeze-drying was applied to obtain dry powder and two types of complexes were obtained, rapeseed fibres/tart cherry polyphenols (RF/TC) and sunflower fibres/tart cherry polyphenols (SF/TC) complexes. Obtained complexes were evaluated for total polyphenols, anthocyanins, proanthocyanidins and antioxidant activities. Complexes were used for screening IR spectra to define structural changes on fibres upon adsorption of tart cherry polyphenols. In addition, colour parameters were evaluated. SF/TC complex had higher contents of total polyphenol (10.83 mg/g) and anthocyanins (16.39 ng/g) than RF/TC (9.65 mg/g and 10.38 ng/g, respectively). On the other hand, it was observed that RF/TC complex had higher proantocyanidins content (7.88 mg/g versus 4.44 mg/g). Antioxidant activities of complexes were evaluated by DPPH, ABTS, FRAP and CUPRAC assays which differ in mechanism of action. DPPH and ABTS assays are based on inactivation of free radicals by donation of H atom by antioxidants, and it was established that RF/TC complexes had higher antioxidant activities by these two methods. However, FRAP and CUPRAC assays are based on reduction of metal ions and by these two methods higher antioxidant activities were achieved by SF/TC complex. Oxidative stability of polyphenols was also evaluated and it was observed that RF/TC complex showed higher protection from oxidation of anthocyanins and proanthocyanisins than SF/TC. Adsorption of tart cherry polyphenols caused changes of all colour parameters (L*, a*, b*, °h and C*). Also, upon adsorption of tart cherry polyphenols, structural changes on fibres were observed. The most significant change was observed in region from 930 cm-1 to 700 cm-1 indicating out-of-plane vibrations. This complexation can be perceived as a green approach in the formulation of functional food additives, which can be further used to forficate products with polyphenols and fibers.

Keywords: tart cherry polyphenols, sunflower fibres, rapeseed fibres

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NUTRITIONAL CHARACTERISATION AND MOLECULAR DOCKING ANALYSIS OF THE BROWN SEAWEED RUGULOPTERYX OKAMURAE

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Abstract

The study provides a detailed characterization of the invasive algae Rugulopteryx okamurae, highlighting its nutritional composition, mineral content, and potential bioactive compounds. This biomass contains 14.18 % protein, 21.29 % lipids (with a high omega-3 content), fibre (31.32 %), and significant amounts of minerals like calcium, sodium, potassium, sulphur, and iron. Phenolic compounds (0.74 %) and volatile compounds, such as retinol, were also identified. Peptidome analysis revealed 626 unique peptides, with 21 low molecular weight peptides showing potential activity against angiotensin converting enzyme and dipeptidyl peptidase IV when assessed using in silico tools and using molecular docking. Additionally, the antioxidant capacity of the alga was demonstrated with a significant free radical inhibition (EC50: 2.09 mg/mL). Overall, this study provides initial evidence on the nutritional potential of R. okamurae, which may have potential for future applications in food and biotechnology fields.

Keywords: Algae, Bioactive compounds, peptides, Molecular docking, antioxidant capacity

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PROTECTIVE EFFECTS OF HEMPSEED OLIGOPEPTIDES AGAINST NEUROINFLAMMATION IN AN ALZHEIMER'S DISEASE ANIMAL MODEL

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Abstract

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline, synaptic dysfunction, and neuronal loss. Neuroinflammation plays a crucial role in AD pathogenesis, driven by activated microglia and astrocytes, which exacerbate oxidative stress and amyloid-beta toxicity. Targeting neuroinflammatory pathways has emerged as a promising strategy to mitigate disease progression and preserve cognitive function. Nutritional strategies, such as using bioactive peptides with anti-inflammatory properties from sources like hemp protein, are gaining interest as an alternative to pharmacological therapies. In this study, we used a scopolamine-induced AD mouse model to test the efficacy of a hempseed protein hydrolysate (HPH15A) with antioxidant and anti-inflammatory properties. Mice were given HPH15A (10 mg kg−1 day−1) orally for 8 weeks. After treatment, brain tissue was analyzed to assess neuroinflammation markers. Additionally, the neuroavailable peptidome was characterized using an in vitro model simulating the intestinal and blood–brain barriers. The oral treatment has been shown to reduce protein aggregates of Iba1, GFAP, iNOS, and COX2 in the brain. The treatment also significantly lowered the cytokine gene expression in the hippocampus. The peptides NVDTELAHKL and DSETVKRL were proposed as potentially highly active peptides, able to exert anti-inflammatory effects in the brain. The results have shown that HPH15A is capable of alleviating neuroinflammation by reducing the expression of pro-inflammatory cytokines, which could have promising effects in AD.

Keywords: Hempseed, Bioactive peptides, Alzheimer's disease, Neuroinflammation, Neuroavailable peptidome.

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A NEW APPROACH TO COMBAT IRON DEFICIENCY ANAEMIA USING A SUSTAINABLE SOURCE OF MICROALGAE

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Abstract

Iron deficiency anaemia remains a global health challenge, affecting over 2 billion individuals and contributing to cognitive impairment, decreased productivity, and increased maternal mortality. Traditional iron supplementation strategies often suffer from poor bioavailability and undesirable side effects, necessitating alternative, sustainable solutions. Microalgae, particularly species such as Chlorella vulgaris, Arthrospira platensis, and Galdieria sulphuraria, have emerged as promising sources of bioavailable iron due to their high mineral content, natural presence of iron absorption enhancers (e.g., ascorbic acid), and ease of cultivation in controlled environments.

This study explores the potential of microalgae as an iron-rich dietary source by assessing iron bioaccessibility, bioavailability, and bioactivity. A multidisciplinary approach was adopted, incorporating in vitro digestion simulations, ex vivo absorption studies using human intestinal epithelial cells, and in vivo validation. The findings highlight significant variations in iron bioavailability across different microalgae species, influenced by cell wall composition, processing methods (e.g., spray drying, lyophilization), and interactions with dietary inhibitors. Additionally, we address challenges related to microalgae-derived iron assimilation and propose biotechnological strategies to enhance its uptake, including probiotic-assisted bioconversion of ferric (Fe^{3+}) to ferrous (Fe^{2+}) iron.

Beyond its nutritional advantages, microalgae-based iron supplementation offers a sustainable alternative aligned with global food security goals. Unlike conventional iron-fortified foods, microalgae cultivation requires minimal land and resources, making it an environmentally friendly solution. Furthermore, microalgae-based formulations could particularly benefit individuals following plant-based diets, where iron deficiency is prevalent.

This research paves the way for innovative functional food development and reinforces microalgae's role in addressing micronutrient deficiencies. Future investigations will optimise processing techniques to maximize iron bioavailability and explore regulatory pathways for widespread adoption. By harnessing microalgae's untapped potential, we aim to revolutionize dietary interventions for iron deficiency anaemia, offering a natural, sustainable, and effective solution to a critical global health issue.

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Keywords: microalgae, iron deficiency anaemia, sustainable nutrition, bioaccessibility, iron bioavailability

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STRUCTURAL AND TEXTURAL CHARACTERIZATION OF TRADITIONAL FERMENTED GREEK PRODUCT "LANGITES" ENRICHED WITH LEGUME FLOUR

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Abstract

Nowadays there is a great interest from the consumers for healthy, easy-to-consume, plant-based food products with increased protein content. Moreover, there is a growing consumer desire to reconnect with culinary heritage and embrace authenticity and tradition. Of great interest is to draw consumers' nostalgia by reintroducing old recipes, appealing to the 65% of consumers who want more traditional options on supermarket shelves. Baked products, a globally popular category, represent a key area of innovation within this trend. Within this category is a well-known traditional fermented Greek product named "langites.". The product is a specific thin, crepe (pancake)-like product with a characteristic porous surface. This investigation explored the influence of legume flour addition on the properties of the "langites". The product was produced by partial wheat flour replacement and using the traditional production technique. Non-gluten legume flour (lentil and chickpea) was added at legume to wheat flour ratios of 0:100, 10:90, and 30:70. The production procedure includes the dough development step, followed by the yeast fermentation step and the final baking process of the fermented "batter type dough" on a hot flat surface of a pan at 210°C. The substitution of wheat with legume flour had an impact on the properties of the final products. Legume incorporation significantly affected the elasticity of langites, measured both instrumentally and sensorially. Moreover, the hardness of the product increased with increasing legume flour from 0.788 N to 1.482 N. The characteristic porous structure was assessed through image analysis, where the morphological properties of the product's "eyes" were determined. The number and diameter distribution of the eyes were determined, revealing that incorporating legume flour reduced the number of eyes while increasing their mean diameter. The correlation among instrumental and sensory structural and textural characteristics of the product revealed important information for the design and production of highly accepted langites with improved quality characteristics and higher nutritional value.

Keywords: image analysis, legume flour, sensory evaluation, texture, traditional fermented food

OLIVE OIL-ENRICHED MEALS IMPROVE THE POSTPRANDIAL IMMUNOMETABOLIC PROFILE AND CIRCULATING EXTRACELLULAR VESICLE PHENOTYPE OF HEALTHY SUBJECTS COMPARED TO SATURATED FAT-RICH MEALS

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Abstract

Dietary fatty acids play a crucial role in modulating metabolic and immune responses, influencing long-term health outcomes. Extracellular vesicles (EVs) have recently emerged as key players at the immunometabolic crossroads due to their role in mediating intercellular communication. Despite growing evidence on the role of fatty acids in immunometabolic regulation and ongoing discoveries regarding the potential of EVs as markers and therapeutic targets, gaps remain in our understanding of the effect of different fats during the postprandial period and the role that EVs may play in these processes. Therefore, in this study, we aimed to examine how isocaloric meals rich in monounsaturated fatty acids (MUFAs) from olive oil and omega-3 long-chain polyunsaturated fatty acids (ω3-LCPUFAs) exert distinct and beneficial postprandial effects on the immunometabolic profile and circulating EV phenotype in healthy individuals compared to meals rich in saturated fatty acids (SFAs). Ten healthy volunteers (6 men and 4 women) were recruited for an interventional study involving meals enriched in fatty acids (MUFAs, ω3-LCPUFAs, and SFAs). Blood samples were collected at baseline and at 2-3 hours (postprandial peak) and 5-6 hours (postprandial peak) after meal consumption. Biochemical, haematological, and immunological parameters were analysed. EVs were isolated from plasma and phenotypically characterised by flow cytometry, assessing the expression of 37 parental cell biomarkers. Our results showed that MUFAs and ω3-LCPUFAs significantly decreased plasma immune cells levels during the postprandial phase compared to dietary SFAs. Flow cytometry also revealed higher plasma levels of immune cell-derived EVs following SFAs consumption. In contrast, meals rich in MUFAs- and ω3-LCPUFAs-rich appeared appeared to attenuate postprandial inflammation and immune activation in healthy individuals, likely through cellular communication mechanisms mediated by EVs. These findings highlight the potential role of MUFAs- and ω3-LCPUFAs-rich foods in maintaining homeostatic control of the innate immune system via EV-mediated intercellular communication. This insight opens new avenues for developing functional nutritional strategies to support health and prevent metabolic and cardiovascular diseases.

Keywords: metabolic syndrome, dietetic fatty acids, cardiovascular risk, exosomes, cell origin

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ENHANCEMENT OF ANTIOXIDATIVE PROPERTIES AND TOTAL PHENOL CONTENT IN COOKIES WITH NATIVE AND LYOPHILIZED SOURDOUGH FROM ANCIENT AND MODERN WHEAT VARIETIES

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Abstract

The growing interest in improving the nutritional and functional qualities of baked goods has led to an increased use of sourdough as an approach to enhance product properties. Sourdough fermentation, one of the oldest biotechnological processes, offers a wide range of benefits, such as improving dough properties, enhancing and diversifying the sensory quality, enriching the nutritional composition and functional properties of baked goods. Moreover, this technology has been proposed as a suitable solution to overcome the challenges associated with processing ancient whole wheat flours. These flours (emmer, spelt, and Khorasan) are known for their genetic diversity, rich nutritional profiles, and distinctive flavours. However, due to their lower technological quality and higher fiber content, they negatively affect the rheological behaviour of the dough and, consequently, the texture and sensory properties of the final products. To unlock the potential of these flours, using modern whole grain flour as a benchmark, this study applied spontaneous sourdough fermentation. The obtained mature sourdoughs (in both native and lyophilized forms) were incorporated into cookie formulations, and their antioxidative properties were investigated. A total of 12 cookie samples were prepared, with three formulations for each wheat variety: a control (100% whole wheat flour), lyophilized sourdough, and native sourdough. The antioxidative properties of the cookies were assessed using ABTS, FRAP, and DPPH assays, along with the determination of total phenol content. The results revealed that the addition of sourdough significantly improved the antioxidative properties of the cookies. This effect was more pronounced in samples containing native sourdough, though lyophilized sourdough also exhibited positive effects. The total phenol content was notably higher in the sourdough-enriched cookies compared to the control group. Antioxidative properties varied across the wheat varieties, with ancient wheat varieties generally showing greater improvements in antioxidative activity and phenol content than modern wheat. These findings suggest that sourdough fermentation, particularly with native sourdough, is an effective approach to enhancing the antioxidative properties and nutritional quality of baked goods. Further research is recommended to investigate the broader impact of sourdough fermentation on the digestibility of bakery products, as well as its potential health benefits.

Keywords: sourdough, antioxidative properties, total phenol content, ancient wheat, cookies.

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THE INFLUENCE OF NATIVE AND LYOPHILIZED KHORASAN SOURDOUGH ON THE QUALITY OF SOURDOUGH-ENRICHED COOKIES

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Abstract

As awareness of healthy lifestyles grows, the demand for baked goods made with whole grains and functional ingredients for healthy food production and special dietary uses is also increasing. Underutilized ancient grains, such as Khorasan wheat, are gaining attention due to their high nutritional value and potential health benefits. Additionally, combining sourdough technology with this ancient wheat can further enhance its effects. Given that the incorporation of nonstandard ingredients, such as sourdough, can significantly influence product characteristics, this study examines the impact of native and lyophilized Khorasan sourdough on the quality of whole grain cookies, focusing on their nutritional, rheological, textural, colour, and sensory properties.

Lyophilized sourdough was incorporated at a 25% substitution level, while native sourdough was added to match the dry matter substitution level of the lyophilized sourdough. The rheological properties were assessed by Haake MARS rheometer. The nutritional composition of the cookies, including protein, fiber, and energy content, was analyzed. Physical properties such as mass, diameter, height, spread factor, and eccentricity were measured, while textural properties were assessed using Texture Profile Analysis. Additionally, the cookies colour was evaluated using the L*, a*, and b* values, and sensory analysis was performed using the RATA method.

The chemical composition of the cookies was similar across all samples except for the soluble dietary fiber and carbohydrates content where addition of sourdough increased it significantly. The addition of native sourdough resulted by noticeably affecting dough rheology by softening the dough, making in difficult to process. It also resulted with softer texture of cookies, higher cookies, and more pronounced fracturability compared to the control and lyophilized sourdough samples. While lyophilized sourdough also affected physical properties, the changes were less pronounced. Both sourdough treatments contributed to higher yellow hues compared to the control cookie. Sensory analysis revealed distinctive yeasty and sour notes in the native sourdough cookies, which were absent in the control and lyophilized sourdough samples.

Although sourdough is recognized for its potential as an ingredient in cookie production, our study determined that the form in which it is used significantly affects the quality properties of the final product, as well as dough processability. Therefore, the choice between native and lyophilized sourdough should be carefully considered, taking into account not only the impact on texture, flavour, and appearance but also the other benefits associated with each form. Achieving the right balance between these factors is essential for optimizing the overall product quality.

Keywords: sourdough, Khorasan, cookies, quality, lyophilization

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DESIGN OF A WHEAT-BASED YOGURT-LIKE PRODUCT FERMENTED BY PEDIOCOCCUS PENTOSACEUS

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Abstract

In recent years, cereal-based yogurt has emerged as a popular alternative to traditional dairy yogurts. Fermented food products from cereals are known to be beneficial for health. Cereals have an adequate amount of minerals, vitamins, carbohydrates, protein, oligosaccharides and fiber. Cereals are an excellent matrix for the growth of lactic acid bacteria (LAB), and fermentation produces desirable changes in the biological availability of nutrients and also contributes to the formation of functional compounds. In this study, three wheat-based yogurts were produced and fermented by a previously selected probiotic strain of Pediococcus pentosaceus at 37 ºC during 8 h. The first yogurt contained only wheat flour, the second 2% of glucose and the third was prepared including hydrolytic enzymes in the process (amylase and glucoamylase). Yogurts were produced with 10% wheat, 3% starch, 0.5% pectin plus calcium, 2% sunflower oil and 2% of pea protein. Results showed that the pH values decreased, and titratable acidity increased with the fermentation process. The use of hydrolytic enzymes to degrade starch in the base resulted in a higher concentration of fermentable sugars and viable counts. Additionally, yogurts showed similar textural parameters to dairy-based products. This was due mainly to the presence of hydrocolloids and proteins in the formulation. These results indicated the promise of hydrolysate and LAB fermentation as a functional ingredient and process, respectively, for the food industry. Further studies on nutritional and rheological properties, health benefits, as well as improving the acceptability to consumers, should be conducted.

Keywords: wheat-based yogurt, probiotic, hydrolytic enzymes

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PROFILING THE BIOACCESSIBLE FRACTION OF PHENOLIC COMPOUNDS FROM COFFEE HUSKS DURING IN VITRO GASTROINTESTINAL DIGESTION

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Abstract

Coffee husks are coffee processing by-product containing significant concentrations of phenolic compounds, mainly chlorogenic, protocatechuic, and gallic acids, that have been associated to the prevention of diseases related to oxidative stress, such as type 2 diabetes and obesity [1]. However, to exert their beneficial effects, phenolics must go through the digestive tract, where factors such as pH and enzymatic action can modify their chemical structures or cause degradation [2]. Thus, this study evaluates the phenolic profile of coffee husks bioaccessible fractions after in vitro gastrointestinal digestion. The stability and biotransformations of the target phenolic bioactives were evaluated.

Dried coffee by-products, previously ground, were digested in vitro according to the INFOGEST protocol [3]. Bioaccessible fractions were analysed by UHPLC-ESI(-)-QTOF-MS/MS, and phenolics were identified based on MS data (accurate mass, isotopic distribution and MS/MS fragmentation pattern), positive match with MS databases (e.g., NIST, Metlin, MoNA), data reported in literature, and commercial standards, when available.

A total of 25 phenolic compounds were identified, including 7 flavonoids (mainly flavones) and 18 phenolic acids (mainly hydroxycinnamic and hydroxybenzoic acids). The predominant compound was 5-caffeoylquinic acid, with concentrations of 43.68 and 38.52 mg/100 g digested coffee pulp in the gastric and the intestinal phases, respectively. A significant increase in caffeic acid, p-coumaric acid, ferulic acid, quercetin-3-O-glucoside, and 3,4-di-O-caffeoylquinic acid was observed, whereas trans-cinnamic acid decreased significantly. No significant differences were found in the total phenolic content between the digestion phases. These findings indicate that some phenolic compounds in coffee pulp remain stable during digestion, while others undergo significant alterations. Further studies are being carried out to evaluate their beneficial impact on gut microbiota during colonic fermentation.

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Keywords: Coffee by-products; coffee husks; phenolic compounds; chlorogenic acids; bioaccessibility; in vitro digestion; LC-QTOF-MS

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BIOACTIVE EXTRACTS FROM THE EDIBLE INSECT HERMETIA ILLUCENS: POTENTIATION THROUGH FEEDING WITH OLIVE OIL BY-PRODUCTS

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Abstract

Among the different types of insects that are being evaluated for food and feed, Hermetia illucens larvae (black soldier fly, BSFL) is gaining importance due to its high protein and fat content, as well as its bioactive compounds with potential health benefits. At the same time, feeding these insects with agri-food by-products, rich in bioactive compounds, may enhance the bioactive properties of the larvae, contributing simultaneously to a circular and sustainable economy.

This study evaluated the production of bioactive extracts from BSFL and the effect of feeding the larvae with bioactive-rich by-products from olive oil by-products, such as olive leaves (OL) and olive pomace (OP), on the potentiation of the bioactive properties of such BSFL extracts.
The larvae were reared on a substrate of wheat bran partially replaced with 15%, 30%, and 50% ground dried OL or 30%, 50%, 70%, and 90% OP. After rearing, larvae were slaughtered, dried, ground, and defatted using supercritical fluid extraction. Extracts were obtained via ultrasound-assisted extraction with ethanol-water (70:30) at a 1:20 solid-to-liquid ratio for 25 minutes at 40°C. The extracts were analyzed for antioxidant (DPPH method), anti-inflammatory (lipoxygenase inhibition), hypolipidemic (pancreatic lipase inhibition) and antimicrobial activities (against Staphylococcus aureus and Listeria monocytogenes growth).
The antioxidant activity showed that feeding BSFL with OL and OP generally enhanced antioxidant activity, being especially notable as the level of inclusion in the diets increased. Thus, the IC50 value for the extracts improved from 0.8 mg/mL for control extracts up to 0.4 mg/mL for OL50 and to 0.1 mg/mL for OP90.
The inclusion of OL and OP also enhanced anti-inflammatory activity, with improvements of IC50 values of 18–45% and 41–54%, respectively, compared to the control (0.5 mg/mL). In hypolipidemic activity, most experimental extracts also showed significant improvements respect to the control extracts, with lower IC50 values of pancreatic lipase inhibition (values in the range of 2.1-2.7 mg/ml respect to the control at 3.1 mg/mL). All extracts containing OL exhibited antimicrobial activity against at least one microorganism, with the OL30 extract completely inhibiting the growth of both species at the highest concentration analyzed (5 mg/mL). Similarly, the same was observed for OP30.
These findings highlight the potential of BSFL extracts as a novel functional ingredient, supporting its potential application in health-related food industries, but such extracts can be even improved in bioactive properties by dietary strategies, in the context of circular economy, by feeding with bioactive-rich agri-food by-products.

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Keywords: Edible insects, bioactive extracts, ultrasound assisted extraction, by-products, circular economy

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ENHANCING THE BIOACTIVITY OF EDIBLE INSECTS BY FEEDING WITH BIOACTIVE BY-PRODUCTS: THE CASE OF TENEBRIO MOLITOR

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Abstract

Insects have gained significant attention as food and feed in part due to their ability to convert organic side streams into nutritive biomass and their low environmental impact. However, at the same time, feeding plays a crucial role in the composition and modulation of the bioactive properties of edible insects. This study explores the impact of different dietary inclusion levels of olive oil industry by-products—olive leaves (OL) and olive pomace (OP)—on the bioactivity of Tenebrio molitor larvae extracts.

Larvae were reared on wheat bran-based diets (control) or diets partially replaced with OL (15%, 30%, 50%) or OP (30%, 50%, 70%, 90%). After rearing, larvae were slaughtered (blanching), dried (oven) and defatted using supercritical CO_2. Larvae extracts were obtained from the defatted meal by ultrasound-assisted extraction with 70% ethanol. Total phenolic compounds (TPC) content (Folin-Ciocalteu method, expressed as g gallic acid equivalent, GAE/100 g extract) and the antioxidant (DPPH and ABTS assays), anti-inflammatory (lipoxygenase -LOX- inhibition) and hypolipidemic (pancreatic lipase inhibition) activity of extracts were measured, all activities expressed as IC50 value.

Inclusion of olive oil by-products in mealworm diets led to increased TPC and antioxidant, anti-inflammatory and hypolipidemic activity in the insect extracts. The highest TPC content was observed in extracts from OL50 (3.2 g GAE/100 g), which was significantly higher than those from control larvae (2.2 g GAE/100 g extract). OL30 exhibited the greatest antioxidant potential, with DPPH IC50 values ranging from 144.0 µg/mL (OL30) to 339.0 µg/mL (OP30). In contrast, the value for control treatment was 560.1 µg/mL. The ABTS assay also showed increased antioxidant capacity, mainly for OL30 (42.3 µg/mL), OP50 (43.0 µg/ml) and OP70 (42.8 µg/mL) extracts. Regarding the anti-inflammatory activity, all the extracts from larvae fed on olive by-products showed enhanced effects compared to control larvae (0.82 mg/mL), with IC50 values ranging from 0.38 mg/mL (OL30) to 0.63 mg/mL (OP50). Similarly, lipase inhibition was improved for all inclusion percentages of by-products, with IC50 values ranging from 3.4 mg/mL (OL30, OL50 and OP70) to 3.8 mg/mL (OP30), compared to 5.3 mg/mL of control.

In conclusion, these findings highlight the potential of incorporating bioactive by-products from olive oil industry into insect diets as a sustainable approach to enhance the bioactive properties of insects and the derived insect extracts, contributing to both circular economy goals and the development of novel ingredients for health.

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Keywords: edible insects, by-products, bioactive properties, mealworm.

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BIOACTIVE ENRICHMENT OF EDIBLE INSECTS THROUGH FEEDING WITH BIOACTIVE BY-PRODUCTS: THE CASE OF HERMETIA ILLUCENS LARVAE

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Abstract

Together with the nutritional relevance, studies concerning the biological properties of edible insects, including the popular larvae of Hermetia illucens (black soldier fly, BSFL), are increasing, suggesting that insects might be developed as novel bioactive ingredients. However, both the presence of bioactive molecules as well as the derived bioactivity seems to be extremely variable depending on diverse factors, the insect feeding being pointed out as one of the most remarkable one. Thus, the feeding of insects with bioactive-rich agrifood by-products can be an innovative strategy to simultaneously use insects as bioconversors of by-products and to confer an extra-added value to the derived insect products, either due to bioactive enrichment of the insect or due to bioactivity improvement.

The aim of this study was to study the effect of BSFL feeding with different levels of by-products from olive oil, as dry olive leaves or dry olive pomace, on the bioaccumulation of bioactive compounds and bioactivity of the BSFL meals. The defatted larvae meals were obtained, and the characterization of target bioactive compounds (hydroxytyrosol, tyrosol, oleuropein, erythrodiol, uvaol, oleanolic acid, ursolic acid, maslinic acid) was performed (by GC-MS previous silylation or HPLC-DAD). The antioxidant activity was also evaluated (DPPH, ABTS methods). A comparison with the same parameters from the diets was performed.

All the experimental BSFL meals accumulated most of the targeted bioactive compounds from the diets, a finding that was supported by the lack of detection of these compounds in the control larvae. However, while the diets based on by-products were mainly rich in oleuropein (in case of olive leaf) and hydroxytyrosol (in case of olive pomace), the insect meals mainly accumulated oleanolic acid and maslinic acid. Therefore, the achieved bioactive profile in the BSFL meals did not exactly match that observed in the substrates, neither in the type of molecule nor the proportional abundance of the molecule respect to the diet. The sum of total quantified bioactive molecules in the meals was strongly correlated with the DPPH antioxidant activity (IC50 value) of the meals ($r = -0.929$, $p<0.05$). On the contrary, a lack of relationship was found between the bioactive molecules and the ABTS antioxidant activity.

This study evidences the possibilities of bioactive enrichment of insect products by dietary strategies, with the additional advantage of being achieved in the context of a circular economy, through valorisation of bioactive rich by-products.

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Keywords: edible insects, bioactive compounds, bioconversion, bioaccumulation, antioxidants

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CHARACTERIZATION AND BIOACCESSIBILITY OF POLYPHENOLS AND MINERALS IN BUTIA YATAY ENCAPSULATES USING AN IN VITRO DIGESTION MODEL

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Abstract

The Butia yatay (Mart.) Becc. palm, which grows in high density in the central-eastern region of Entre Ríos Province, Argentina, holds significant international tourism value and represents a resource of interest for local producers. Its fruit is traditionally used in artisanal products such as liqueurs and jellies; however, its utilization remains limited. Due to its potential for innovative food product development, it has become the focus of recent research.

This study aims to characterize yatay encapsulates by evaluating their mineral content and the bioaccessibility of their polyphenolic compounds. Fresh yatay juice was obtained following the methodology described by Díaz MF et al. (2022) and supplemented with three different formulations: maltodextrin (F1), modified starch (F3), and a blend of both (F2). The samples were then spray-dried using a Büchi B-290® Mini Spray Dryer under controlled conditions.

A static in vitro digestion model was employed to simulate the adult human digestive process to assess bioaccessibility. This model, based on the standardized methodology proposed by INFOGEST, includes three stages: oral, gastric, and intestinal. Each digestive phase was simulated using digestion solutions with specific pH values: saliva (SSF, pH = 7), gastric juice (SGF, pH = 3), and intestinal juice (SIF, pH = 7). Following digestion, both the encapsulated samples and their bioavailable fractions were analyzed for total polyphenol content (TPC) using the Folin-Ciocalteu reagent. Elemental composition was identified and quantified using ICP-MS.

It is important to note that this study is in its preliminary stages, aiming to identify the most suitable yatay encapsulate formulation for potential applications in the food or pharmaceutical industries.

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Keywords: Encapsulation, Bioaccessibility, Minerals, Polyphenolic compounds, Yatay.

UTILIZATION OF DEFATTED SPIRULINA VIA SUPERCRITICAL FLUID EXTRACTION AS A FERMENTATION MEDIUM FOR *LACTOBACILLUS PLANTARUM* AND *LACTOBACILLUS CASEI*: ENHANCING BIOACTIVE COMPOUND PRODUCTION AND ANTIOXIDANT POTENTIAL

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Abstract

Fermentation is a widely utilized method in the food industry, and *spirulina* (*Arthrosporia platensis*), a protein-rich source, can serve as a valuable substrate for generating bioactive compounds, particularly through lactic acid bacteria (LAB) fermentation. In this study, *spirulina* was defatted using a sequential extraction process combining supercritical fluid extraction (SFE: 25.0 MPa, 60.0 min, 50.0 ºC, and 16.0 mL/min flow). The defatted spirulina was then used as a medium to ferment *Lactobacillus plantarum (L. plantarum*) and *Lactobacillus casei (L. casei)* over 18 hours, with bacterial counts and pH changes monitored throughout the process. After fermentation, solid matrices and supernatants were separated by centrifugation and analysed for protein content, bioactive peptides, minerals, and total antioxidant capacity (TAC) of fermentation supernatant. The results demonstrated that both LAB strains significantly increased protein content in the supernatants ($P<0.05$). Large quantities of bioactive peptides were identified using liquid chromatography-tandem mass spectrometry (LC-MS/MS), with specific antioxidant peptide sequences confirmed through the BIOPEP-UWM database. Fermentation significantly enhanced ($P<0.05$) the production of antioxidant bioactive peptides. Mineral content analyses revealed the substantial potential for mineral recovery from the fermented defatted *spirulina*, while further tests showed that the LAB strains significantly improved the antioxidative properties of the fermentation supernatants, as evidenced by TAC measurements. This study highlights the potential of defatted *spirulina* as a sustainable raw material for generating bioactive compounds through fermentation. By transforming underutilized biomass into valuable resources, this approach not only reduces environmental impact but also contributes to the development of functional foods and nutraceuticals. The findings underscore the importance of innovative fermentation techniques in promoting resource efficiency and sustainability in the food industry, offering a promising pathway for the utilization of *spirulina*-derived by-products.

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Keywords: Spirulina fermentation, Lactic acid bacteria (LAB), Bioactive peptides, Antioxidant capacity, Sustainable functional foods

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THERAPEUTIC POTENTIAL OF PLEUROTUS RESIDUES IN INFLAMMATION AND IMMUNITY REGULATION

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Abstract

The industrial production of edible mushrooms has significantly increased in recent years due to their recognized nutritional properties and health benefits. However, this increased production generates thousands of tons of cultivation residues annually, most of which are discarded. This study aimed to evaluate the biological activity of active compounds present in discarded mushrooms and residues of Pleurotus to determine their potential as novel nutraceuticals and promote their valorization through sustainable reutilization strategies. Aqueous extracts were obtained from the fruiting body (AF) and residues (R) of P. citrinopileatus, P. eryngii, P. ostreatus, and P. salmoneo. These extracts were enriched in β-glucans via ultrafiltration with 1 kDa (fraction 1p) or 10 kDa (fraction 10p) membranes, followed by ethanol purification, generating fractions AF1p, R1p, AF10p, and R10p. These were analyzed in cellular models, including intestinal epithelial HT-29 cells, HEK-hTLR2, HEK-hTLR4, and HEK-Dectin-1a reporter cells, as well as THP-1 macrophages, assessing NF-κB activation, TLR2 and TLR4 activation, and IL-6 and IL-10 production. HEK-Dectin-1a assays showed that the 10p fractions of fruiting body extracts had the highest Dectin-1A receptor activation, except in P. ostreatus, where the crude fraction (POAF) exhibited the highest activation. In residues, activation was lower, with the 1p fraction being the most effective, while unpurified P. ostreatus residues showed the highest activation. Variability in response suggests that β-glucan, heteropolysaccharide, and glycoprotein composition influences receptor activation. The extracts activated TLR4, except in P. ostreatus residues, indicating that β-glucans alone do not fully explain this activation. All extracts induced TLR2 activation, with the 1p fraction showing the highest response in most cases. In HT-29 cells under pro-inflammatory conditions with TNF-α, P. citrinopileatus and P. salmoneo fractions reduced inflammation by up to 25% and 28.6%, respectively, while residues had no effect. Only the 1p fractions of P. eryngii and P. ostreatus displayed anti-inflammatory activity. The extracts also induced NF-κB activation, except for the crude P. ostreatus residue extract (POAF), which lacked immunostimulatory effects. In THP-1 macrophages, all extracts stimulated IL-6 and IL-10 production, with P. citrinopileatus and P. salmoneo showing the strongest effect. NF-κB activation appears linked to adaptive and innate immune responses. Correlations were found between cytokine secretion, inflammation reduction in HT-29 cells, and TLR2 and TLR4 activation with glycoproteins rich in fucose, rhamnose, and arabinose. No extract exhibited toxicity.

In conclusion, Pleurotus extracts, particularly from P. citrinopileatus and P. salmoneo, contain bioactive compounds with immunomodulatory and anti-inflammatory properties, suggesting potential health benefits.

Keywords: Pleurotus, β-glucans, cell lines, anti-inflammatory activity, immunostimulatory activity

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UTILIZATION OF FRUIT AND VEGETABLE BY-PRODUCTS IN THE DEVELOPMENT OF SUSTAINABLE FOOD PRODUCTS

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Abstract

From 2000 to 2022, global vegetable production increased by 71% and global fruit production by 63%. The most produced vegetables are potatoes, tomatoes and onions, while the most produced fruits are bananas, watermelons and apples. Traditional waste management methods have become inadequate in the face of the significant increase in vegetable and fruit waste, leading to major environmental and economic challenges. Fruit and vegetable by-products are rich in dietary fiber and phytochemicals that offer numerous health benefits, such as antioxidant, anti-inflammatory, antimicrobial and anticarcinogenic effects. By utilizing these by-products, functional foods can be developed that maintain their good organoleptic properties and consumer acceptance. This poster highlights some of the most common bioactive components and their benefits and applications in the food industry, e.g. in the fortification of bakery, dairy and meat products. The use of fruit and vegetable by-products provides an opportunity to reduce costs and pollution, promote sustainable food solutions and contribute to a circular economy and the protection of the environment.

Keywords: Food industry by-products, dietary fiber, peel, functional food, sustainability

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FATTY ACID PROFILE OF HOT AIR DRIED BUTTERNUT PUMPKIN PULP AND ITS FRESH BY-PRODUCTS

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Abstract

Due to the widespread consumption of fresh pumpkin and its extensive use in dried form as an additive to various foods, e.g. breakfast cereals, snack bars, soups and ready meals, etc., it has become necessary to confirm the nutritional value of both fresh and dried pumpkin. In this work, since the fresh butternut pumpkin pulp is processed by hot air drying (HAD), the nutritional value of the HAD pulp was monitored in terms of fatty acid composition and yield before further use. To test the efficiency of the HAD process at a temperature of 50 and 60 °C and an airflow velocity of 0.5 and 1.0 m/s, the comparative fatty acid profile of the fresh butternut pulp was also investigated. In addition to the pumpkin pulp (fresh and HAD), the fatty acid composition of the pumpkin by-product, i.e. the peel and seeds produced during the preparation of the pulp for drying purposes, was also analysed. The results of the fatty acid profiles show that palmitic acid, oleic acid, linoleic acid and linolenic acid, each saturated, monounsaturated and polyunsaturated, predominate in the fresh and dried pumpkin pulp as well as in the by-products. Their quantities differ in the pulp, peel and seeds fractions, so that palmitic acid is highest in the seeds at 32.22 %, followed by the peel. The seeds contain a lot of oleic acid (34.37 %), as does the dried pulp (up to 27.83 %, depending on conditions) and the fresh pulp (23.34 %). Compared to other pumpkin fractions, the pulp, especially the dried pulp, is a good source of linoleic acid as omega-6 fatty acids with a content of up to 21.39 %. Dried pulp is also richer in linolenic acid as an omega-3 fatty acid than other fractions, with a content of up to 20 %. The peel is also a good source of linolenic acid with a content of 12 %. Obviously, all pumpkin fractions have a good fatty acid profile, making the whole pumpkin a valuable source of nutrients. In particular, the use of seeds and peels should be emphasised as they are discarded but both contain some fatty acids in representative amounts. In addition to the fatty acid profiles determined for each pumpkin fraction, it was also shown that drying the pulp significantly affects the fatty acid composition. For example, the content of some fatty acids is higher than in fresh pulp, so drying can achieve a good fatty acid composition and yield with a longer shelf life of the pulp. Considering the results obtained for dried pulp, the drying of peels and seeds would be an additional challenge for the future, as they contain representative amounts of some fatty acids equal to or even better than those of fresh pulp.

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Keywords: pumpkin pulp, pumpkin by-products, drying, fatty acids

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PROTEIN HYDROLYSATES OBTAINED DIRECTLY BY ENZYMATIC HYDROLYSIS OF RAPESEED PRESS CAKE

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Abstract

Rapeseed cakes are the residue after oil extraction from seed. This cake contains residual protein up to more than 40%. Due to its chemical composition, rapeseed cake is attractive for the development of sustainable ingredients, although there is concern about some antinutrients, whose content depends on the type and variety. Traditionally, it has been used as animal feed and soil compost, which has been reported to be an economically viable way to dispose of this by-product and obtain some benefit without additional cost. In recent years, other uses have been found. These have focused on the production of target bioactive products, mainly proteins. Several technologies being developed and products being brought to large scale production, but there are still not many commercially available rapeseed protein products.

The most frequently used technique for obtaining protein from this source is alkaline extraction with isoelectric precipitation, although the simple technique has a number of its drawbacks. Hence, in this work protein hydrolysates produced directly from rapeseed cake omitting the alkaline extraction process. In this way protein yield was increased and obtain hydrolysate with improved properties.

Hydrolysis was performed using two enzymes, alcalase and pepsin, the degree of hydrolysis was determined and the obtained hydrolysates were characterized using electrophoresis. In addition, the antioxidant activity of the obtained hydrolysates was determined. The results showed that protein hydrolysates obtained with the application of both used enzymes have high antioxidant properties, which makes them potentially good for use in different formulations of food products. Moreover, the results from the present study might offer a new procedure for scaling-up the production of protein hydrolysate towards valorization of presscakes on a commercial level.

Keywords: plant protein, rapeseed press cake, enzymatic hydrolysis

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ADVANCEMENTS IN FABA BEAN PROTEIN EXTRACTION: METHODS, INNOVATIONS, AND SUSTAINABILITY

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Abstract

Faba beans (Vicia faba L.) are increasingly recognized as a sustainable protein source due to their high protein content, nitrogen-fixing capability, and low environmental impact. However, the industrial adoption of faba beans is encumbered by several challenges, including the presence of anti-nutritional factors (ANFs), the preservation of protein functionality, and scalability issues. This work critically examines dry, wet, and hybrid protein extraction methods, alongside pretreatment strategies, to optimize yield, purity, functionality, and sustainability, while identifying key research gaps.

Pretreatment strategies have been identified as crucial factors in enhancing extraction efficiency and mitigating ANFs. Enzymatic treatments and fermentation have been shown to effectively degrade ANFs, including tannins and vicine, thereby improving protein digestibility and functionality. Furthermore, physical pretreatments, such as ultrasound and microwave processing, have been demonstrated to modify protein structure, enhancing solubility and extraction rates. Innovations in the field, such as deep eutectic solvents (DES) and enzyme-assisted extraction, offer greener alternatives that reduce chemical dependency and improve recovery efficiency. Dry extraction methods, such as air-classification, offer energy-efficient processes that maintain protein integrity and minimize water consumption. These methods yield protein concentrates with moderate purity but retain higher ANF levels, limiting their applicability in high-value food products. Conversely, wet extraction techniques, such as alkaline-isoelectric precipitation, produce high-purity isolates with superior functional properties (e.g., emulsification, solubility). However, these techniques are resource-intensive, requiring significant amounts of water, chemicals, and energy. Hybrid methods, which integrate dry pre-fractionation with selective wet extraction, offer a balance by improving yield and purity while reducing resource consumption. These integrated systems show promise for scalability but require optimization to address operational complexities and costs. In conclusion, selecting an appropriate faba bean protein extraction method requires a context-driven approach that aligns with sustainability and functionality objectives. Dry methods are suitable for sustainable bulk production, wet techniques facilitate superior ingredient development, and hybrid methods offer adaptable, resource-efficient solutions. Improving pretreatment technologies, green solvents, and scalable processes will require interdisciplinary collaboration among food scientists, engineers, and policymakers. Addressing current limitations and fostering innovation has the potential to elevate faba beans from a niche ingredient to a mainstream food resource, thereby supporting global food security and ecological resilience. This review synthesizes recent advancements and proposes actionable strategies to accelerate the transition of faba bean proteins into sustainable plant-based food systems.

Keywords: faba bean, Vicia faba L., protein extraction, pretreatment, plant-based protein

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PHYSICOCHEMICAL PROPERTIES OF FABA BEAN (Vicia faba) PROTEIN ISOLATES OBTAINED USING DIFFERENT EXTRACTION METHODS

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Abstract

Plant proteins are becoming in focus of research interest due to their nutritional value, functional properties as well as ecological advantages to animal proteins. This study investigates physicochemical properties of faba bean (Vicia faba) protein isolates obtained by three different extraction techniques: alkaline extraction, salting-out method and extraction using natural deep eutectic solvents (NADES). The aim of this research was to determine the impact of the applied protein extraction procedure on protein yield as well as their techno-functional properties such as solubility, water and oil capacity and foaming ability.

According to obtained result, alkaline extraction showed the highest protein yield (14.7 % calculated based on faba bean; 49.3% calculated based on protein content of faba bean). However, this method led to more pronounced protein denaturation resulting in decreased solubility at certain pH values. The protein yield by salting-out method was lower than that by alkaline extraction method (11.2% calculated based on faba bean; 33.6% calculated based on protein content of faba bean), but the functional properties were more preserved. The lowest protein yield was obtained by using natural deep eutectic solvents (6.6% calculated based on faba bean; 22.9% calculated based on protein content of faba bean), but the obtained protein isolate exhibited the highest water retention capacity (3.23 g/g) and the highest foaming stability (24.75% after 120 min).

The protein content of obtained protein isolates were: 91.77% for the alkaline extraction method, 95.63% for the NADES method and 96,06% for the salting-out method, indicating that salting-out method resulted in the purest protein isolate. The solubility of all protein isolates was the lowest at pH 5-6, and the highest at pH 2 and pH 10, reaching 76.66% and 75.02%, respectively, for protein isolates obtained by alkaline extraction method. The highest oil retention capacity was observed for alkaline extracted proteins (5.32 g/g), whereas NADES extraction achieved balance between oil and water retention capacity, which could contribute to better stability in various food products.

The obtained results revealed that extraction conditions significantly influence the final protein properties as well as their application in food industry. NADES extraction procedure showed potential for preserving protein structure and ensuring protein extraction sustainability, while alkaline extraction was the most efficient in protein yield, but resulted in poorer functional properties. These findings can contribute to development of novel, functional plant proteins with broad applications in food industry.

Keywords: Faba bean, protein extraction, physicochemical properties, functional characteristics, green processing

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INFLUENCE OF FERMENTATION PROCESS ON QUALITY OF LEGUMES SPREADS

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Abstract

Starter cultures for plant-based product fermentation are currently available on the market. The use of different plant raw materials can present challenges to the fermentation process, as the starter used may perform differently in terms of composition and temperature. Finding specific starter cultures and fermentation conditions (temperature, pH) for plant-based alternatives could provide optimal quality of the final product. The current study mainly focuses on the reduction of undesirable aroma compounds by lactic acid bacteria fermentation applying different temperatures and starters. The protein concentrates (PC) (LTD Aloja-Starkelsen, Latvia): brown pea (B), yellow pea (Y), faba (F) and Alomix (A); starter cultures: Danisco® VEGE 033 (Danisco, Denmark) and CHN22 (Chr. Hansen Holding, Denmark) were used in the research. The legumes spread were produced according to the following scheme: PC (B, Y or F) was mixed 1:1 with A, and obtained mixes (AB, AY, AF) were diluted in water (proportion 1:5), thermally treated (71 ± 1 °C, 30 ± 5 min), cooled till fermentation temperature (for CHN22 - 22°C, 26°C, 30°C; for VEGE033 - 37°C, 40°C, 43°C), inoculated, and fermented (till pH 4.8±0.2). Content of tannins was detected using spectrophotometer Jenway 6300 (Baroworld Scientific Ltd., UK). Volatile compounds were detected in fermented spreads using Perkin Elmer Clarus 500 GC/MS with Elite-Wax ETR columns (60 m × 0.25 mm i.d.; DF – 0.25 µm). The antiradical activity of the samples was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH˙) reagent, a freshly prepared DPPH˙ solution in ethanol (0.004 g per 100 mL ethanol) was used. The tannin content increased significantly in all fermented samples, except AB samples fermented (40 °C, 43 °C) with starter VEGE033. Higher DPPH activity was established in AB and AF samples fermented with CHN22. Samples fermented with CHN22 starter exhibit higher total volatile compounds values, particularly for AF and AY. AB samples showed lower peak area of volatile compounds, except VEGE033 (43°C). Samples fermented with CHN22 exhibited significantly higher content of acetic acid and ethanol showing fermentation metabolites. Fermentation dramatically changed volatile compounds values and spectrum. CHN22 starter could be recommended for better volatile compound profile in legume spreads. The choice of PC, starter and fermentation temperature affect the volatile compounds profile and tannin content of fermented legume spreads, further research should be done using mixture of starters for obtaining better results.

Acknowledgement: This study was supported by Project Nr. 22-00-A01612-000016 “Potential for the application of pulses for alternatives dairy products” supported by Ministry of Agriculture and Rural Support Service of the Republic of Latvia.

Keywords: spread, DPPH, volatile compounds, tannin

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THE IMPACT OF NATIVE AND TREATED PROTEIN ISOLATES ON THE QUALITY AND SENSORY CHARACTERISTICS OF GLUTEN-FREE BREAD

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Abstract

Incorporating plant protein isolates into bread formulations is a growing area of interest due to their potential nutritional and functional benefits. This study investigates the effects of native and treated faba bean and lupine protein isolates on the physicochemical and sensory properties of gluten-free bread based on buckwheat flour. Five formulations were tested: a control (without protein addition), bread with 10% native faba bean protein, 10% native lupine protein, 10% hydrothermally treated faba bean protein, and 10% hydrothermally treated lupine protein. Texture analysis was done on TA.XTplus texture analyzer, the color of the crust and crumb was determined using Chroma Meter CR-400 (Konica Minolta, Japan), and specific volume was measured with volscan profiler. Sensory analysis was performed by a trained panel. The results revealed statistically significant differences in crust and crumb color, firmness, specific volume, and sensory attributes between the samples ($p < 0.05$). The addition of protein isolates generally darkened the crust (lower L* values), with the control sample being the lightest. The crumb color was also affected, with lupine-treated samples exhibiting the highest yellowness values. Firmness increased with protein addition, with lupine protein showing the most pronounced effect. Specific volume was the highest in the control bread, decreasing with protein addition, particularly with lupine isolates. However, hydrothermally treated lupine protein isolates improved bread quality by increasing specific volume and softening crumb texture compared to their native counterparts. Sensory evaluation indicated that protein-enriched samples had stronger legume-like and buckwheat-like flavors, while bitterness was more pronounced in lupine-treated formulations. Bitterness decreased in the sample that contained thermally threated faba bean protein isolate. The overall acceptability of the samples varied, with the control having the most balanced sensory profile. These findings highlight the influence of protein source and treatment on the overall physical and sensory characteristics of gluten-free bread. Further optimization is needed to exploit the potential of protein hydrothermal treatment in improving the functionality of gluten-free bread.

Keywords: Faba protein, lupine protein, gluten-free bread, thermally treated proteins

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DEFENOLIZATION OF RAPESEED CAKE: IMPROVING PROTEIN FUNCTIONALITY AND VALORIZING BY-PRODUCTS

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Abstract

Polyphenols have become the subject of intense research due to their beneficial biological properties and potential for commercial applications. In rapeseed cake, which remains after oil extraction, the concentration of these bioactive compounds is significantly higher compared to other oilseeds. Although they can contribute to the nutritional value, their presence makes further processing difficult, especially during protein isolation, where they negatively affect protein yield, solubility and structure. In addition, polyphenols contribute to pronounced bitterness and dark color of proteins, limiting their application in food products.

This study investigates the reduction of phenolic content in rapeseed cake through defenolization using ethanolic solutions to obtain high-quality proteins with improved sensory properties.

Phenolic compounds in rapeseed cake exist in three forms: free, esterified, and bound. HPLC-DAD analysis indicated a significant decrease in total phenolic content after defenolization. Free polyphenols decreased from 8392.98 µg/g in cake to 542.96 µg/g in isolated proteins, with hydroxybenzoic, caffeic, syringic acids, and sinapin being completely removed. This is particularly important since sinapine is the dominant phenolic ester in rapeseed and is primarily responsible for the bitter taste and dark color of protein isolates.

Esterified polyphenols reduced from 4256.70 µg/g to 137.44 µg/g, while bound polyphenols were decrease from 519.24 µg/g to 163.39 µg/g. Sinapic acid, which is present in all forms, showed the highest residual content among the remaining phenolic compounds, but in a significantly reduced concentration. The defenolization process removed up to 95% of free and esterified phenolic compounds, while bound phenolics were reduced by approximately 68%. However, considering that bound phenolic compounds are present in significantly smaller amounts compared to free and esterified ones, their residual content should not negatively affect the protein isolation process, its functionality, or purity.

The results of this study confirm that the applied defenolization process effectively reduces phenolic content in rapeseed protein isolates, improving sensory attributes and expanding their potential food applications. Furthermore, the removed phenolic compounds, particularly sinapin, which constitutes about 73% of free phenolic compounds, may hold additional value in the food, pharmaceutical, and cosmetic industries due to their antioxidant and potential neuroprotective properties. This approach not only enhances protein functionality but also enables the valorization of by-products.

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, grant no. 6673, PROTein from Rapeseed Oil Processing Waste: Application in Food and Wastewater Treatment –PROTOPOWER and the Ministry of Science, Technological Development and Innovation, Republic of Serbia (Contract No. 451-03-136/2025-03/200222).

Keywords: phenolic compounds, proteins, rapeseed press cake, HPLC-DAD analysis

EXPLORING THE TECHNO-FUNCTIONAL PROPERTIES OF RAPESEED PROTEIN ISOLATES AS A FOUNDATION FOR THEIR PRACTICAL USE

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Abstract

Techno-functional properties of protein isolates play a key role in determining their suitability for various applications in the food industry. This study investigated the solubility, water and oil absorption capacities, foaming properties, and gelation ability of rapeseed protein isolates obtained through alkaline extraction and extraction using deep eutectic solvents (DES) – betaine:citric acid (1:1) and ChCl:urea (1:2).

The isolate obtained through alkaline extraction exhibited the highest solubility across the pH range of 2–10, which can be attributed to partial denaturation in the alkaline medium, leading to the disruption of the compact protein network and exposure of polar residues on the surface. Differences in the solubility of isolates obtained via DES extraction can be explained by variations in their extraction conditions.

The highest water absorption capacity (WAC) was observed in the isolate obtained through alkaline extraction, while a slightly lower value was recorded for the isolate extracted with betaine:citric acid DES. The lowest WAC was found in the isolate obtained with ChCl:urea DES. A similar trend was observed for oil absorption capacity (OAC), with the highest value recorded for the alkaline isolate, while the DES-extracted isolates exhibited slightly lower but still significant OAC.

The isolate obtained through alkaline extraction also demonstrated the highest foaming capacity, whereas significantly lower values were recorded for the isolates obtained via DES extraction. Regarding foam stability, the alkaline isolate maintained a stable foam volume after an initial slight reduction. In contrast, the ChCl:urea isolate exhibited the lowest stability, with a pronounced decrease in foam volume over time. The betaine:citric acid isolate initially exhibited high foam stability, followed by a gradual decline, yet it still retained superior stability compared to the ChCl:urea isolate.

In terms of gelation ability, the minimum concentration required for gel formation was 14% for both the alkaline isolate and the isolate obtained with betaine:citric acid DES, although gel formation was observed even at 12%. In contrast, the ChCl:urea isolate formed a stable and firm gel only at a concentration of 16%.

These findings highlight the impact of extraction methods on the techno-functional properties of rapeseed protein isolates. The results provide valuable insights into their potential application in food formulations, with alkaline-extracted isolates offering enhanced functionality compared to those obtained using DES. However, the unique characteristics of DES-extracted isolates suggest that further optimization could expand their applicability in food systems.

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Keywords: rapeseed protein isolate, alkali extraction, DESs, techno-functional properties

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SUSTAINABLE EXTRACTION OF RAPESEED PROTEIN: COMPARISON OF DEEP EUTECTIC SOLVENTS AND ALKALINE EXTRACTION

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Abstract

The growing global population and increasing food demand require sustainable protein sources, with rapeseed meal emerging as a promising alternative to meat. It contains over 40% protein with a favorable amino acid composition. Traditionally, protein isolation relies on alkaline extraction, but this method can lead to protein denaturation and reduced digestibility. Therefore, alternative methods such as enzymatic treatment, ultrasound-assisted extraction, and deep eutectic solvents (DESs) have been explored. DESs are eco-friendly and biodegradable solvents that enhance protein extraction efficiency while preserving the native structure and functionality of proteins.

This study compares the efficiency of two DESs (ChCl:urea and betaine:citric acid) with conventional alkaline extraction at pH 12 for rapeseed protein isolation, focusing on yield and antinutrient content. The highest yield was achieved with ALK12 (36.9%), followed by DES2 (betaine:citric acid) at 31.3%, while DES1 (ChCl:urea) had the lowest yield (23.2%). Interestingly, despite its lower yield, DES1 provided the highest protein purity (95.8%), significantly surpassing ALK12 (86.0%) and DES2 (70.3%). These differences may be attributed to the physicochemical properties of the solvents, such as viscosity, polarity, and alkalinity, which influence protein solubilization, diffusion, and stability during extraction and precipitation. The antinutrient content varied depending on the extraction method. Isolates obtained with DESs contained approximately 1.4 times more phytic acid compared to the ALK12 isolate, likely due to pH conditions favoring its solubility. The total phenolic content in the ALK12 isolate was nearly three times higher than in DES2 and almost four times higher than in DES1, indicating enhanced polyphenol extraction under alkaline conditions. Similarly, tannin content in the ALK12 isolate was about 1.5 times higher than in the DES isolates. No glucosinolates were detected in any of the isolates.

These findings suggest that DESs represent a sustainable alternative for rapeseed protein isolation, with acidic formulations offering a balance between extraction efficiency and retention of antinutritional compounds. While ALK12 achieved the highest yield, DESs provide environmental benefits and better protein structure preservation, making them promising candidates for advancing plant protein extraction technology.

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Keywords: rapeseed protein isolate, alkali extraction, DESs, antinutrients

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CHARACTERIZATION OF BURITI (MAURITIA FLEXUOSA L. F.) FRUIT BY-PRODUCT FLOUR AND ITS POTENTIAL USE IN THE FOOD INDUSTRY

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Abstract

The oil extracted from the pulp of Buriti (Mauritia flexuosa L. f.), a fruit native to South America, has many applications in the pharmaceutical and cosmetics industries. Industrial extraction of the oil generates over 6000 tons of pulp bran per year, a by-product that is either discarded or used as animal feed. However, it presents potential uses for the food industry, since they can be viewed as a source of dietary fibers and antioxidant compounds, among other substances. In this study, the residue obtained from oil extraction of Buriti was characterized in terms of proximate composition, neutral monosaccharides profile (GC) and by FTIR. The moisture content was approximately 7.6 g/100 g. Results indicated significant amounts of carbohydrates (~72 g/100 g), followed by protein (~8.2 g/100 g), lipids (7.3–7.6 g/100 g) and minerals (4.2–5.0 g/100 g). Evaluation of the neutral monosaccharide profile indicated high amounts of glucose (~57%), followed by uronic acid (~15%), xylose, arabinose, mannose and galactose (~5-8% each). Small amounts of fucose, rhamnose and ribose were also detected. FTIR analysis indicated the presence of pectic polysaccharides and hemicelluloses, including arabinoxylans, xyloglucans and galactomannans. Our results indicate that this by-product has potential uses in the food industry, either as a source of dietary fibers or as a source of polysacharides (pectin, for instance) that could be used in the development of food packages (biopolymeric films).

Keywords: Agricultural waste valorization, buriti

APPLICATION OF ZERO EMISSION IN GASTRONOMY

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Abstract

Zero emission in gastronomy represents an approach in which carbon dioxide and other harmful gas emissions are reduced or eliminated through sustainable practices in food production, transportation, preparation, and consumption. This paper explores the application of zero emissions in various aspects of the gastronomic sector, with a particular focus on the use of renewable energy sources, waste reduction, sustainable agriculture, and the use of environmentally friendly materials. The aim of the paper is to analyse the current state of these practices in the industry and provide a framework for implementing strategies that could contribute to emission reduction and improvement of sustainability in gastronomic processes. Through the use of case studies and analysis of existing initiatives, the paper offers recommendations for improving energy efficiency and reducing the ecological footprint in this sector. The objectives of the paper were to analyse existing technologies and practices that enable zero emission in gastronomy, examine the impact of zero emission on the sustainability of food production and consumption, develop guidelines for the implementation of zero emission in gastronomic establishments, and present examples of successful industry initiatives focused on reducing carbon dioxide emissions. Based on the mentioned objectives, the following results were obtained: the research showed that there is significant potential for implementing zero emissions in gastronomy through the use of energy-efficient appliances, local and organic food products, waste reduction, and the use of recycled materials. Some restaurants and hotels are already applying these practices, achieving a significant reduction in emissions, while other components of the industry, such as logistics and distribution, still require improvements. Based on the results, the following conclusion was drawn: achieving zero emission in gastronomy is a challenge, but also an opportunity to reduce the industry's negative environmental impact. The implementation of sustainable practices and technologies can lead to significant ecological and economic benefits, including reduced energy costs, waste reduction, and improved brand image. Further development of policies and education in the industry will be crucial for achieving zero emission goals.

Keywords: zero emission, ecology, environmental protection, gastronomy, food.

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MODELS OF CIRCULAR ECONOMY IN THE FOOD INDUSTRY

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Abstract

Circular economy (CE) represents a new approach to resource production and consumption, based on sustainability, waste reduction, and material reuse. In the food industry, the application of circular economy principles is becoming crucial for reducing environmental impact as well as improving business efficiency. This paper explores models of circular economy applied to the food industry, analysing various strategies such as waste reduction, packaging recycling, and the use of by-products in production. The aim of this research is to provide an overview of existing circular economy practices, identify the challenges and advantages of their implementation, and present their impact on both economic and ecological aspects. The results show that implementing circular principles can significantly contribute to cost reduction, enhanced sustainability, and the decrease of greenhouse gas emissions. In conclusion, further research and innovation in this field are key to achieving long-term sustainability in the food industry and globally reducing negative environmental impacts.

Keywords: circular economy, food industry, sustainability, environmental impact, economic effects

EVALUATION OF THERMAL PROPERTIES AND CHEMICAL COMPOSITION OF APPLE, BEETROOT, AND CELERY POMACE FLOURS FOR SUSTAINABLE FOOD INDUSTRY APPLICATIONS

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Abstract

This study examines the thermal properties and chemical composition of flours derived from apple (AP), beetroot (BT), and celery (CL) pomace to assess their potential for sustainable applications in the food industry. Thermogravimetric analysis (TGA) was conducted to analyze the thermal degradation (TD) process of flour samples under controlled heating (25–700°C) with a heating rate of 5°C/min. Additionally, the proximate chemical composition of all three flour samples was determined and correlated with their thermal behavior.

Moisture content was highest in CL (9.8%) and lowest in BT (3.4%), while AP had 4.2%. CL was richest in minerals (9.7% ash), whereas AP had the lowest mineral content (1.7%). CL and BT contained similar protein levels (around 15%), significantly higher than AP (approximately 5%). Simple sugar content (glucose, fructose, sucrose) was notably lower in CL (5%) compared to AP and BT (around 25%). In AP, glucose (11.6%) and fructose (8.2%) predominated, whereas sucrose was dominant in BT (23.3%). Total dietary fiber content across all samples ranged from 46.2% to 48.5%.

Three thermal decomposition (TD) phases could be identified in the thermograms. The first phase (TD1) represented moisture loss and volatilization of light compounds (room temperature to ~120°C), with the highest weight loss in CL (7.8%) compared to 3.5–4% in AP and BT, aligning with moisture content. The second phase (TD2; ~120–370°C for CL and BT, and up to ~400°C for AP) involved degradation of sugars, proteins, and fibers. Differential thermogravimetric (dTG) curves revealed three peaks for CL and BT, and two for AP. The first peak (~150°C for CL, ~210°C for BT and AP) was attributed to simple sugar degradation, with higher sugar content shifting the peak to higher temperatures in BT and AP. The second peak (~250°C for CL and BT) is attributed to the thermal degradation of proteins, which is absent in AP due to its low protein content. Fiber degradation occurred around ~340°C in AP and ~300°C in CL and BT.

Based on composition and thermal analysis, celery flour is suited for savory products due to its high protein and low sugar content, while apple flour is better for confectionery applications due to its high sugar levels. Beetroot flour has potential for both savory and sweet products, given its balanced protein and sugar content. However, caution is required when processing celery and beetroot flours due to their lower thermal stability compared to apple flour.

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66/2024-03/200051 and 451-03-66/2024-03/200168. Authors express gratitude for apple and beetroot pomace materials to domestic juice producers Fruvita doo Smederevo and ColdPressok, Beograd.

Keywords: thermal analysis, TGA, pomace, dietary fibre.

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EFFECT OF STORAGE TIME ON QUALITY PARAMETERS OF FLOURS FROM FRUIT AND VEGETABLE POMACE

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Abstract

The storage period is a critical factor influencing the quality of flours derived from fruit and vegetable residues, as it affects their physicochemical properties. Glass transition temperature (Tg), water activity (aw), and color parameters (L, a, b, c, and h) serve as indicators of flour quality, impacting their functionality and shelf stability. Understanding these parameters helps optimize storage conditions and extend flour quality over time.

This study evaluated the effect of storage time on the physicochemical characteristics of flours produced from fruit and vegetable residues. Tg, aw, and color parameters (L, a, b, c, and h) were measured at three storage intervals: at the beginning (0 months), after 3 months, and after 6 months. Eight types of flours were analyzed: three apple flours (AP1, AP2, and AP3), beetroot flour (BT), celery flour (CL), and three flours from mixed fruit and vegetable residues (MIX1, MIX2, and MIX3). The average Tg values ranged from 47.9 to 53.1 °C, with MIX2 exhibiting the highest Tg and MIX1, MIX3, BT, and AP1 the lowest. The aw values ranged from 0.266 to 0.416, with CL showing the highest value and BT and AP2 the lowest.

Repeated measures ANOVA analyzed the impact of storage time (within-subject factor: Time; three levels: 0, 3, and 6 months; degree of freedom = 2) and flour type (between-subjects factor: Flour type; eight levels: AP1, AP2, AP3, BT, CL, MIX1, MIX2, and MIX3; degree of freedom = 7), including their interaction (Flour × Time; degree of freedom = 14). Both factors and their interaction significantly influenced all tested parameters ($p < 0.05$), except for the b parameter of color, where time had no significant effect ($p > 0.05$). Tg, aw, a, and c parameters increased over time, while L and h parameters decreased. In order to determine similarities among samples based on the analyzed parameters, Principal Component Analysis (PCA) was conducted. PCA grouped the samples into three clusters: Group 1 (AP1, AP2, and AP3), Group 2 (CL, MIX1, and MIX3), and Group 3 (BT and MIX2).

Findings in this study indicate that storage time significantly impacts the glass transition temperature, water activity, and color of flours produced from fruit and vegetable residues, thereby affecting their overall quality. Special attention should be given to packaging and storage conditions to preserve the quality of these flours over time.

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Keywords: Thermal analysis, DSC, Glass transition, Pomace

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STABILITY OF THE OSMOTICALLY DRIED PORK MEAT (LONGISSIMUS DORSI) FOLLOWED BY THERMOANALYTICAL TECHNIQUES

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Abstract

Food drying is a process that removes water content from food products, effectively inhibiting the growth of microorganisms responsible for spoilage and extending the shelf life of food. The process of meat drying is a traditional and highly effective method for preserving its nutritional value and extending its shelf life. By removing water content, the growth of spoilage-causing microorganisms is significantly reduced. Moreover, the drying process minimizes the risk of foodborne illnesses by eliminating bacteria and other pathogens, making dried meat a safer and more durable product. Osmotic dehydration is a particularly effective drying technique for partially reducing the water content in raw materials while preserving the quality of the final product. This process allows the enrichment of food with osmotic solutions, such as sugar beet molasses used in this study, resulting in products that are nutritionally enhanced. Such products can be classified as functional foods due to their potential health benefits, combining preservation with added nutritional value. During the storage changes caused by microbial activity, oxidative processes, and variations in water activity inevitably lead to structural changes in food. These changes are reflected in the thermal stability and thermal properties of the food. Therefore, thermal methods of analysis could be used as a rapid "screening" tool for products with known thermal characteristics. The aim of this study is to monitor the thermal characteristics water activity (aw) of dried meat to identify any potential changes that may indicate sample instability during storage. The thermal properties of osmotically dried pork (OD) meat (Longissimus dorsi) were monitored over 60 days using differential scanning calorimetry (DSC) and thermogravimetry (TGA) in nitrogen flow. DSC was performed on dried meat samples in a temperature range of 5°C to 120°C in sealed aluminum pans and TGA in a temperature range of 25-700°C, with a heating rate (Hr) of 5°C/min. The results obtained from the DSC curves for the enthalpy of transition (ΔH ~680J/g), onset temperature of transition (To ~ 59ºC) and peak temperature of transition (Tm ~80°C) values, which corresponded to water evaporation and protein denaturation, did not show significant differences over the two-month period. Also, there were no significant changes for the mass losses observed through TGA, which correspond to water loss, thermal degradation of organic matter (loss at 500°C), and residual mass (residue at 700°C) and water activity (aw) indicating the stability of samples.

Acknowledgements: This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, grant numbers: 451-03-66/2024-03/200051.

Keywords: thermal analysis, DSC, TGA, thermal stability, dried meat.

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POTENTIAL OF FRUIT AND VEGETABLES RESIDUES IN FUNCTIONALIZATION OF CONFECTIONERY PRODUCTS AND MINIMIZATION OF GLYCEMIC RESPONSE

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Abstract

Pomace from fruit and vegetable juice production is a rich source of dietary fiber (DF) and polyphenolics. Apple and beetroot pomace flour (APF and BPF), obtained from minimally processed pomace using recently disclosed technological procedure, were evaluated as a source of biomolecules with antioxidant, antidiabetic and antiobesity effects. Here, APF and BPF were employed to obtain healthy alternative to jelly candies burdened with energy -aiming to meet the recommendations for DF intake and glucose spike minimization.

An experimental setup was conducted utilizing a gelling agent (pectin) x 2 sweeteners (sucrose or combination of erithritol, stevia, fructose and inulin) x 3 levels of enrichment (APF, BPF and no flour). Jelly candies sweetened with sucrose (P-APF, P-PBF and control P) and sucrose alternatives (P*-APF, P*-PBF and control P*) were subjected to proximate composition -analysis, determination of insoluble and soluble DF, total polyphenolic content (TPC) and AO activity (DPPH and FRAP), as well as in vivo determination of postprandial glucose response (upon consumption of the same amount of jelly candies). For each sample, the incremental area under the curve (IAUC) for capillary blood glucose concentration over 120 min was calculated.

In P-APF and P-PBF fiber content was above 3 g per 100 g of product enabling claim “fiber source” to be reached, while in P*-APF and P*-PBF exceeded by far requirement for claim “high in fiber” (at least 6 g per 100 g). Jelly candies with such high fiber content can significantly contribute recommended intake of 14 g DF per each 1,000 kilocalories (4,184 kJ). Content of TPC and AO activity in all jelly candies was prominent. The difference in IAUC for P and P* (137 and 55 mM×min) showed that sucrose substitution resulted in 60% reduction. The reduction related to sucrose substitution was found similar to the reduction caused by flour incorporation. The incorporation of APF and BPF resulted in IAUC decrease to 61 and 55 (P-APF and P-BPF) and 24 and 22 mM×min (P*-APF and P*-BPF). In comparison to P and P*, the reduction was 55-60%. Samples P*-APF and P*-BPF had 82 and 84 % lower IAUC than P.

Efficiency of applied approach in functionalization of confectionery burden with calories and minimization of glucose spike represent an example of agro-residues re-introduction into a diet with the highest potential contribution to anti-obesity strategy. Results obtained show that health promoting properties of agro-residues can be available to all consumers, including those who avoid sucrose.

Acknowledgements This research was supported by the Science Fund of the Republic of Serbia, 7439 GRANT No, From Waste to Food and Soil Enrichment - minimizing waste by applying circular economy in fruits/vegetables processing industry- WasteBridge and by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, grant numbers: 451-03-66/2024-03/200051 and 451-03-66/2024-03/200168. Authors express gratitude for apple and beetroot pomace materials to domestic juice producer ColdPressok, Beograd.

Keywords: pomace, dietary fibre, antioxidants, in vitro digestion, carb to fiber ratio

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ANTIOXIDANT ACTIVITY OF FRUITS AND VEGETABLES POMACE DURING 9 MOUNTS STORAGE DETERMINED UPON IN VITRO DIGESTION USING THREE ANTIOXIDANT METHODS

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Abstract

An increased intake of antioxidants and anti-inflammatory nutrients such as polyphenols are related to prevention of obesity and type 2 diabetes and improvement of their management. Pomace from fruit and vegetable juice production is a by-product rich in dietary polyphenolics that can play an important role in prevention of diseases. Technological process developed at the Institute of General and Physical Chemistry (Belgrade, Serbia) was applied to transform various minimally processed fruits and vegetables pomace obtained from juice industry (Cold Pressok) into stable flour, with low water activity and high temperature of glass transition, determined by differential scanning calorimetry. Here, content of total polyphenolic along with anti-radical and ferric reducing activity was determined upon in vitro digestion in fresh and nine month stored pomace flour in order to get an insight into antioxidants retention. Three method of antioxidant activity determination were applied to determine the antioxidant activity of eight flours from fruits, vegetables or their mixtures (celery, apple and beetroot pomace or their mixtures with cucumber, kale, spinach, parsley, ginger and lettuce) subjected to in vitro digestion. In vitro digestion of analyzed samples was conducted using the Infogest consensus method that simulates the oral, gastric and intestinal phases of human digestion. A blank solution was prepared containing all reagents except the sample. The digested samples were analyzed for total phenolic content (TPC) determined by Folin-Ciocalteu (FC) and antioxidant (AO) activity using spectrophotometric DPPH and FRAP assay. Measurements were done in triplicate. Results were expressed in gallic acid equivalent (GAE) per g of sample (µg GAE/g) and µmol of Trolox equivalents per g of digested sample (µmol TE/g). High values of total phenolic content (7.6±0.3 -13.4±1.1 µg GAE/g) were found immediately after production of flour, as well as prominent antiradical activity (16.9±0.9 -55.5±4.5 µmol TE/g) and ferric reducing power (98±6 - 314±22 µmol TE/g). Decrease of TPC was almost negligible during 9 mounts storage. Range of decrease of antiradical activity towards DPPH was 13.0 to 25.8 %. The highest decrease of reducing activity determined using FRAP was 14.3%.
These results, which show a satisfactory preservation of the carriers of antioxidant activity, are in good agreement with the results of thermal analysis, as well as a very slow increase in water activity. In our future work, individual phenolic compounds will be identified and their contribution to the overall antioxidant activity will be evaluated.

Keywords: Antioxidant, Antiradical, Pomace, Flour

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FIBER AND FIBER´S FRACTIONS IN BISCUITS ENRICHED WITH ANTI-GRAIN FLOUR OBTAINED AT INDUSTRIAL SCALE LEVEL FROM MINIMALLY PROCESSED APPLE POMACE

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Abstract

Sustainability and waste minimization are key principles that guide the modern food industry. By-products from the fruits and vegetables processing industry, obtained by juicing, have enormous potential as a source of bioactive compounds, primarily fibers, as well as individual fiber fractions.
Here, apple pomace flour obtained by application of recently disclosed technological procedure developed at the Institute of General and Physical Chemistry (Belgrade, Serbia) was employed to enrich one of confectionery products at industrial scale level in Atlantic Štark doo. The aim of this study was to determine the proximate composition and fiber fractions in standard and enriched product - biscuits. The standard product contained whole and white wheat flour while in enriched one a part of the white wheat flour was replaced with apple pomace flour.
Pectin, a soluble fiber that functions as a prebiotic and anti-lipemic factor, is present in apple pomace flour. Insoluble fiber, such as arabinoxylan that exhibits prebiotic activity and also helps regulate postprandial glycemia and insulin response, is present in wheat flour. The combination of apple pomace flour and whole wheat flour, as raw materials, significantly contributes the fiber content in the enriched product and thereafter improves its nutritional value in compassion to standard product.
Proximate composition was determined by standard AOAC methods, total fiber by enzymatic-gravimetric methods, while resistant starch, pectin and arabinoxylan were determined by spectrometric methods. Standard and enriched biscuits contained 5 g/100g and 8.3 g/100g of total fiber, respectively (increased for 66%). The content of arabinoxylan and resistant starch in standard product was 0.9 g/100g and 1.7 g/100g, while in the enriched one their content was 0.8g/100g and 1.1 g/100g, respectively. Upon apple pomace incorporation into the standard product without pectin its content reached value of 2.2 g/100g. The significant change was noticed in starch content, standard product contained 47.5 g/100g, while in enriched biscuit reduction was 23%.
The application of pomace in confectionery can compensate the lack of fiber and enrich the product with fiber such as pectin, with proven health benefits. Since the lack of fiber in modern diet causes a range of non-communicable diseases (NCD), such as obesity, diabetes, gastrointestinal and heart disease, effectively valorizing and utilizing minimally processed apple pomace, can be beneficial in terms of NCD prevention. The reduction of starch content, accompanied by the reduction of phytic acid which is commonly present in cereal flours, can also have a positive effect on the health.

Keywords: Biscuits, Pomace, Fiber, Pectin, Resistant Starch, Arabinoxylan

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REDUCING FOOD WASTE IN SOCIAL CATERING: A CASE STUDY FROM DOBRI DOM INSTITUTION

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Abstract

Introduction:
Food waste is a significant global issue, particularly in social catering institutions that provide free meals to vulnerable populations. The Institution City of Zagreb DOBRI DOM has implemented a systematic approach to waste reduction, aligning with environmental regulations and sustainable practices. This study examines the progress made in reducing food waste between 2023 and 2024.
Objectives:
The primary goal of this study is to analyse the impact of implemented measures on food waste reduction in DOBRI DOM The study aims to highlight the effectiveness of waste management strategies and their role in promoting sustainable eating habits.
Methods:
A comparative analysis was conducted using data from the Environmental Pollution Register (ROO) and internal records of DOBRI DOM for 2021–2024. The total amount of waste generated, including mixed municipal waste and separately collected waste, was assessed. Additionally, the impact of staff training and awareness campaigns on waste reduction was evaluated.
Results:
The total amount of waste generated in 2024 was 63,289 kg, marking a 12.4% reduction compared to 2023 (72,293 kg). The institution significantly decreased the amount of mixed municipal waste by 14.5%, from 33,400 kg in 2023 to 28,570 kg in 2024. Notably, food waste (bio-waste) was reduced by 22.6%, from 17,639 kg in 2023 to 13,658 kg in 2024. Additionally, the amount of paper and cardboard waste slightly declined from 11,650 kg to 11,100 kg (-4.7%).
On the other hand, the amount of separately collected waste remained high, reaching 34,719 kg in 2024, demonstrating the effectiveness of waste separation efforts. The introduction of a composting facility contributed to this trend, and the share of separately collected waste increased to 54.9%, surpassing both the city of Zagreb's average (42%) and the national average (48%).
Discussion:
The reduction in food waste can be attributed to the institution's proactive initiatives, including enhanced staff engagement, improved waste separation practices, and investments in infrastructure such as recycling facilities. The findings suggest that targeted awareness campaigns and systematic waste management can lead to significant improvements in sustainability within social catering services.
Conclusion:
DOBRI DOM's waste reduction efforts demonstrate that sustainable food management practices can be successfully integrated into social institutions. By continuously improving waste monitoring and staff training, further reductions in food waste can be achieved, contributing to broader environmental and social benefits.

Keywords: Food waste, sustainability, waste reduction, social benefits, social catering

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BIO-BASED TECHNOLOGIES TO SUPPORT AFRICAN FARMERS: KEY FINDINGS FROM A SWOT ANALYSIS

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Abstract

Rising average temperatures caused by climate change threaten food security in water-scarce regions, such as sub-Saharan African countries. Thus, there is a need for innovative technologies that enhance water management and improve agricultural productivity by promoting circular farming systems. Bio-based technologies, such as biochar kilns, solar desalination greenhouses, biogas digesters, multifunctional constructed wetlands, and biorefineries, have the potential to support farmers accordingly. However, these technologies require thorough assessment to fully understand their potential. A comprehensive SWOT analysis was conducted to assess the potential of these bio-based technologies by identifying their key strengths, weaknesses, opportunities, and threats. Semi-structured interviews and a workshop with scientists and experts from Botswana, Ghana, South Africa, and Namibia were held. Based on our findings, we formulated recommendations to support the adoption and implementation of these technologies in their respective contexts.

Keywords: SWOT Analysis, Water Management, Small-Scale Farming, Circular Economy.

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ENZYMATIC EXTRACTION AS A SUSTAINABLE APPROACH FOR SIALIC ACID RECOVERY FROM EDIBLE BIRD'S NEST CO-PRODUCTS

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Abstract

Edible bird's nests (EBN) are one of the most valuable animal-derived products, widely consumed for their nutritional and health benefits. However, a significant amount of co-products is discarded during EBN processing, despite being an abundant source of bioactive compounds such as sialic acid. Traditional extraction methods, like acid hydrolysis, can lead to unwanted degradation, making enzymatic hydrolysis a promising alternative for controlled and efficient sialic acid recovery. In this study, we performed a sequence space analysis using phylogeny and sequence similarity network of known bacterial sialidases and selected Clostridium tarantella as a candidate enzyme source for further study. A synthetic sialidase gene was designed, transformed into E. coli, and expressed under optimized conditions. The recombinant enzyme was purified using immobilized metal affinity chromatography (IMAC) and size exclusion chromatography (SEC). To evaluate its hydrolytic activity, enzymatic hydrolysis experiments were conducted on EBN co-products at various pH values (3-7) and sialidase concentrations (0.01-1 U/mL). High-performance anion-exchange chromatography (HPAEC) was used to quantify the released sialic acid. The highest yield, 0.7 g/L, was observed at pH 5, demonstrating the enzyme's effectiveness under mild conditions. Our results suggest that enzymatic hydrolysis is a viable and sustainable approach for extracting sialic acid from EBN co-products, providing an alternative to acid hydrolysis while minimizing industrial waste. Ongoing work focuses on optimizing reaction conditions, such as temperature and EBN concentration, to further improve efficiency.

Keywords: Edible bird's nest, Enzymatic hydrolysis, Bacterial sialidase, Co-product4, Sialic acid

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VALORIZATION OF BY-PRODUCTS OBTAINED FROM COLD-PRESSED HAZELNUTS IN SWEET SPREADS

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Abstract

The food industry is faced with a new challenge, managing by-products obtained after producing final products. Scientists are looking for ways to valorize these by-products. In that way, not only is sustainability achieved, but also the value of raw materials is enhanced. This study explored alternative substitutions for pure hazelnut paste in sweet spreads. When hazelnuts are cold-pressed, by-products derived from that process are hazelnut press cake and oil sediment, which are used in samples instead of pure hazelnut paste. Sweet spreads were prepared in a ball mill, a device where stainless steel balls collide, which leads to a reduction of particle size. That is the main reason why the texture of sweet spreads is creamy. Due to the presence of fibers, especially in hazelnut press cake, samples with hazelnut by-products have increased particle size, resulting in different rheological properties compared to control samples made with pure hazelnut paste. Furthermore, the color, measured with a chroma meter, also changes as a result of the substitution. Analysis showed that hazelnut by-products do not influence oxidative and colloidal stability. Sweet spreads with hazelnut press cake and sediment have acceptable sensory properties, with minor disadvantages, demonstrating their potential on the market in the future, while supporting food waste reduction and promoting a circular economy.

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Keywords: sweet spreads, cold-pressed hazelnut oil, hazelnut press cake, hazelnut oil sediment

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VALORIZATION OF GRAPE LEAVES AS A PHYTOGENIC ADDITIVE FOR FOOD AND FEED APPLICATIONS

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Abstract

Grapevine leaves are often regarded as agro-industrial waste, despite being rich in bioactive compounds with numerous health benefits. They contain high levels of flavan-3-ols, flavonols such as quercetin, and resveratrol derivatives, making them an affordable source of polyphenols with significant biological activity. Studies have shown that polyphenols in grape leaf extracts exhibit antioxidant, anti-inflammatory, anticancer, and anti-aging properties. Additionally, grape leaves have demonstrated antimicrobial activity against both gram-positive (Staphylococcus aureus, Bacillus cereus) and gram-negative food-borne pathogenic bacteria (Escherichia coli, Salmonella Infantis, Campylobacter jejuni). In addition to polyphenols, grape leaves are a good source of polyunsaturated fatty acids like linoleic and alpha-linolenic acids, carotenoids, tannins, and polysaccharides. These polysaccharides promote beneficial lactic acid bacteria fermentation and can positively influence gut health by reducing intestinal pH, inhibiting pathogen growth, and lowering blood lipids and insulin response.

Grape leaves, with their potent antioxidant and antimicrobial properties, offer significant potential to enhance food quality and safety. Their application in food products can prevent oxidative and microbiological spoilage, thereby improving the sustainability and shelf life of the products. In animal feed, their antibacterial and biofilm-forming abilities may reduce the reliance on antibiotics, in line with increasing regulations on antibiotic use in livestock production. Furthermore, the dietary inclusion of grape leaves as feed additives can mitigate oxidative stress in animals, promoting better health outcomes.

Beyond food and feed, the phytonutrients from grape leaves may serve as a valuable source of novel compounds, with promising applications in other industries such as pharmaceuticals and cosmetics. However, the bioavailability of these nutrients can be low due to structural inaccessibility, and grape leaves may contain anti-nutritional factors that hinder nutrient utilization. To address these challenges, enzymatic treatment or bacterial fermentation of grape leaves could enhance the bioavailability of their beneficial compounds, improving their digestibility and amplifying their antioxidant and antimicrobial effects. With appropriate processing, grape leaves can be transformed from a byproduct into a valuable, health-enhancing resource, benefiting applications in food, animal nutrition, and beyond.

Keywords: Agro-industrial waste valorization, Phytonutrients, Polyphenols, Antioxidant properties, Health benefits

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OPTIMIZING POLYHYDROXYALKANOATE (PHA) PRODUCTION FROM GLUCOSE BY CUPRIAVIDUS NECATOR

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Abstract

Polyhydroxyalkanoates (PHAs) are biodegradable and biocompatible biopolymers synthesized by microorganisms as intracellular energy reserves under nutrient-limiting conditions. PHA biosynthesis is highly dependent on bacterial nutrition, with the availability of a suitable carbon source and the limitation of essential nutrients (e.g., ammonium) playing a crucial role in promoting intracellular polymer accumulation. Among various fermentation strategies, submerged fermentation (SmF) is widely utilized for PHA production, with glucose being one of the most preferred carbon sources due to its affordability, rapid uptake, and efficient microbial metabolism. Several bacterial genera, including Bacillus, Pseudomonas, and Cupriavidus, have been extensively investigated for PHA biosynthesis, either in pure cultures or co-culture systems. Optimizing fermentation parameters and microbial selection remains essential for improving PHA yields while minimizing production costs.

In this study, the optimization of submerged fermentation conditions for PHA production was performed using glucose as the primary carbon source and Cupriavidus necator as the bacterial strain. A full factorial experimental design was employed, incorporating three factors at three levels: glucose concentration (10, 25, and 50 g L^{-1}), initial optical density (OD) of the bacterial suspension (1, 2.5, and 5), and the carbon-to-nitrogen (C/N) ratio (20:1, 40:1, and 60:1). The fermentation was conducted over three days, during which OD and reducing sugar concentration were monitored daily. Additionally, pH, electrical conductivity, dissolved oxygen concentration, colony-forming units (CFU), and mixed liquor suspended solids (MLSS) were determined at the beginning and end of the experiment. PHA extraction was performed using a 4% sodium hypochlorite solution and chloroform, while the extracted polymers were characterized using Fourier-transform infrared (FTIR-ATR) spectroscopy, thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC). The optimal conditions for PHA production were determined to be a glucose concentration of 50 g L^{-1}, an optical density of 5, and a C/N ratio of 40:1. Under these conditions, a maximum PHA accumulation of 73.43% was achieved.

This research was conducted as part of the project „Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products" (NPOO.C3.2.R3-Il .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).

Keywords: polyhydroxyalkanoates, submerged fermentation, glucose, optimization

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VALORIZATION OF ACID WHEY BYPRODUCT IN PRODUCTION OF FUNCTIONAL VEGETABLE JUICE

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Abstract

Acid whey is the major byproduct left after yoghurt and cheese manufacturing. Rich nutrient composition with proteins, minerals and vitamins render it a valuable food ingredient. However, handling and processing of acid whey are difficult due to its high acidity. In this study, vegetable juices were developed by using acid whey and tomato juice forming the main fluid base, red beet and celery stalk as vegetable ingredients, and parsley, cress and citric acid as flavoring ingredients. Three vegetable juice formulations were developed where two samples contained acid whey (80-50, wt%), tomato juice (10-25%) and vegetable ingredients (10-25%) at different ratios and one sample contained only acid whey and tomato juice (50:50%). Vegetables were pasteurized and homogenized to a puree. All the ingredients were blended with a high shear blender to obtain a homogeneous mixture. Composition, serum separation, rheological properties, color values, sensory properties, total phenolic content, antioxidant activity and α-amylase inhibitory activity of the three juice samples were measured to determine the best formulation. Samples contained 5-6% dry matter, 0.5-0.6% minerals and had a pH around 3.5. Serum separation in the samples was dependent on the amount of acid whey. Samples exhibited pseudoplastic flow behavior and the sample with 50% acid whey had the highest viscosity. The sample with high amount of red beet had the highest a* value while the sample with the acid whey and tomato juice had the highest L* and b* values. In sensory analysis, the sample with 50% acid whey found to have the highest consistency, particle size and color. The sample with 80% acid whey with lesser vegetable ingredients was the most preferred one by the panelists. All the samples contained significant amounts of phenolic compounds and antioxidant activity where the sample with 50% acid whey and vegetable ingredients showed the highest values. While all the samples almost completely inhibited α -amylase, the sample with 50% acid whey and 50% tomato juice had the highest inhibitory activity. The use of combination of acid whey and vegetables not only created a functional vegetable juice but also allowed valorization of acid whey in the context of sustainable food production systems.

This study was financially supported by the Scientific and Technological Research Council of Türkiye (TUBITAK) under Grant Number 1919B012333905.

Keywords: Acid whey, vegetable juice, amylase inhibition, valorization, sustainability

DEVELOPMENT AND CHARACTERIZATION OF BIODEGRADABLE BLENDS FOR SUSTAINABLE FOOD PACKAGING

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Abstract

The increasing demand for sustainable food packaging has led to a growing interest in biodegradable polymer blends. Thermoplastic starch (TPS), which is derived from natural starch sources and plasticized with glycerol, is widely known for its renewability, compostability and cost efficiency. However, its high hydrophilicity and poor mechanical properties limit its independent use. Poly(lactic acid) (PLA), on the other hand, is a bio-based and compostable polymer with excellent mechanical strength and processability, but suffers from brittleness and slow degradation. Blending TPS with PLA is a promising approach to achieve a balance between flexibility, mechanical strength and biodegradability, making these materials suitable for food packaging.

In this study, TPS was produced from potato starch obtained from the Scala variety grown in the Osijek-Baranja region, plasticized with glycerol, and modified with citric acid (CA) to enhance its compatibility with PLA. The TPS/PLA blends were prepared by melt blending, and their thermal, mechanical and barrier properties were systematically evaluated. The melt flow index (MFI) was also measured to assess viscosity and processability, while biodegradability tests were conducted to determine the environmental impact. Thermal analysis revealed that citric acid acted as a compatibilizer, with lower concentrations of CA improving crystallinity and thermal stability, while higher concentrations caused softening and reduced crystallinity due to increased polymer chain mobility and potential incompatibility. Mechanical testing showed that CA improved interfacial adhesion between TPS and PLA and increased tensile properties compared to unmodified blends. Analysis of barrier properties (water vapor permeability) showed that TPS increased permeability; however, CA-modified TPS showed improved barrier performance due to crosslinking effects. MFI measurements confirmed a reduction in viscosity for CA-modified blends, indicating better processability. Biodegradability evaluations in soil environments showed accelerated degradation of TPS-rich formulations, making them particularly suitable for short-term food packaging. These results underline the potential of CA-modified TPS/PLA blends as an environmentally friendly alternative for sustainable food packaging, offering a promising combination of processability, mechanical strength and biodegradability.

This research was conducted as part of the project „Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products" (NPOO.C3.2.R3-Il .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).

Keywords: Thermoplastic starch, Poly(lactic acid), Citric acid

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HARNESSING THE BY-PRODUCT OF INSECT REARING IN PEPPER CULTIVATION

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Abstract

Insect farming, i.e., the production of insects for food and feed applications, has gained considerable scientific and business interest during the last decade. Insect frass is the by-product of this process, which has positive effects on soil fertility, plant growth and health. The exploitation and valorization of this organic residual side-stream in agriculture improves the sustainability of food production according to the principles of the circular economy. Within the ADVAGROMED project, frass from larvae of the yellow mealworm, Tenebrio molitor, has been evaluated in a pot experiment for the cultivation of a Greek variety of pepper (Bachovitiki). Two rates of frass were tested (0.5 and 1% w/v) and were compared to two rates of poultry manure (2.5 and 5% w/v), which is a common organic fertilizer, and two controls (positive one: conventional inorganic fertilizers; negative one: no amendments). The plants were grown in two soil types, a medium-textured and a sandy soil. This presentation will focus on the effects of treatments and soils on fruit quality, together with an assessment of productivity responses. The 1% frass improved crop productivity on both soils compared to all other treatments. However, the degree of improvement was greater on the unfavourable sandy soil, not only compensating for its low fertility, but also resulting in yields comparable to those on medium textured soils. Minimal effects on fruit quality parameters were observed. The results of this study showed that insect frass supplementation can overcome the inherently low fertility of sandy soils, resulting in increased productivity and high-quality peppers.

This research is supported by the EU-PRIMA program project ADVAGROMED (Prima 2021 – Section 2).

Keywords: insect frass, fruit pH, color, flesh hardness, total sugars

TRENDS AND OPPORTUNITIES OF SHELLS WASTE VALORISATION

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Abstract

The disposal of mollusc and crustacean shells presents a significant environmental challenge, particularly in regions with high seafood consumption and aquaculture activities. These shells, primarily composed of calcium carbonate (CaCO3) and chitin, hold substantial industrial and environmental potential. However, most of this shell waste remains underutilized, often ending up in landfills or being discarded in marine environments, contributing to their pollution.

This study highlights the need for innovative, multidisciplinary approaches to unlock the full potential of shell waste within circular economy models. By implementing waste valorisation practices across various industrial sectors, significant strides can be made towards achieving sustainable resource management, zero-waste goals, and minimizing environmental impact.

The valorisation of shell waste and its potential application is crucial for alleviating the burden of waste disposal. Several key sectors can benefit from the diverse applications of shell-derived materials. These include environmentally friendly applications such as water purification, bio-filtration, heavy metal adsorption, soil amendment, acid mine drainage (AMD) treatment, and ocean deacidification. Additionally, shells can be utilized in the production of food and feed additives, providing valuable sources of calcium and protein. Shell-derived bioactive molecules, including antioxidants, antimicrobials, and compounds with potential benefits for cholesterol and blood pressure reduction, also lead to potential application in pharmacology and medicine. Biopolymers derived from waste shells can be used to produce eco-friendly bioplastics, bioceramics, and biocomposites, for industrial and household applications. Moreover, the shells can be integrated into biomedical biomaterials for bone tissue regeneration and wound-dressing materials.

This research emphasizes the importance of advancing shell waste valorisation within circular economy frameworks. By unlocking the diverse applications of shell-derived materials, it is possible to reduce environmental pollution, support sustainable practices, and contribute to the development of innovative, eco-friendly solutions. Further research and cross-industry collaboration are essential to realize the full potential of shell waste, ultimately promoting a zero-waste future.

Acknowledgements: This research was supported by the Science Fund of Republic Serbia, #GRANT No. 7417. "Reducing the negative impact of invasive crayfish Faxonius limosus in the Danube by smart exploitation of their meat and shells" DANUBEcare.

Keywords: Shell waste, circular economy, chitin, calcium carbonate, sustainable materials, invasive species utilization, zero waste

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STRUCTURAL AND TEXTURAL MODIFICATIONS OF PEACHES DURING STORAGE

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Abstract

Extending peach shelf life is a strategic approach to reduce fruit losses and promote circular economy principles in the agri-food sector. Through innovative storage and processing methods, the sensory and physical characteristics of fruits change at a slower rate, preserving longer theirinitial quality. As peaches ripen and age, their physical properties change due to physiological processes and external storage conditions, such as temperature, relative humidity, and atmosphere composition. Cold storage delays ripening but may cause chilling injury (CI), which may lead to detrimental loss of taste, delayed ripening, increased deterioration, and even sensory rejection. Therefore, developing effective nondestructive tools for monitoring the structural and morphological changes of fruits during storage is essential. This research aims to analyze and monitor the morphological characteristics changes of peaches under different storage conditions through the correlation of physicochemical properties, such as total soluble solids, acidity, color parameters, and mechanical properties, both instrumental and sensorial, with morphological and structural parameters derived from image analysis. Peaches were stored at different temperatures (1 & 20°C) and measurements were performed at 5 time points during a 35 days storage. Findings showed that firmness decreased rapidly in peaches stored at ambient temperature, with a sharp reduction by the third day, from 16.83 to 2.59 N, respectively. In contrast, firmness declined gradually under refrigeration, maintaining significantly higher values than those stored at 20°C, from 16.83 to 6.32 N, respectively. Gumminess was higher in refrigerated fruits, and chewiness was reduced after 28 days at 1°C, reaching levels of peaches stored at 20°C. Mechanical properties, assessed through a texture analyzer, were strongly correlated with sensory attributes. The most notable correlation was between maximum force and firmness (R^2=0.9115). Storage conditions affected sensory perception with moisture loss and softening being more pronounced under ambient storage, while crispness was better preserved under refrigeration. Fruit morphological characteristics were assessed using image analysis software (Image-Pro Plus 7). These results correlated with sensory and objective data, providing promising insights for predicting storage behaviors through nondestructive image processing techniques. Overall, this research determined the optimal storage duration for peaches at ambient and refrigerated temperatures, enabling the prediction of physical and morphological changes through sensory evaluation and image analysis. Refrigerated storage is recommended for extending shelf life and preserving firmness, while ambient conditions may be preferred for faster ripening and enhanced sweetness. The results pave the way for advanced image-based quality assessment tools to optimize storage practices, reduce waste, and prioritize fruit consumption.

Keywords: image analysis, peach, structure, sensory evaluation, texture

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INFLUENCE OF SIMULATED GASTROINTESTINAL DIGESTION ON THE PHENOLIC COMPOSITION AND ANTIOXIDANT PROPERTIES OF OLIVE MILL BY-PRODUCTS

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Abstract

Olive oil production generates significant by-products, such as alperujo (solid olive mill by-product) and wastewaters, which are rich in bioactive compounds, including phenolics. These compounds exhibit antioxidant and neuroprotective effects, making them promising functional ingredients. However, their bioavailability and bioactivity may be influenced by digestion. This study evaluates the effect of in vitro gastrointestinal digestion (INFOGEST model) on the composition (phenolic compounds, amino acids, and organic acids) and bioactivity of extracts from alperujo and wastewaters obtained from olives at two ripening stages. Phenolic extracts were obtained from alperujo and wastewaters of early- and late-harvested olives through ethanolic maceration and liquid-liquid extraction with ethyl acetate. Extracts were subjected to in vitro digestion following the INFOGEST protocol. Post-digestion composition was analyzed using UHPLC-MS for phenolics, amino acids, and organic acids. Antioxidant activity was assessed using DPPH and FRAP assays. Pearson's correlation and regression models were applied to examine relationships between composition and bioactivity. In vitro digestion significantly altered the phenolic profile, reducing hydroxytyrosol and caffeic acid content while increasing phenolic degradation products. Amino acids and organic acids showed differential stability, with glutamic and citric acids persisting through digestion. Antioxidant capacity (DPPH and FRAP) decreased post-digestion but correlated positively with residual phenolic content ($r > 0.85$, $p < 0.05$). Early-harvest extracts retained higher bioactivity than late-harvest samples ($p < 0.05$). Simulated digestion modifies phenolic composition, affecting bioavailability and antioxidant activity. Despite losses, phenolic compounds from olive by-products retain functional potential, particularly in early-harvest samples, supporting their use as bioactive ingredients.

Keywords: Phenolic compounds, Olive by-products, Antioxidant activity, in vitro digestion, valorization.

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ENHANCING BIOACTIVE COMPOUNDS RECOVERY FROM TOMATO PROCESSING WASTE: PRETREATMENT STRATEGIES FOR SUSTAINABLE VALORISATION

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Abstract

Tomato processing waste (TPW) is gaining recognition for its potential as a valuable secondary raw material due to high content of various bioactive compounds (BC), including carotenoids and polyphenols. Even though the recovery of BC from plant material is highly dependent on the conditions of raw material pretreatment, the data is scarce. Therefore, the aim of this work was to investigate the impact of different drying and milling conditions on the content of phenolic compounds, β-carotene, lycopene and Maillard reaction products (MRP). Namely, drying significantly reduces the weight, volume, and water activity of the raw material and, depending on the temperature and duration, it can significantly influence the content of thermolabile compounds. Milling can contribute to degradation and loss of BC due to heat, light, and oxygen exposure during milling, while the degree of mechanical degradation of sample influences their extractability. TPW was obtained from thermally processed tomatoes (95°C, 90 min). Prior to extraction of BC, TPW samples were homogenized and dried in a thermostat (at 70°C and 50°C); in a vacuum dryer and by freeze-drying. The grinding was performed 0−40 seconds, resulting in samples with varying particle size ranges. Particle size analysis was performed using laser light diffraction. The content of β-carotene and lycopene was determined by HPLC-DAD; total antioxidants spectrophotometrically; MRP were determined spectrofluorometrically and the content of particular polyphenolic compounds was determined by HPLC-MS-MS. The obtained results showed that TPW contained up to 230.2 ± 17.7 mg of Gallic acid equivalents/100g and 77.6 ± 5.9 mg of Trolox equivalents/100g, which estimate the content of polyphenols. In the case of carotenoids, TPW contained more lycopene (up to 164.8 ± 3.5 mg/100g) compared to β-carotene (up to 14.1 ± 0.2 mg/100g). The yields were significantly influenced by the drying method – the highest carotenoid yields were obtained from vacuum-dried sample and the highest polyphenol yields were obtained by drying in a thermostat at 70°C and freeze-drying. Formation of MRP was negligible regardless of the drying technique applied. The grinding showed less pronounced impact on the extractability of BC – the highest yields were obtained from fractions with 90% of particles smaller than 1000 µm (obtained by 18 sec milling). Obtained results underscore the importance of optimizing pretreatment conditions to maximize the recovery of BC from TPW, contributing to the efforts to promote its sustainable valorisation in various industries.

Keywords: tomato processing waste, pretreatment, bioactive compounds, polyphenols, carotenoids

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THE POSSIBILITY OF BREWERS' SPENT GRAIN FERMENTATION USING *SACCHAROMYCES CEREVISIAE*

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Abstract

The brewing industry is one of the traditional industries with significant economic value in the agri-food sector. In addition to being a highly water-intensive industrial facility, breweries generate large amounts of by-products during beer production. Brewers' spent grain (BSG) is the most abundant by-product of the brewing industry that is currently discarded or used as animal feed. However, to increase the sustainability of brewing, biotechnological utilization of BSG is a much-preferred solution. The aim of this research was to examine the fermentative ability of *Saccharomyces cerevisiae* on BSG composed of old wheat bread and barley malt. The selected yeast strain was tested on hydrolysed (BSG treated with commercial preparations of cellulolytic and hemicellulolytic hydrolases) and non-hydrolysed (untreated BSG) substrate. Fermentation on both substrates was performed at 30°C for 24 h under anaerobic conditions. To evaluate the bioprocess success, the yeast cell number, reducing sugar content, pH value, and total titratable acidity of the fermented media were determined, as they provide a comprehensive assessment of microbial activity, metabolic dynamics, and fermentation progress. The experimental data suggest that both fermented media were acidic (pH value of about 5) and had similar numbers of *S. cerevisiae* cells (about 8 $\log_{10}$ CFU/g). However, the values of other parameters analysed after fermentation were higher in the medium based on hydrolysed BSG compared to the medium prepared with non-hydrolysed BSG. Specifically, the reducing sugar content was about 40% higher, while the total titratable acidity was about 10% higher. The obtained results represent a reliable basis for further research aimed at improving the BSG fermentation using *S. cerevisiae*.

Keywords: Bakery Leftovers, Brewer's spent grain, Fermentation, Conventional yeast, Brewing Sustainability

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VALORIZATION OF ACID WHEY IN SINGLE CELL PROTEIN PRODUCTION

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Abstract

Whey has attracted attention in recent years due to the decline in food resources and its negative impact on the environment. Whey is a source of nutritionally and technologically valuable compounds that have not been efficiently exploited, in particular lactose. Lactose can be converted into new products useful for human/animal nutrition. The study focuses on the use of yeasts – Kluyveromyces marxianus DSM 5422, Cyberlindnera jadinii DSM 2361 (DSMZ, Germany) – for single cell protein production using acid whey as a substrate. Acid whey (produced by local producer Tukuma piens, Latvia) was used for the current study. The composition of whey was determined using MilkoScanTM Mars (Foss, Denmark). Acid whey was fermented with Kluyveromyces marxianus DSM 5422 at 30 °C on adjusted pH 6.5 using batch mode fermentation, and with Cyberlindnera jadinii DSM 2361 at 30 °C on adjusted pH 6.0-6.5 in bottle mode fermentation. Fermentation patterns (growth rate, oxygen supply, aeration rate, pH control) and biomass yield and protein content in it were studied. Protein content was determined by the Kjeldhal method. Kluyveromyces marxianus DSM 5422 was able to produce up to 5 g/L dry cell weight and achieved protein content in the biomass was 44%. Cyberlindnera jadinii DSM 2361 achieved 7 g/L dry cell weight and 40% protein content in the biomass. The study showed that the challenge for efficient whey valorization is the selection of microbial strains that can metabolize lactose and bioconvert it into single cell protein, that continuous fermentation process with cell recycling could be applied for single cell protein production. Mixed cultures appear to be a promising approach that could lead to higher dry cell weights.

This study was funded by the State Research Programme VPP-ZM-VRIIILA-2024/1-0002 project Scientifically Grounded Solutions for a Sustainable Food System to Achieve the Goals of the European Green Deal (GreenAgroRes) (GreenAgroRes).

Keywords: valorization, whey, single cell protein, fermentation

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BIOGAS PRODUCTION FROM OLIVE POMACE: A SUSTAINABLE APPROACH

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Abstract

Olive pomace (OP) is the main solid byproduct from the production of virgin olive oil. It is considered highly phytotoxic to the environment due to its high content of polyphenols. Conversely, these compounds are of significant interest for various sectors, including agriculture, cosmetics, and food. Consequently, their extraction is advantageous using unconventional technologies, in order to reduce the environmental impact of OP. Moreover, the OP extraction residue (OPER) is still rich in compounds useful for biogas production through anaerobic digestion.

The production of a polyphenol-rich extract from OP was performed using a high-pressure temperature extractor (HPTE). The extraction process involved the use of a 1:1 (v/v) ethanol/water solution using a solid/liquid ratio of 1:10 (w/v), operating at 180 °C for 90 minutes, under an inert atmosphere, to preserve the extracted polyphenols. The obtained extract was characterized in terms of total polyphenol content (TPC) and antiradical power (ARP) using the Folin-Ciocalteu colorimetric assay and the ABTS assay, respectively. OP and OPER were dried and submitted to physicochemical characterization, including Fourier-transform infrared spectroscopy (FTIR) and thermogravimetric analysis (TGA). Anaerobic sludge mixed with OP and OPER was subjected to anaerobic digestion for 42 days using an AMPTS II system.

HPTE extraction allowed producing a polyphenol-rich extract with high ARP (15.1 mgTE/mL) and TPC of 6.3 mgCAE/mL.

Regarding biogas production, the results indicated that similar methane yields were obtained using OPER and OP, namely 101.9 and 134.2 mLCH4/gVS added, respectively. This resulted in biomass biodegradability of 29.5% for OPER and 41.1% for OP, respectively.

In conclusion, HPTE extraction allowed the production of a polyphenol-rich extract with higher yields than other unconventional techniques. Overall, these findings suggest that OP, after polyphenol recovery, can still be used as feedstock for the anaerobic digestion process, leading to significant methane production, which is essential for the desired reduction of greenhouse gas emissions and effective waste management of agricultural waste.

Keywords: Agrofood waste reuse, Unconventional extraction, Biogas production, Anaerobic digestion

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GRAPEVINE LEAVES (*VITIS VINIFERA L.*): A VALUABLE BY-PRODUCT FOR THE REALIZATION OF FUNCTIONAL FOODS

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Abstract

The global wine industry has been constantly growing over the last decades. However, the wine industry results in significant amounts of by-products, which have negative consequences for the environment. Grapes and their by-products have nutritional and functional characteristics, due to the presence of bioactive compounds with beneficial effects on human health, due to their anti-cancerogenic, anti-inflammatory, immunomodulatory, and antioxidant properties [1,2]. Leaves from Vitis vinifera L. represent the less studied and valorised wastes of grape crops and the winery industry. This study aims at investigating the main bioactive compounds in the leaves from two of the most representative grapevine cultivars of Campania region in Italy. The main studied phytochemicals were carotenoids, tocols, polyphenols, together with the antioxidant activity. Moreover, the evolution of the investigated bioactive compounds during the harvesting time, from June to November, was also studied, showing that the content of phytochemicals varies, according to the development stage of grape leaves. The final goal of the study will be the application of the investigated grapevines leaves as functional food ingredients for the realization of innovative products, such as foods and beverages, with health and nutritional benefits and environmentally friendly

Keywords: Grapevine leaves, by-products, bioactive compounds, functional foods

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FOOD INDUSTRY BY-PRODUCTS AS NATURAL AGENTS FOR AFLATOXIN CONTROL: A SUSTAINABLE APPROACH

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Abstract

Fungi and their metabolites, mycotoxins, can contaminate food and feed, leading to long-term global issues and increased exposure to their harmful effects in both humans and animals. Aflatoxins, particularly aflatoxin B1 (AFB1), a Group 1 carcinogen, are among the most prevalent mycotoxins found in food and feed. Various antifungal and detoxification strategies have been developed to mitigate risks to human and animal health and reduce the economic losses caused by aflatoxin contamination in agri-food commodities. Growing awareness of environmental protection and food safety has led to the adoption of eco-friendly approaches for controlling fungi and mycotoxins in food production. A key method for preventing aflatoxins in food involves inactivating A. flavus and inhibiting its growth. By-products from fruit and vegetable processing, such as seeds, pulp, and peel, are rich in bioactive phytochemicals that demonstrate significant antifungal activity. Polyphenol compounds, extracted with food-grade solvents, possess antifungal properties, making them potential natural agents for a variety of industrial applications. Furthermore, the by-products remaining after phenolic compounds extraction can effectively adsorb mycotoxins. The effectiveness of agri-food by-products as low-cost biosorbents for mycotoxin decontamination has been proven, particularly for removing aflatoxins. Biological strategies to controlling fungal growth and aflatoxin contamination seem promising to reduce food loss and prevent human disease. The valorization and reutilization of food and agricultural waste streams provide significant environmental, health, and economic benefits. This integrated approach offers a sustainable solution for reducing waste and promoting circular economies.

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Keywords: Food industry by-products, Antifungal activity, Aflatoxins, Detoxification strategies

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PHYSICOCHEMICAL, FUNCTIONAL AND STRUCTURAL CHARACTERISTICS OF MUSHROOM (PLEUROTUS OSTREATUS) BY PRODUCT POWDERS DEVELOPED WITH DIFFERENT DRYING METHODS

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Abstract

Over the years, mushroom production and consumption have gained popularity due to their high nutritional value. However, this industry generates large amounts of byproducts that require utilization to support a circular economy and enhance the economic and environmental benefits of mushroom cultivation. Mushroom stems, in particular, have a short post-harvest lifespan due to their high water activity (aw), making their novel valorization into stable, functional powders essential. In this study, a comparison of the physicochemical, functional and structural characteristics between freeze- and air-dried (40°C, 55°C, and 70°C) Pleurotus ostreatus stem powder was conducted. The air-drying kinetics were modeled using a modification of Page model, incorporating process temperature in rate constant. The properties included water content (w.b.), aw, water and oil absorption indices (WAI, OAI), water solubility index (WSI), color parameters - L*, a*, b*, color difference (ΔE), Browning Index (BI), and total phenolic content. Moreover, the microstructure of the powder granules was observed using scanning electron microscopy and stereoscopy. As the drying temperature is increased, the air drying constant also increases. The freeze-dried powder exhibited statistically significant differences ($p < 0.05$) in almost all parameters compared to the air-dried samples, except for WSI, which remained similar to that of the 55°C air-dried powder. Additionally, the freeze-dried sample exhibited a highly porous, flaky microstructure, whereas air-dried powders had a more compact, lamellar surface. Overall, freeze-drying preserves superior quality characteristics. However, air-drying remains a viable option depending on the intended application of the powder.

Keywords: air drying kinetics, freeze drying, mushroom by product, scanning electron microscopy, structure

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NUTRITIONAL COMPOSITION OF THE EDIBLE INSECT HERMETIA ILLUCENS USED AS BIOCONVERSOR OF OLIVE OIL BY-PRODUCTS

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Abstract

Edible insects, as the larvae of Hermetia illucens, not only represent a sustainable source of protein, but also offer an interesting potential as bioconversors of organic wastes. Concerning agrifood by-products, a huge number of sources remains unexplored for insect feeding. As example, those derived from the olive oil industry, such as the problematic olive leaves or olive pomace, represent an interesting opportunity to be tested in insect feeding. However, the feeding of insects can directly influence their nutritional composition. This research evaluates the impact of different diets formulated with by-products from olive oil processing on the composition and nutritional quality of H. illucens larvae. Dry olive leaves at 15%, 30% and 50% (OL15, OL30, OL50) and dry full-fat olive pomace at 30%, 50%, 70% and 90% (OP30, OP50, OP70, OP90) were used as partial replacement of conventional feed. The larvae were processed by blanching, oven drying and defatting with supercritical CO_2 to obtain the meal. The proximate composition of both fresh larvae and defatted meals was evaluated. In addition, the digestibility and amino acid profile of the meals were analysed. Edible insects, as the larvae of Hermetia illucens, not only represent a sustainable source of protein, but also offer an interesting potential as bioconversors of organic wastes. Concerning agrifood by-products, a huge number of sources remains unexplored for insect feeding. As example, those derived from the olive oil industry, such as the problematic olive leaves or olive pomace, represent an interesting opportunity to be tested in insect feeding. However, the feeding of insects can directly influence their nutritional composition. This research evaluates the impact of different diets formulated with by-products from olive oil processing on the composition and nutritional quality of H. illucens larvae. Dry olive leaves at 15%, 30% and 50% (OL15, OL30, OL50) and dry full-fat olive pomace at 30%, 50%, 70% and 90% (OP30, OP50, OP70, OP90) were used as partial replacement of conventional feed. The larvae were processed by blanching, oven drying and defatting with supercritical CO_2 to obtain the meal. The proximate composition of both fresh larvae and defatted meals was evaluated. In addition, the digestibility and amino acid profile of the meals were analysed. In general, olive oil by-products reduced protein and ash in larvae, but increased lipids and chitin. Most changes showed a dose-dependent relationship with the inclusion of olive leaves and olive pomace in the diet. Nevertheless, regarding the amino acid profile, the OP50 diet stood out for having a slight higher total amino acid content compared to the control (48 g/100 g vs. 44 g/100 g), as well as a slight higher content of essential amino acids (28 g/100 g vs. 25 g/100 g). In terms of digestibility, no significant differences were found in the degree of gastrointestinal hydrolysis between the means, and protein digestibility was between 60-70%, with no negative effects from the diets. Therefore, in general, these results suggest a potential use of olive oil by-products in H. illucens feeding without

extremely compromising the nutritional quality of the insect meals, although levels up to 15% of OL and 50% of OP would be preferred to keep a macronutritent composition closer to conventional meals. These findings highlight the impact of diet composition on insect nutrition, demonstrating that tailored feeding strategies can modulate their nutritional value while maintaining sustainability a factor of particular importance to the this emerging industry based on circular economy.

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Keywords: edible insects, black soldier fly, nutritional quality, agri-food by-products, functional ingredients

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IMPROVEMENT OF THE FATTY ACID PROFILE OF EDIBLE INSECTS BY FEEDING WITH OLIVE OIL BY-PRODUCTS

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Abstract

The interest in insects as a food source has grown exponentially due to their potential as a sustainable protein alternative. However, beyond their protein content, the lipid fraction derived from insect processing represents a high-value co-product that deserves greater attention, as the species Hermetia illucens or Tenebrio molitor. At the same time, these species also stand out for their ability to act as bioconverters of agri-food waste, transforming by-products into high-value-added compounds. This approach not only optimizes resource utilization but also contributes to the circular economy and waste reduction. In this sense, olive industry by-products, such as olive leaves (OL) and olive pomace (OP), pose an environmental challenge in Mediterranean countries due to their high generation and limited reuse. Therefore, their use in insect feeding may be an interesting way for valorisation. However, the insect feeding may impact on the subsequent composition of the insects, including the lipid fraction.

In this study, larvae of H. illucens and T. molitor were reared on wheat bran-based control diets and experimental diets partially replaced with OL at 15%, 30%, and 50% or OP at 30%, 50%, 70%, and 90%. The objective was to assess how dietary modifications influenced the fatty acid profile of the lipid fraction in both species.

Results showed that diets containing OP significantly increased monounsaturated fatty acids (MUFA), primarily oleic acid, which is the major fatty acid present in olive-derived by-products. This increase followed a progressive trend, with higher inclusion levels of OP. Additionally, the polyunsaturated to saturated fatty acid (PUFA/SFA) ratio, an important indicator of lipid quality, improved compared to the control in H. illucens when reared on OP-based diets and OL at 50%. In contrast, in T. molitor, the PUFA/SFA ratio was more favourable with OL-based diets. Furthermore, key lipid health indices, including the atherogenic index, thrombogenic index, and the hypocholesterolemic/hypercholesterolemic ratio, were estimated. These indices improved in both species, especially when fed OP-based diets, with a consistent positive correlation to the inclusion level.

Thus, this study demonstrates that dietary modifications can effectively enhance the nutritional quality of the insect lipid fraction, supporting simultaneously a more sustainable insect farming practices within a circular economy framework.

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Keywords: edible insects, bioconversion, fatty acid profile, lipid compounds, olive oil by-products

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FIBRE-RICH INGREDIENTS OBTAINED AFTER RAPESEED PROTEIN ISOLATE PRODUCTION VIA ALKALI AND DES EXTRACTION

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Abstract

Rapeseed is primarily grown for oil production, but its high-protein cake is also suitable for protein isolate production. The conventional method for protein extraction involves alkaline extraction followed by acid precipitation. However, deep eutectic solvents (DESs) are emerging as promising alternatives. After protein isolate production, residual by-products are generated, and to align with circular economy principles, valorizing these fibre-rich by-products is essential.

Fibre-rich ingredients obtained from cold-pressed rapeseed meal after protein isolate production were compared using three extraction systems: 1) alkali extraction at pH 12 with ethanol (84%) pretreatment, 2) DES extraction with choline chloride:urea (ChCl:urea), and 3) betaine:citric acid. The ingredients were analyzed for their chemical profile, mineral content, amino acid profile, antinutrient content, and colour.

In all the ingredients, dietary fibers dominated (46.9 ± 2.36%–63.0 ± 1.44%), but they still contained a significant amount of proteins (22.5 ± 0.24%–35.5 ± 0.66%). The ingredients were rich in minerals, especially potassium, magnesium, zinc, manganese, and iron. Choline chloride:urea extraction resulted in the highest lysine and methionine content compared to the other ingredients, with methionine being present only in DES-based ingredients.

Glucosinolates were not detected in any of the ingredients. Alkali extraction was the most effective at minimizing total phenolic content (0.01 ± 0.0003 g GAE/100 g) and tannins due to the pretreatment for polyphenol removal. DES extraction resulted in fibre-rich ingredients containing 0.13 ± 0.04 g GAE/100 g (ChCl:urea) and 0.14 ± 0.04 g GAE/100 g (betaine:citric acid). The lowest phytic acid content was achieved with betaine:citric acid extraction (1.05 ± 0.06 mg/100 g), while ChCl:urea resulted in the highest phytic acid content (2.24 ± 0.07 mg/100 g).

Both DESs outperformed alkali extraction in terms of ingredient colour parameters. The L^* value of the alkali extraction-based ingredient was 44.1 ± 0.02, compared to 51.1 ± 0.05 for ChCl:urea-based ingredient and 56.9 ± 0.08 for betaine:citric acid-based ingredient.

These results suggest that further investigation into DES systems for rapeseed protein isolate production is warranted, considering not only the proteins but also the valorization of fibre-rich by-products, which seem to be potential ingredients for food-grade systems.

Acknowledgments

This research was supported by the Science Fund of the Republic of Serbia, grant no. 6673, PROTein from Rapeseed Oil Processing Waste: Application in Food and Wastewater Treatment – PROTOPOWER and the Ministry of Science, Technological Development and Innovation, Republic of Serbia (Contract No. 451-03-136/2025-03/200222).

Keywords: rapeseed protein isolate, fibre-rich ingredients, alkali extraction, DESs, characterisation

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IN VIVO AND IN VITRO EVALUATION OF THE ANTIOXIDANT AND PROTECTIVE POTENTIAL OF AN AQUEOUS EXTRACT OF ORANGE SWEET POTATO PEELS OBTAINED BY PULSED ELECTRIC FIELDS AND PRESSURIZED LIQUID EXTRACTION

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Abstract

The food industry generates large volumes of waste, such as peels and seeds, which contain high levels of bioactive compounds, including tannins and polyphenols, in many cases exceeding their concentration in the pulp. Among these, sweet potato (Ipomoea batatas L.) is a tuber widely consumed in developing countries, generating up to 6% of its weight in peel waste during its processing into snacks, flours and flakes. These wastes represent an opportunity for revalorization due to their content of phenolic compounds and minerals. This study compared orange sweet potato peel extracts obtained by non-thermal technologies, pulsed electric fields assisted extraction (PEF), Pressurized liquid assisted extraction (PLE) and maceration (M). The total phenolic compounds (TPC) content was determined by Folin-Ciocalteau and the antioxidant capacity by ABTS in vitro studies. Additionally, the in vivo antioxidant response was evaluated in Saccharomyces cerevisiae, a model organism in oxidative stress studies, using different extract concentrations (0.1-20 mg/mL) in a multiwell plate. The results showed that the extract obtained by PLE presented the highest concentration of TPC (625.53 mg gallic acid equivalent/g solid), followed by PEF (218.44 mg gallic acid equivalent/g solid) and M (154.54 mg gallic acid equivalent/g solid). In terms 160arto vitro antioxidant activity (ABTS), the PLE extract also showed the highest capacity (4.34 µmol/g solid), followed by PEF (3.15 µmol/g solid) and M (2.23 µmol/g solid). In in vivo assays, with 0.5 mM H2O2, PLE and PEF extracts showed significant antioxidant effects at concentrations of 10-20 mg GAE/mL. However, under more extreme conditions (4 mM H2O2), the M extract presented a pro-oxidant effect at 20 mg GAE/mL, while PLE showed a dual behavior, switching from antioxidant to pro-oxidant. In contrast, PEF extracts maintained a stable antioxidant effect, especially at 20 mg GAE/mL. In conclusion, agro-industrial residues, such as sweet potato peels, contain bioactive compounds with antioxidant potential, promoting their use in the food industry as functional ingredients. PEF extracts demonstrated higher antioxidant stability compared to PLE and M, suggesting their applicability in sustainable and healthy products in line with EU regulations.

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Keywords: antioxidant potential, sweet potato peels, Pulsed Electric Fields (PEF), Pressurized Liquid Extraction (PLE)

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WATER RESIDUES OF COFFEE AND COFFEE BY-PRODUCTS AS A SOURCE OF BIOACTIVE COMPOUNDS

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Abstract

The coffee silver skin (CSS) produced during coffee roasting and the spent coffee grounds (SCG) produced after coffee preparation are the by-products that generally remain unused. Considering the current status of CSS and SCG, their valuable properties and the global trend towards sustainable reuse of food by-products, their further utilization should be promoted. This paper therefore describes the idea of how they can be reused for the isolation of bioactive compounds, opening up the possibility of using them in reformulated foods and dietary supplements while reducing contamination from coffee residues. In this study, the Clevenger purified water hydrodistillation technique was applied as an environmentally friendly method for the extraction of bioactive compounds from CSS and SCG as well as from green and roasted coffee beans (GC and RC) and their ground fractions (GCM and RCM). After obtaining two fractions from hydrodistillation, i.e. essential oil and hydrolate, the water residues obtained as the third fraction, which are usually discarded, were analyzed as a source of bioactive compounds. The UPLC-MS^2 analysis shows that the purine alkaloid caffeine and the phenolic acids 5- and 3-caffoylquinic acid dominate in the water residues of coffee and coffee by-products. The caffeine content is particularly high in the water residues of RC (387.81 mg/L) and RCM (449.82 mg/L) and in CSS (329.80 mg/L), while it is lower in SCG (21.74 mg/L). These results are to be expected considering that most of the caffeine is released from RCM to the coffee beverage. The content of 5-caffeoylquinic acid is particularly high in the green coffee samples, i.e. GC (399.02 mg/L) and GCM (351.94 mg/L), confirming the fact that it is the main component of green coffee. 3-caffeoylquinic acid follows the same trend as 5-caffeoylquinic acid, with the highest content found in GC (130.45 mg/L) and GCM (170.03 mg/L) water residues. In view of the lower content of caffeoylquinic acid in RC and RCM and the significantly lower content in CSS and SCG water residues, it can be assumed that both the roasting and the grinding process have an influence on the degradation of the acid. In addition to phenolic acids, coffee and coffee by-products also contained diterpenes, i.e. cafestol and kahweol. The highest content of cafestol was found in CSS, while the kahweol content was highest in RC and RCM samples. Overall, the results obtained indicate that water residues from coffee and coffee by-products can serve as a good substrate for the production of various bioactive compounds and should be further investigated for their future potential applications.

Keywords: coffee, coffee by-products, hydrodistillation, silver skin, spent grounds, phenolic compounds

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ISOLATION AND IDENTIFICATION OF LACTIC ACID BACTERIA (LAB) FROM WHEAT GRAIN AND SPIKES BY COMBINING RAPD-PCR PATTERNS AND 16S RIBOSOMAL DNA SEQUENCING, AND ITS SAFETY EVALUATION

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Abstract

Lactic acid bacteria (LAB) are pivotal in the food and health industries, but their diversity on wheat surfaces remains underexplored. This study aimed to isolate LAB strains from wheat grains and spikes, to determine their molecular characteristics and to assess their safety. LAB was isolated using MRS agar plates and then 199 strains were screened by morphological and Gram tests. LAB were phenotypically and genotypically differentiated by randomly amplified polymorphic DNA (RAPD)-PCR into eight groups including 45 strains belonging to the species The genetic diversity of the isolates was analysed by random amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) and a representative strain was selected for 16S rRNA gene sequencing and phylogenetic identification with the GenBank database, which classified the 45 isolates into 8 strains representing the genetic information of the isolated bacteria at the species level: Enterococcus faecium (24), Pediococcus acidilactici (7), Pediococcus pentosaceus (4), Enterococcus mundtii (4), Enterococcus durans (2), Lactiplantibacillus plantarum (2), Lacticaseibacillus casei (1), Loigolactobacillus coryniformis (1). By blood agar hemolytic activity, 17 strains showed γ-hemolysis with a low risk of pathogenicity. These strains were all susceptible to chloramphenicol, clindamycin, erythromycin, penicillin, tetracycline, and ampicillin, although the degree of susceptibility varied. The mucin degradation test showed that they could not degrade mucin and would not cause damage to the gastrointestinal mucosa, meeting the safety requirements of probiotics and possessing the potential for further application. The present study underscored wheat as a novel source of safe LAB and established a systematic framework for the screening of functional probiotics, with important implications for food biotechnology and microbial resource development.

Keywords: Wheat; Lactic acid bacteria; RAPD-PCR, 16S rRNA sequencing, Probiotic safety

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NOVEL STRATEGIES TO COMBAT ANTIBIOTIC RESISTANCE: EXTRACTS FROM MUSHROOMS AND ALGAE

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Abstract

Antibiotic-resistant bacteria pose a significant global challenge, extending beyond individual health to impact economies and societies worldwide. This escalating issue imposes a considerable burden of morbidity and mortality on the global population, with particular concern for its effects among newborns. The gut microbiota plays a pivotal role in human health by executing a variety of critical functions. Probiotics and postbiotics within our commensal microbiota hold significant value in shielding against colonization by pathogenic strains harbouring antibiotic resistance genes. Sustaining a healthy intestinal microbiota can be achieved through the consumption of prebiotics in the diet.

The study explores the importance of probiotics, prebiotics, and postbiotics in protecting against pathogenic strains. Firstly, we have obtained extracts from mushrooms and algae and their composition has been characterized. Next, we have examined the potential prebiotic benefits associated with enhanced growth of probiotic strains, emphasizing the interest in the effect of novel biocompounds such as β-glucans from mushrooms and ulvans from seaweeds. To this end, the growth kinetics of strains of interest of the Lactobacillus and Bifidobacterium genus were followed in the presence of extracts. The results were adjusted to the Gompertz model and compared to controls to obtain statistically significant results. In parallel, the antimicrobial effect on the growth of pathogenic strains of E. coli, K. pneumoniae and S. aureus and the inhibition of the conjugation of plasmids with resistance genes have been explored.

Our results show how the consumption of these natural compounds can be very beneficial for health, improving the growth of probiotic strains present in our commensal microbiota and increasing the production of postbiotics. Ulvan-rich extracts obtained from algae appear to increase the latency time of pathogenic strains, delaying their exponential growth and potentially being a tool to be considered in combating them. On the other hand, purified extracts from mushrooms improve the growth of probiotic strains, making them good candidates for use as prebiotics.

This research offers a fresh perspective on combating antibiotic-resistant bacteria by investigating alternative therapies with mushrooms and seaweeds. These efforts not only contribute to scientific advancements but also have significant economic and social implications, due to the increasing demand for sustainably sourced natural products and prebiotics to combat infectious agents. Ultimately, our goal is to make these nutraceuticals accessible to all, leading to improved overall health outcomes.

Keywords: Biotic compounds, prebiotic, probiotic, antimicrobial

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REVALORIZATION OF ALGAE WASTE FOR THE DEVELOPMENT OF INNOVATIVE NUTRACEUTICALS

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Abstract

Algal biomass is produced on a large scale globally, yet it remains underutilized, with up to 95% of the initial biomass being discarded as by-products. However, this by-product can be up-cycled into high-value products. Microalgae and macroalgae contain biomolecules that may offer benefits for animal and human gut health, such as prebiotic, anti-inflammatory, immunomodulatory, and antioxidant properties. This study explores algae residues as nutraceuticals, focusing on their prebiotic effects, antimicrobial activity against antibiotic-resistant pathogens, and anti-inflammatory properties.

Purified fractions of the algae extracts from microalgae (Nannochloropsis, Phaeodactylum and Spirulina) and macroalgae (Ascophyllum, Gracilaria, Laminaria and Saccharina) were first obtained. The prebiotic potential of these extracts was assessed by examining the growth kinetics of Lactobacillus and Bifidobacterium strains. Growth rates, maximum growth and latency time were determined using the Gompertz model. The antimicrobial activity was evaluated using a plate diffusion assay with Escherichia coli and Staphylococcus aureus. Anti-inflammatory effect was assessed by monitoring NF-κB activation in the HT-29 intestinal epithelial cell line after extracts and TNF-α incubation, and cytotoxicity was measured via LDH release assay.

The analysis of bacterial growth kinetics revealed that fucoidan extracts, particularly from Saccharina and Ascophyllum, significantly increased the maximum growth of Lactobacillus, especially Lactiplantibacillus plantarum. However, no growth enhancement was observed in the case of Bifidobacterium animalis strain, indicating that the prebiotic effect of fucoidans is strain-specific. Furthermore, we did not detect an inhibition of E. coli and S. aureus in the presence of fucoidans or other extracts tested. Most extracts reduced TNF-α-induced NF-κB activation, with variations depending on the extract composition and algae species. P. tricornutum showed the strongest anti-inflammatory effect, with its ethanolic, aqueous, protein-pigment, and protein-depigment extracts reducing NF-κB activation to 9%, 1%, and 2%, respectively. However, its ethanolic extract exhibited significant cytotoxicity (25%-80%). Fucoidan-rich extracts from L. hyperborea and Saccharina reduced TNF-α-induced inflammation, with extract 848 from L. hyperborea reducing NF-κB activation by 53%-55%. Additionally, Spirulina and Nannochloropsis extracts showed lower NF-κB activation compared to the TNF-α control. In contrast, ultrafiltered Gracilaria effluent induced a pro-inflammatory response.

These results highlight the promising potential of algae extracts, particularly fucoidans promoting the growth of specific probiotic bacteria such as Lactobacillus, and P. tricornutum modulating inflammation by reducing NF-κB activation, suggesting their application in developing functional ingredients and prebiotics from algae residues.

Keywords: algae, prebiotic, probiotic, antimicrobial, anti-inflammatory

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GASTROINTESTINAL RESILIENCE OF SELECTED PROBIOTIC STRAINS ISOLATED FROM WHEAT: SURVIVAL IN SIMULATED GASTRIC AND INTESTINAL CONDITIONS

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Abstract

The effectiveness of probiotics depends on their ability to survive the harsh conditions of the gastrointestinal tract. This study evaluates the survival of selected lactic acid bacteria (LAB) strains isolated from wheat in simulated gastric and intestinal fluids. The results indicate that all tested strains demonstrated high tolerance to gastric conditions, with survival rates exceeding 89% after exposure to pepsin. Among them, Lactobacillus coryniformis (WD13) exhibited the highest survival rate (97.42%), whereas Enterococcus faecium (WD3) had the lowest (89.51%), possibly due to differences in cell wall structure and acid stress-related gene expression. Following treatment with enteric fluid containing trypsin and bile salts, survival rates significantly declined, ranging from 39.77% (L. coryniformis WD13) to 59.91% (Lactobacillus casei WG33). L. casei (WG33) exhibited the highest tolerance to intestinal conditions, maintaining the largest bacterial population (5.46 ± 0.10 log CFU/mL) compared to other strains. Conversely, E. faecium (WD3) and L. coryniformis (WD13) demonstrated the lowest survival rates (39.94% and 39.77%, respectively), potentially due to their sensitivity to bile salts and the absence of adaptive tolerance mechanisms. These findings highlight the significant variation in gastrointestinal resilience among LAB strains and suggest that L. casei (WG33) is the most viable candidate for probiotic applications due to its superior survival under simulated digestive conditions. This study contributes to the selection of robust probiotic strains for functional food and nutraceutical development

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Keywords: Probiotic survival, Gastrointestinal tolerance, Lactic acid bacteria (LAB) wheat, Bile salt resistance, Acid stress adaptation

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RESPONSE SURFACE OPTIMIZATION OF ULTRASOUND CONDITIONS TO INCREASE THE BIOACCESSIBLE FUCOXANTHIN CONTENT FROM THE SEAWEED SEA SPAGHETTI

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Abstract

Fucoxanthin is the primary carotenoid in brown seaweed and is recognized for its potential health benefits. This study was aimed at optimizing the fucoxanthin bioaccessible content from Himanthalia elongata (sea spaghetti) using ultrasound treatment. The seaweed was obtained from Porto-Muíños S.L. (Spain), desalted with cold water, freeze-dried, ground, and sieved. A 0.5 g sample was mixed with 20 mL of distilled water (S/L = 2.5%). The ultrasound treatments were performed using a Q500 ultrasound system (QSonica, USA) with a QS-4220 probe, maintaining samples in an ice bath to prevent overheating. After sonication, samples were centrifuged (3220 g, 10 min) and the solid residue was subjected to in vitro digestion. The in vitro digestion followed a static model based on Brodkorb et al. (2019), simulating salivary, gastric, and duodenal phases. Specific enzyme concentrations, pH conditions, incubation temperatures, and digestion fluids were applied as described in the reference. Carotenoid content in the micellar fraction was extracted and analysed following the validated protocol by Stinco et al. (2019). A Response Surface Methodology (RSM) with a central composite design (CCD) was applied to optimize ultrasound conditions The model considered ultrasound amplitude (20–50%) and treatment time (1–5 min) as independent variables in a three-level factorial design (-1, 0, 1). A total of 13 randomised experiments were performed to maximize the response variable (fucoxanthin bioaccessible content). According to the model prediction ($R^2 = 0.8351$), the optimal ultrasound conditions were a treatment time of 1 minute and an amplitude of 40%. The Pareto plot indicated that the factor with the greatest effect was the amplitude*amplitude interaction, showing that increasing ultrasound amplitude significantly enhanced the fucoxanthin bioaccessible content, while the treatment time had a lower effect. The increased bioaccessible content can be attributed to the cavitation produced by the ultrasound waves, which disrupts cell structures and facilitates fucoxanthin release. Under optimal conditions, a 40% increase in fucoxanthin bioaccessible content was achieved compared to the untreated control.
These results highlight the potential of ultrasound technology as a sustainable processing method to improve the nutritional value of seaweed products. By increasing the potential bioavailability of bioactive compounds, ultrasound processing can reduce the amount of raw material required to obtain the desired nutritional benefits. This contributes to sustainability goals by promoting resource-efficient processing and supporting the development of environmentally friendly, high-value seaweed-based foods.

Keywords: carotenoids, bioaccessibility, ultrasounds, sea spaghetti, seaweed

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IMPACT OF FERMENTATION ON THE ANTIOXIDANT ACTIVITY AND COLOUR OF *HAEMATOCOCCUS PLUVIALIS* AND *PORPHYRIDIUM CRUENTUM*

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Abstract

Haematococcus pluvialis and *Porphyridium cruentum* are microalgae with potential applications in the pharmaceutical, nutraceutical, cosmetic, food, and beverage industries. Despite their benefits, microalgae have an intense flavour and odour that limit their incorporation into food products. Biomass fermentation with bacteria has emerged as a strategy to mitigate these sensory challenges, although it may alter other biomass characteristics (Kurt et al., 2023).

This study evaluated the colour and antioxidant activity of *H. pluvialis* and *P. cruentum* biomass before and after fermentation. Biomass samples provided by GreenCoLab were individually fermented by *Lactobacillus plantarum* at 30 °C for 48 hours under static conditions (0.1 LAB: 1 biomass; 10^6 CFU/mL LAB). Antioxidant activity was assessed on methanolic extracts (0.6/10.0 w/v) using the ABTS and ORAC methods (n=3). Colour analysis (n=10) of fermented and non-fermented samples was performed using the C.I.E. colour system. Results revealed a higher antioxidant activity in non-fermented *H. pluvialis* biomass compared to *P. cruentum*, with values of 2.30±0.13 and 0.32±0.028 µmol TE/100 mg DW for ABTS and 43.33±2.90 and 1.38±0.12 µmol TE/100 mg DW for ORAC, respectively. Significant differences ($p<0.05$) were observed in a*, b*, L*, C*, and h° parameters before and after fermentation, indicating that fermentation significantly affected biomass colour. Colour values before and after fermentation were: L*=9.51±0.51, hue =27.8±1.1°, and C* =5.00±0.22 and L=12.32±0.38, hue=35.3±2.2°, and C*=3.50±0.15, respectively, for *H. pluvialis*; L*=19.11±1.29, hue=40.0±1.1°, and C*=10.13±1.01 and L* =16.77±1.34, hue=34.3±0.6°, and C*=7.74±0.81, respectively, for *P. cruentum*. Further assays will be performed to evaluate the antioxidant activity of fermented biomass and its application in food products will be studied.

Acknowledgments

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Keywords: Microalgae fermentation, Lactobacillus, Haematococcus pluvialis, Porphyridium cruentum, color, antioxidant activity

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EVALUATION OF THE EFFECTS OF SALMON AND COD SIDE STREAM HYDROLYSATES ON CELL VIABILITY OF CACO$_2$ CELLS

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Abstract

The seafood industry generates substantial amounts of by-products, which can account for up to 50% of total fish mass. These by-products are often discarded as waste, leading to environmental and economic concerns. Enzymatic hydrolysis has emerged as an efficient approach for valorizing these by-products by extracting bioactive compounds with potential health benefits. However, the biological effects of fish hydrolysates, particularly on intestinal cells, remain underexplored.

This study aimed to evaluate the effects of salmon (*Salmo salar*) and cod (*Gadus morhua*) side-stream hydrolysates on the viability of Caco-2 cells. Hydrolysates were obtained through enzymatic hydrolysis at different degrees of hydrolysis and subsequently tested for their impact on cell viability using the MTT assay. The assessment covered a range of concentrations to determine potential cytotoxic or bioactive effects.

Our results showed that fish hydrolysates did not exhibit cytotoxic effects at the tested concentrations. On the contrary, hydrolysates, particularly at higher concentrations, significantly enhanced Caco-2 cell viability, suggesting a potential proliferative or protective effect. These findings indicate that bioactive peptides and other compounds present in hydrolysates may contribute to cellular health, supporting their potential application in functional foods and nutraceuticals.

The results of this study provide valuable insights into the safety and potential health-promoting properties of fish by-product hydrolysates. Future research should explore the underlying mechanisms responsible for the observed effects and assess their bioavailability and efficacy in vivo. These findings highlight the importance of sustainable utilization of fish processing side streams and support the development of novel functional ingredients aimed at improving gut health.

Keywords: Fish by-products, Hydrolysates, Caco-2 cells, Cell viability, Functional foods

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NERDS: NOVEL ENZYMES, RECONSTRUCTION AND DESIGN FOR INDUSTRIAL SYNTHESIS

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Abstract

Peptides and dipeptides are essential in the food industry due to their roles in flavor enhancement, bioactive functions, and nutritional benefits. A wide variety of chemical and enzymatic processes have been developed to produce dipeptides and oligopeptides. Traditionally, chemical synthesis has been the dominant approach for peptide production at an industrial scale. However, this method is costly and environmentally problematic due to the use of toxic solvents and reagents. In contrast, enzymatic approaches offer a more eco-friendly and efficient solution. As consumer demand for natural and sustainable food additives increases, enzymatic peptide synthesis is emerging as a more eco-friendly and efficient alternative to traditional chemical methods.

One promising enzymatic approach involves α-amino acid ester acyl transferase (AET), which catalyzes the bond formation using an Nα-unprotected amino acid ester as a donor and an Nα, Cα-unprotected amino acid as an acceptor. A gene encoding such an enzyme, aet, was found in Empedobacter brevis and Sphingobacterium siyangensis (SAET and EAET). The dipeptide that can be produced by this enzyme with maximum efficiency is Ala-Gln.

The aim of this study is to find novel enzymes that produce different dipeptides with varied substrate specificities. This was done by first investigating enzymes that are closely linked to SAET using a sequence similarity network (SSN) study. To have a deeper knowledge of their evolutionary connections, a phylogenetic tree was then constructed. From the tree, 31 distinct enzyme sequences were chosen, synthesized, and their enzymatic activity evaluated.

Additionally, GRASP tool was used to perform ancestral sequence reconstruction, aiming to predict evolutionary variants that might have improved thermostability and perhaps wieder substrate specificities.

This research aims to contribute to the development of sustainable food production processes by identifying new peptide-synthesizing enzymes. By replacing traditional chemical synthesis with enzymatic methods, this study offers a pathway to more environmentally friendly and cost-effective peptide production.

Keywords: Peptides, Novel Enzymes, Sustainable Food Production

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APPLICATION OF TECHNOLOGICAL-TECHNICAL PACKAGING SYSTEMS IN GASTRONOMY

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Abstract

The application of technical-technical packaging systems plays a key role in gastronomy, because they enable the preservation of food quality, improve efficiency, reduce losses and enable easier distribution. The application of these systems in the gastronomic industry includes various aspects, from food packaging in restaurants and hotels to the transportation of products to consumers. The food packaging process is as important as the food production process itself. As the final step in the very complex process of food production in the "from field to table" system, the technological-technical packaging system must satisfy multiple criteria that are often contradictory. Knowledge of the packaging and packaging process of agricultural and food products can greatly facilitate the design and optimization of transport and storage on farms and, therefore, lead to certain savings both in terms of energy and economics. The ultimate goal of the packaging and packaging of agricultural and food products is certainly twofold, namely, first of all, maintaining the quality of the packaged product, but also commercial in terms of advertising the packaged goods as well as possible. Technological and technical systems of food packaging can be viewed from several aspects, namely from the aspect of the science of packaging materials, then from the aspect of the science of food and the process of its production itself, through information technology and from the socio-economic aspect. The aim of the paper is to show the basics of packaging technology as well as the most important functions of packaging and packaging of agricultural and food products. Examples of possible analyzes of technological and technical packaging systems are given in the paper, the application of which results in an optimal technological and technical solution of the packaging system of food products in gastronomy. The given examples can be seen as practical tips that combine elements of packaging function and socio-economic parameters as well as elements of packaging function and ecology. In the further course of work, the basic elements and influential factors of the development of the technological-technical system of packaging food products in gastronomy are presented. Here, first of all, we mean the determination of the needs of the product being packaged, then the analysis of the material from which the packaging is made and the technical packaging systems, as well as the evaluation of the created prototype and its final appearance on the market.

Keywords: food products, packaging, technology, technological development, gastronomy.

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THE INFLUENCE OF THE DEPROTEINIZATION STEP ON THE STRUCTURAL PROPERTIES OF CHITOSAN OBTAINED FROM THE SHELL OF THE CRAYFISH FAXONIUS LIMOSUS

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Abstract

The deproteinization step, in which the most commonly used chemical process uses NaOH, elevated temperature and time, is the subject discussed in the literature. The deacetylation step, implying extreme conditions in terms of base concentration and temperature, is analyzed as a possibility for the simultaneous sample deproteinization.

In this paper, the impact of the deproteinization step on the quality of chitosan obtained from the waste after the use of Faxonius limosus crayfish meat captured along the Danube river course through Serbia is considered. In the deproteinization step, chitosan was obtained using 0.3M NaOH, at 80-85 °C in a number of baths. The number of baths needed to efficiently purify chitosan from the proteins was analyzed from a structural point of view. The previous step of demineralization, as well as the subsequent deacetylation, was the same for all samples. Chitosans obtained with zero, one and three baths, as well as using autolysis for protein extraction by UV radiation (253.7 nm; 20 W; 20 min) followed with gradient temperature treatment from 40 °C to 65 °C, without the use of a base, were analyzed. Commercial medicinal chitosan was used as a standard.

FTIR spectra of the obtained chitosans differ from each other and differ from the spectrum of the standard. The spectra of zero-bath sample and autolysis sample showed a mutual correlation coefficient of 0.97, implying a structurally similar compound was obtained. One-bath sample spectrum showed a correlation coefficient of 0.92 and 0.93 with the previously mentioned spectra. Observed minimal differences mainly refer to the part of the spectrum 650-950cm^{-1}. The three-bath sample differs from all previous spectra, with a correlation coefficient of 0.66-0.88. This spectrum is close to the standard sample. A detailed analysis, with an emphasis on areas where the contribution of protein residues is expected: amide I (1700–1600cm^{-1}), amide II (1600–1500cm^{-1}), amide III (1300–1200cm^{-1}), revealed the differences between zero-bath, one-bath and the autolysis spectra, on the one hand, and three-bath and the standard sample on the other hand, indicating a residual protein in the first group of samples.

Considering the obtained results, it couldn't be expected that by omitting/reducing the number of baths in the deproteinization step, a pure sample of chitosan can be obtained, through the deacetylation step, in the case of F. limosus shell. Depending on the purpose of chitosan and the desired purity, it is necessary to adjust the deproteinization phase.

Keywords: chitosan, deproteinization, shell, crayfish, Faxonius limosus

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BIOFUNGICIDES AS A POTENTIAL ALTERNATIVE TO SYNTHETIC FUNGICIDES FOR THE CONTROL OF PHOMOPSIS CANE AND LEAF SPOT (PCLS) IN GRAPEVINE

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Abstract

Phomopsis cane and leaf spot (PCLS) affects grapevines (*Vitis vinifera*) wherever vines are grown, and especially in regions characterized by humid temperate climates at the beginning of the growing season. Symptoms of the disease appear as dark lesions on the primary internodes, which can later become visible as small cankers wounds during the winter. This disease leads to shoot breakage at the base, stunted growth, which negatively affects the yield in the vineyard. The main method of controlling the disease is chemical treatments using copper preparations or contact fungicides in the early stages of vegetation. However, present of great concern at the global level about the use of pesticides from the aspect of food safety. The Green Deal agreement of 2020. year planed to reduce the use of synthetic plant protection products by 50%. Today, the list of available active substances for the control of PCLS is getting shorter and copper preparations are used for the main treatments against this disease. It is important to note that research shows that intensive and long-term use of copper preparations negatively affects the environment due to the accumulation of copper in the soil to toxic concentrations. Directive EC No. 473/2002 limited the amount of application of copper fungicides in organic production therefore, biofungicides are now an alternative to synthetic plant protection products for disease control in vineyards. During 2024, in the phytopathology laboratory of Biotechnical faculty in Podgorica, study of the effectiveness of certain commercial biofungicides on the pathogen *Phomopsis viticola* was conducted. In direct *in vitro* testing, the antagonistic potential of three BCAs was tested: *Trichoderma atroviride* SC 1 (Vintec®), *Bacillus amyloliquefacies* strain FZB24, (Taegro®) and *Bacillus subtilis* strain QST 713 (Serenade ASO). The tested microorganisms reduced the growth of *Phomopsis viticola* by 58.05% for *Trichoderma atroviride* SC 1, 26.53% for *Bacillus amyloliquefaciens* and 48.78% for *Bacillus subtilis*, compared to the control. Statistical analysis of the data shows that there is no significant difference between the antagonistic potential of *Trichoderma atroviride* SC1 and *Bacillus subtilis* strain QST 713 and that these two BCAs have the greatest potential in suppressing *Phomopsis viticola*. The results obtained indicate the potential possibility of including the biofungicides Vintec® and Serenade ASO in grapevine protection programs against PCLS.

Key words: Vitis vinifera, food safety, cooper, Trichoderma, Bacillus, in vitro

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PRELIMINARY STUDY OF DIFFERENT PART OF BLUE POPPY (PAPAVER SOMNIFERUM) AS A SOURCE IN BIOACTIVE COMPOUNDS AND UTILIZATION IN FOOD INDUSTRY

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Abstract

Poppy (Papaver somniferum) represent one of the oldest medicinal plant, which is widely used in the food industry. It is also extensively used in alternative medicine due its rich content of alkaloids, phenols, tocopherols, vitamins, and minerals. The present study was aimed to investigate the bioactive compounds in various parts of the poppy (leaves, stems, roots, capsules and cold-pressed cake). All parts were extracted by conventional solid-liquid extraction (SLE) using different concentration of ethanol (0, 20, 40, 60, 80 and 96%) as extraction solvent. Cold-pressed cake was obtained from seed during the cold-pressing oil process as a by-product. One portion of cold-pressed cake was defatted using Soxhlet extraction with methylene-chloride as a solvent, and then extracted by SLE.

The total phenolic content (TPC), hydroxycinnamic acids (HCA), flavonols (FL), total flavonoids (TF), condensed tannins (CT) from obtained extracts were determined in this work. The ethanol concentration had an important effect on the amount of bioactive compounds. In all parts of poppy, it was found that 20% and 40% ethanol were the best for isolating polar compounds. The TP content ranged within 0.33 – 8.80 mg GAE/g DW. According to TP and TF content, the extract obtained from capsule stood out as the richest extract. Hydroxycinnamic acids were present in large amounts in the extract obtained from the leaves, capsules, and cold-pressed cake. The root was rich in flavonols, with content ranging from 7.94 to 12.26 mg QE/100 g sample, depending on the ethanol concentration. The condensed tannins content in stalk extract ranged from 1.25 to 28.25 mg CE/100 g sample, in the leaf extract from 2.45 to 74.02 mg CE/100 g sample, in root extract ranged from 1.63 to 53.72 mg CE/100 g sample and in the capsule extract the content of tannins was 6.70 – 157.27 mg CE/100 g sample. The best results for CT from all parts were observe in the extracts obtained using 20% ethanol. As a result, all parts of poppy are a promising candidate for future investigation and their application in various industries as potential functional foods.

Keywords: Papaver somniferum, by-products, total phenolic content, hydroxycinnamic acids, flavonols, total flavonoids, condensed tannins

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UNDER-RESEARCHED PLANTS FROM ASTERACEAE FAMILY: DIFFERENT CLASSES OF PHENOLIC COMPOUNDS AND EXTRACTION YIELD CHARACTERIZATION

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Abstract

Due to oversaturated market with synthetic drugs there is a space for plant-based products to replace them, and satisfy the consumers need. The Asteraceae family of plants, as an economically very important family of plants, provides basic groceries in the diet, ornamental garden plants, and a variety of medicinal herbs. Therefore, the main goal of this study was to characterize under-researched plants from Asteraceae family in terms of total phenolic (TP), flavonoids (TF), flavonols (FL), hydroxycinnamic acids (HCA) and condensed tannins (CT) content and yield of extraction (Y). Twenty tree samples from 19 plants were subjected to examination. Herb of the plants was used as raw material. However, for four plants root was also investigated beside herb. Fifteen different plant genera were covered, in some cases three plant varieties were researched within the same genus (Tanacetum and Inula). The extracts were obtained by using traditional maceration. Solid/liquid ratio was 1:20 m/v, 60% ethanol was used as solvent in extraction process which lasted 24 h with constant shaking (180 rpm), at room temperature. The extraction yield was ranged from 0.57% to 1.74%. The highest yield of extraction was isolated from Cichorium endivia, while the lowest was obtained from Silybum marianum. Five plants expressed higher content of different classes of bioactive compounds in comparison to other samples. For TP, TF, FL, and HCA the same five samples stood out with highest content. Solidago virgaurea had the highest content of TP (56.52±2.72 mg GAE/g dry weight (DW)), while Tanacetum vulgare stood out as plant richest in TF content (51.85±2.98 mg CE/g DW). Within assays for other classes of bioactive compounds such as HCA content, the highest amount was obtained from Tanacetum vulgare (448.12±12.61 mg CAE/100 g sample). Furthermore, Solidago virgaurea was the richest in FL content (161.91±4.72 mg QE/100 g sample), while highest content of CT was measured in Helianthus tuberosus (60.24±5.16 mg CE/100 g sample). In the following examination, the content of different classes of bioactive compounds for Asteraceae plants may be increased by applying novel extraction techniques which have positive environmental impact and higher effectiveness. Incorporation various extracts of Asteraceae plants in wide products to increase nutritional and biological activity should be in main focus in future.

Keywords: under-researched plants from Asteraceae family, total phenolic content, total flavonoids content, content of total flavonols, content of hydroxycinnamic acids, content of condensed tannins, extraction yield

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THE EFFECT OF HPMC-CHITOSAN COMPOSITE EDIBLE COATINGS ENRICHED WITH MANDARIN PEEL EXTRACT ON FLAVONOID CONTENT IN MANDARIN FRUIT DURING STORAGE

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Abstract

In the last decade, mandarin consumption has considerably grown, therefore the potential in analysing them came in centre of attention. Also biodegradable edible coatings have become alternative to traditional food packaging materials. Both chitosan and HPMC are considered good substitute because of their properties, such as moisture and oxygen barrier properties, elasticity and resistance. Mandarin peels represent a valuable source of bioactive compounds and are considered a beneficial form of biowaste. The extraction process was optimized to maximize the yield of bioactive constituents, ensuring the highest possible concentration of these beneficial compounds in the obtained extract. This study examines the impact of chitosan and HPMC composite edible coatings enriched with mandarin peel extract on the total phenolic and flavonoid content of mandarin fruit over a nine-day shelf life at room temperature. The total phenolic and flavonoid content was quantified using spectrophotometric analysis. The findings indicate that the composite coating enriched with mandarin extract effectively preserves the total phenolic content throughout the storage period. Similarly, the retention of total flavonoid content was also observed, highlighting the protective role of the coating in maintaining these bioactive compounds.

Keywords: chitosan, HPMC, mandarin fruit, phenols, flavonoids

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EFFECT OF ENCAPSULATION OF BIOACTIVE AGENTS ON GROWTH AND BIOACTIVE COMPOUNDS CONTENT OF LACTUCA SATIVA L.

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Abstract

Encapsulation is a promising method for improving the nutritive value and growth of lettuce by delivering and controlled releasing of essential nutrients, bioactive compounds, and beneficial microorganisms from the capsule. Encapsulation of bioactive agents was used to improve the nutritive value of lettuce by increasing the production of secondary metabolites and antioxidant activity. Encapsulated agents used in this experiment were calcium ions, humic acid, and Trichoderma Harzianum U-22 spores(encapsulated and non-encapsulated). Calcium ions play a crucial role in plant growth, development, and the production of secondary metabolites. Similarly, humic acid supports plant growth, enhances nutrient absorption, and serves as a food source for beneficial soil microbes. Trichoderma also enhances nutrient uptake and is essential for root development while acting as a natural defense against plant diseases by consuming harmful fungi responsible for infections. The highest increase in chlorophylls and carotenoids was obtained by microparticles with humic acid while non-encapsulated Trichoderma spores obtained the highest increase in phenolic and antioxidant activity. Encapsulation proved to be a simple, sustainable, and green approach to the production of lettuce with increased nutritive value.

Keywords: encapsulation, Trichoderma, humic acid, lettuce

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NADES-ASSISTED PRESSURIZED HOT WATER EXTRACTION TO OBTAIN READY-TO-USE HOP CONE EXTRACTS WITH ENHANCED ANTIOXIDANT POTENTIAL

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Abstract

Hop cones, rich in polyphenols and bitter compounds, possess antioxidant, anti-inflammatory, neuroprotective, antimicrobial, and potential anti-cancer properties. While its bitter taste is beneficial in brewing, it poses a limitation for its use in nutraceuticals and pharmaceuticals. Natural deep eutectic solvents (NADES) have emerged as green alternatives for enhancing solvent properties in plant material extraction. This study aimed to optimize the extraction of hop cones using a greener solvent while simultaneously masking the bitter taste of the extracted compounds.
This study investigates the use of a NADES-based solvent composed of choline chloride and glucose (ChChl:Glu, 2:1 molar ratio) for the extraction process, with its performance compared to water and 70% ethanol. The solvents were enriched with HP-β-cyclodextrin (HP-β-CD) to mask the bitter taste of the extracted compounds and enhance extraction efficiency. The extraction process was optimized using pressurized liquid extraction (PLE) at temperatures of 40°C, 100°C, and 160°C. Additionally, ultrasound-assisted extraction (UAE) was evaluated for comparison. Total polyphenol content (TPC) was quantified, and antioxidant activity was assessed using DPPH, ABTS, CUPRAC, and FRAP assays. The extracts were characterized using Ultra high performance liquid chromatography quadrupole time-of-flight mass spectrometry (UHPLC-QToF). The highest TPC was found in the extract obtained using NADES-enriched solvent at 160°C (36.06 ± 2.35 mg GAE/g), followed closely by the extract prepared with 70% ethanol at 160°C (36.04 ± 2.66 mg GAE/g). Antioxidant activity, measured by ABTS, CUPRAC, and FRAP assays, exhibited similar trends, with the extract obtained with NADES-enriched solvent at 160°C showing the strongest antioxidant potential (27.3 ± 1.36 mg Trolox/g, 76.64 ± 6.09 mg Trolox/g 53.54 ± 3.93 mg Trolox/g, respectively). The highest DPPH value (36.52 ± 2.77 mg Trolox/g) was observed in the extract obtained with the same solvent at 100°C. UHPLC-QToF-MS/MS analysis revealed the difference in presence of key bioactive compounds in the extracts. The use of NADES-based solvent with HP-β-CD significantly enhanced the extraction efficiency of polyphenols from hop cones, improving their antioxidant potential. The combination of NADES-based solvents and PLE presents a promising solution for isolating high-value compounds, while also reducing the environmental impact associated with organic solvent-based extraction methods.

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Keywords: Hop, antioxidant activity, natural deep eutectic solvents, pressurized hot water, nutraceuticals

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BENCH- AND PILOT SCALE SUPERCRITICAL CO_2 ($SCCO_2$) EXTRACTION OF TENEBRIO MOLITOR FOR POTENTIAL FOOD APPLICATIONS

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Abstract

Enabling technologies have adopted a decisive role in an attempt for sustainable transformation of chemical sector by promoting green extraction processes. This study focuses on conversion of alternative materials as Edible Insects (EIs), namely Tenebrio molitor (TM), to potential chemicals of interest in the food sector. Equally for bench- and pilot scale processes, a significant degree of defatting was accomplished, resulting in a high-quality post-extraction recovered oil and solid residue. The quantification of the environmental footprint enclosed in both procedures revealed a low impact by assessing metrics as process mass productivity, reaction mass efficiency or eco-scale, which allows to firmly steer this methodology to an industrial scale.

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Keywords: edible insects, process intensification, green chemistry metrics, supercritical fluid extraction, scaling-up

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ELECTROPHORETIC ANALYSIS AND DIGESTIBILITY OF RAPESEED PROTEINS ISOLATED BY DIFFERENT EXTRACTION METHODS

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Abstract

Lab-on-a-chip electrophoresis was used to analyze the protein profile of isolated rapeseed proteins, which mainly consist of two dominant proteins: cruciferin and napin. Cruciferin, a 12S globulin, is present at 55–85% and consists of two trimers with a total molecular mass of 300–350 kDa. Each monomer contains α (~30 kDa) and β (~20 kDa) polypeptides linked by disulfide bonds, with additional stability from non-covalent interactions. Napin, a 2S albumin, is present at 15–45% and consists of two polypeptides (~4 kDa and ~9 kDa) connected by disulfide bridges, with a total mass of 12–16 kDa.

In this study, proteins isolated by alkaline extraction (ALK12) and proteins obtained using deep eutectic solvents (DES) – choline chloride:urea (DES1) and betaine:citric acid (DES2) – were analyzed. Electrophoretic analysis revealed that the ALK12 isolate contained seven dominant fractions with molecular masses of 15, 61, 94, 132, 177, 199, and 229 kDa. The fractions at 132 kDa (38%) and 61 kDa (23%) correspond to cruciferin subunits, while the high-molecular-weight fractions (177–229 kDa) may represent oligomers formed under alkaline conditions. The presence of the 15 kDa fraction suggests the possible presence of napin or oleosin. The DES1 isolate showed two main fractions at 57 kDa (57%) and 145 kDa (43%), whereas the DES2 protein distribution was similar, with 60 kDa (66%) and 149 kDa (34%).

The *in vitro* digestibility of the isolated proteins was assessed using the standardized INFOGEST protocol, and the molecular weight distribution after digestion was analyzed by electrophoretic methods. During digestion, cruciferin breaks down into smaller fragments with masses of 20–40 kDa, while napin hydrolyzes into peptides smaller than 10 kDa. The results revealed significant differences in digestibility among the analyzed isolates. After digestion, ALK12 had a high proportion of peptides below 10 kDa, indicating extensive degradation. In the DES1 isolate, high-molecular-weight proteins were partially degraded into fractions of 10–50 kDa, while the DES2 isolate exhibited the highest susceptibility to enzymatic hydrolysis, with the lowest proportion of proteins above 50 kDa after digestion.

The increased presence of napin in digests may enhance absorption and contribute to bioactive peptide release. Native cruciferin is harder to digest, but partial hydrolysis improves its peptide bioavailability. Extraction and processing methods directly affect rapeseed protein *in vitro* digestibility, ranging from 70% to 100%. Hydrolysis-resistant fragments may reduce digestibility, while hydrolyzed proteins show improved absorption and nutritional value.

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Keywords: Lab-on-a-chip electrophoresis, protein, alkaline extraction, DES

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CONSUMER BEHAVIOR AND SUSTAINABLE NUTRITION: A SCIENTIFIC APPROACH TO ANALYSIS AND CHALLENGES

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Abstract

Consumer behaviour in the context of nutrition plays a key role in achieving sustainability in global society. In recent decades, there has been an increasing focus on sustainable nutrition, which involves consuming products that minimize negative ecological, social, and economic impacts. This paper explores the factors influencing consumer behaviour when choosing sustainable food options, analysing understanding, attitudes, and behaviour's towards the ecological, ethical, and social aspects of nutrition. The aim of this research is to identify the key factors shaping consumer behaviour, including economic, cultural, educational, and psychological elements, and how these factors influence decision-making regarding sustainable nutrition. The results show that the existence of sustainability education, the availability of sustainable products, and the rise in ecological awareness play a critical role in changing consumer behaviour. Based on these findings, it is concluded that it is essential to implement strategies that involve consumer education and strengthen market infrastructure supporting sustainable nutrition.

Keywords: consumer behaviour, sustainable nutrition, ecological awareness, ethical consumption, sustainability education, market infrastructure.

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CROSS-SECTORIAL FRAMEWORK TO SUPPORT THE FOOD SYSTEM TRANSITION TOWARDS SUSTAINABLE AND GREEN SKILLS

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Abstract

The “Glocal Ecosystems and Expanded Knowledge for skills and capabilities in the food sector” (GEEK4Food) project develops a working, cross-sectorial framework to support the food system transition towards sustainable and green solutions by the development of disruptive tools able boost a fluid upskilling and reskilling of the current workforce of the next generation of future professionals. This is achieved by: (1) Design and setting of an Artificial Intelligence (AI)-based tool able to determine and forecast current and future green skills and capability needs for the food sector to timely support the development of both higher education (HE) and training design and better match the job market needs (GEEK4Food tool). (2) Design and exploit forward-looking planning in training design and implementation of HE and cross-sectoral trainings for graduates and food professionals to enhance green skills. (3) Mainstreaming innovative teaching practices and providing paths to entrepreneurial education oriented on green skills and associated technological scale-up of existing solutions via the integration of the knowledge triangle. (4) Setting an interactive learner-centric virtual platform for green skill mapping to merge learners' needs with training offers and agri-food job opportunities (3P-GEEK4Food Hub). (5) Boosting consolidating evidence- and impact-based solutions of the GEEK4Food project to embed multi-level and multi-actor policy actions that

can support skill-fluidity for the green transition of the food sector. The innovation potential of GEEK4Food is based on the switch to AI-supported and impact-driven patterns to favour innovative green training and educational models at the academia, corporate and people-to-people levels.

GEEK4Food will also provide tools for policy makers to promote adherence to green transition and the whole institution approaches to sustainably twin change after the EU Green Deal.

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Keywords: green and entrepreneurial skills, trainings, modules, agri-food sector

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HEALTH, SUSTAINABILITY, AND INTERDISCIPLINARY COLLABORATION: AN INTEGRATED APPROACH TO NUTRITION IN THE PROVIDING OF SOCIAL SERVICES THROUGH LABORATORY ANALYSIS AND RESOURCE OPTIMIZATION

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Abstract

Ensuring nutritionally adequate meals for socially vulnerable groups and immunocompromised individuals presents a key challenge within the providing of social services. This study explores a systematic approach to nutrition through three key aspects: laboratory analysis of meal nutritional value, procurement optimization to reduce waste, and interdisciplinary collaboration across sectors. An analysis of laboratory reports from recent periods confirms that meals meet nutritional standards tailored to individuals with specific dietary requirements. This ensures not only food safety but also the continuous provision of high-quality nutrition within social service institutions. In the area of procurement optimization, systematic monitoring of food returns has provided concrete evidence of waste reduction and improved inventory management. Traceability data clearly indicate more efficient procurement through the adjustment of food supply quantities to the actual needs of users. This strategy contributes to reducing food surplus, achieving financial savings, and lowering greenhouse gas emissions associated with logistics and storage. A key aspect of this model is interdisciplinary collaboration between various sectors, including social service institutions, healthcare facilities, suppliers, and local communities. The exchange of data and expertise enables better planning and improvement of nutrition solutions tailored to people in need. This approach not only optimizes resources but also enhances institutional capacity to provide high-quality services to users.

This study highlights the importance of an integrated approach to nutrition in the providing of social services, combining scientific analysis, efficient resource management, and cross-sector collaboration as key elements of a sustainable and high-quality food system.

Keywords: Nutritional adequacy, Sustainability, Interdisciplinary collaboration, Procurement management, Efficiency in food systems

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RYE: IMPORTANT CEREAL FOR FOOD NUTRITIONAL QUALITY

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Abstract

Rye (Secale cereale L.) is a cereal widely cultivated, particularly in the northern regions of Europe and North America, and is most commonly used in bread production. Among cereals, rye contains the highest levels of dietary fiber and a broad range of bioactive compounds that offer various health benefits. Arabinoxylans, which are among the main polysaccharides of dietary fibers in rye, play a key role as functional ingredients in bakery products, influencing dough properties and other important characteristics of the final product. Rye bread is known for its longer freshness, which is why mixtures of wheat and rye flour are often used to produce bread with high nutritional value and quality. Numerous studies show that increased consumption of rye-based products can provide various health benefits, including alleviating inflammatory processes in the body, preventing cardiovascular diseases, reducing the risk of certain types of cancer, and helping in the prevention of type 2 diabetes and obesity. Commission Regulation (EU) No. 432/2012 establishes the permitted health claim for rye fibers: "Rye fibers contribute to the normal function of the digestive system." This claim applies exclusively to foods with a high fiber content, as specified in the annex of Regulation (EC) No. 1924/2006. Due to the increasing impact of climate change on food production, rye is becoming a key crop in many countries due to its resistance to adverse production conditions and the growing consumer demand driven by the health benefits it provides.

Keywords: rye, food quality, dietary fibers, nutritional quality

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PREPARATION AND CHARACTERIZATION OF BIGEYE SNAPPER (*PRIACANTHUS TAYENUS*) FISH SKIN GELATIN HYDROLYSATES WITH ANTIOXIDANT AND ANTI-DIABETIC ACTIVITIES

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Abstract

This study aimed to prepare and characterize fish gelatin hydrolysate containing bioactive properties. Fish gelatin was extracted from bigeye snapper (*Priacanthus tayenus*) skin, a by-product of fish mince processing industry. Fish gelatin hydrolysate was prepared using papain or alcalase hydrolysis, contributing to GH-PA and GH-AL, respectively. The antioxidant and anti-diabetic activities of these gelatin hydrolysates were investigated. GH-PA exhibited a higher yield and greater anti-diabetic and antioxidant properties than GH-AL. The optimum hydrolysis conditions of GH-PA were 3% papain and 5 h hydrolysis time, resulting in 69.84±0.97% yield, 57.04±1.71% degree of hydrolysis, 96% protein solubility, with good solubility across a pH range of 1 to 10. GH-PA showed 2.42±0.04 mg/mL of the IC50 value for dipeptidyl peptidase-IV (DPP-IV) inhibition and antioxidant activities, as measured by DPPH (IC50 = 2.39±0.02 mg/mL), ABTS (IC50 = 2.01±0.01 mg/mL), hydroxyl radical (OH) (IC50 = 0.23±0.03 mg/mL), and hydrogen peroxide (H_2O_2) (IC50 = 17.28±0.73 mg/mL). These results highlight the potential of fish skin as a sustainable and versatile resource for generating high-value bioactive peptides.

Keywords: Gelatin hydrolysate, Antioxidant, Anti-diabetic, By-products

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CHANGES IN BIOACTIVE COMPOUNDS OF A FUNCTIONAL SMOOTHIE DURING 21 DAYS OF STORAGE

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Abstract

The study analyzed the changes in bioactive compounds in a functional smoothie over 21 days of storage. The key bioactive components examined included total phenolic content (TPC), hydroxycinnamic acids (HCA), total flavonoids (TFL), vitamin C, and carotenoids (CAR). The analysis was conducted at four time points: Day 0, Day 7, Day 14, and Day 21. At the start, the highest TPC was found in the TP-0 sample (944.25 mg/100 mL), followed by VHT4-0 (749.04 mg/100 mL) and VHT3-0 (746.81 mg/100 mL). Vitamin C content was highest in sample K (27.48 mg/100 mL) and significantly lower in other variants, particularly TP-0 (5.59 mg/100 mL). Carotenoid levels were fairly consistent across samples, ranging from 14.97 mg/100 mL to 17.14 mg/100 mL. After one week, TPC showed a decline in most samples, with VHT1-7 recording the most significant drop (621.25 mg/100 mL from 661.17 mg/100 mL). Vitamin C degradation was prominent in TP-7 (down to 0 mg/100 mL), whereas other samples retained some content, with VHT1-7 at 9.40 mg/100 mL. Carotenoids also showed a reduction, though it remained relatively stable compared to other compounds. By the second week, TPC continued to decrease across all samples, with TP-14 dropping to 819.92 mg/100 mL. HCA and TFL levels also declined, with HCA levels in TP-14 falling to 33.88 mg/100 mL. Vitamin C content was significantly diminished, with some samples such as TP-14 showing complete degradation (0 mg/100 mL). Carotenoid levels slightly declined but remained more stable than the other bioactive compounds. At the end of the storage period, all bioactive compounds exhibited substantial reductions. TPC in TP-21 fell to 625 mg/100 mL, while HCA and TFL declined across all samples. Vitamin C was completely degraded in TP-21, and only small amounts remained in VHT samples (e.g., 4.35 mg/100 mL in VHT4-21). Carotenoid levels decreased but remained relatively preserved, with values ranging from 10.50 mg/100 mL to 11.65 mg/100 mL. The study demonstrates a significant decline in bioactive compounds, particularly vitamin C, which was almost entirely lost after two weeks. Total phenolic content, hydroxycinnamic acids, and flavonoids also decreased over time, though at varying rates. Carotenoids exhibited the highest stability. These results suggest that the functional smoothie maintains some bioactive benefits over 21 days but experiences notable nutrient degradation, emphasizing the need for optimized storage conditions to preserve its functional properties.

Keywords: functional smoothie, bioactive compounds, storage stability

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AI -OPTIMIZED ENERGY EFFICIENCYE of ULTRASOUND-ASSISTED APPLE DRYING

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Abstract

Enhancing energy efficiency is a primary goal in modern food processing. This research explores ways to improve energy efficiency as one of the most important goals in the food industry today. The aim of this study is to determine how the use of AI can improve convective drying techniques on apples that have been pre-treated with ultrasound. The apples used in this study were subjected to a direct (immersion probe) or indirect (bath) ultrasonic pretreatment, with amplitudes varying between 30-90% and time intervals between 3-60 minutes. Afterwards, the samples were dried at a temperature of 60°C using convective drying with an air velocity of 0.5 m/s until they reached a final moisture content of 18 %, and the energy consumption per 100 g was measured.

The effect of ultrasonic pretreatment resulted in reduced energy consumption compared to the control sample with an energy consumption of 2.185 kWh/100 g. The highest efficiency was achieved with the direct ultrasound pretreatment with 6 min at an amplitude of 30% (1.512 kWh/100 g) and with the indirect ultrasound pretreatment with 30 min at an amplitude of 30% (1.547 kWh/100 g), resulting in an energy saving of up to 0.31.

Two models that have been used with the aim of more efficient use of energy based on various process parameters: a Random Forest Regressor and an Artificial Neural Network (ANN). Random Forest model shows high predictive accuracy, resulting in R^2 of 0.97 and Root Mean Square Error (RMSE) of 0.036 kWh. Compared to the results of ANN, with the low R^2 of 0.47, which implies that the Random Forest model is much preferable for this data set.

Examination of the most influential factors that influence energy efficiency using Random Forest analysis revealed that treatment time accounted for 48.9% of the impact, while amplitude contributed 46.9%. Although the ultrasound pretreatment method had a smaller effect of 4.2%.

These results indicate that using AI-based modeling, it is possible to enhance the drying process by efficiently using energy without compromising product quality.

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Keywords: ultrasound-assisted drying, Random Forest, artificial neural network, energy efficiency, process optimisation, AI, optimisation

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BIOACTIVE POTENTIAL OF TRUFFLE RESIDUES: PHENOLIC CONTENT, ANTIOXIDANT CAPACITY, AND SAFETY ASSESSMENT IN CACO-2 CELLS

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Abstract

This study investigates the sustainable extraction of bioactive compounds from black truffle (*Tuber melanosporum*) using accelerated solvent extraction (ASE). The objective was to evaluate this green technology on total phenolic content (TPC), antioxidant capacity and bioactivity in CACO-2 cell model, while emphasizing food waste valorization.

ASE was conducted at two temperatures (40°C and 120°C) and compared to a control maceration method. TPC was quantified using the Folin-Ciocalteu method, whereas antioxidant capacity was assessed using TEAC and ORAC assays. Additionally, the mineral and heavy metal content was analyzed to ensure their potential application in food and nutraceuticals. The analysis focused on essential macro- and microelements including magnesium, calcium, iron and zinc, as well as harmful heavy metals, such as cadmium or lead. Cytotoxicity was evaluated in Caco-2 cells using the MTT assay.

The obtained data provided the nutritional value and safety profile of the extracts. The results demonstrated a significant enhancement in TPC and antioxidant capacity in ASE-treated samples, highlighting the potential health benefits. Further assessment in Caco-2 cell model did not reveal the cytotoxic effects for low extract doses (up to 500 µg/mL). These findings support the potential applicability of truffle-derived extracts in nutraceutical and pharmaceutical industries.

Keywords: Truffle, Accelerated solvent extraction (ASE), Antioxidant capacity,Cell viability, Heavy metals

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OPTIMISATION OF CONVECTIVE DRYING OF ULTRASOUND-TREATED APPLE SLICES USING ARTIFICIAL INTELLIGENCE

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Abstract

Convection drying is commonly applied in the food drying process, but it has inherent drawbacks of high energy intensity and long time consumption [1]. The last few years have seen an increased inclusion of AI into the operations of the food processing industry, which has brought about new practical approaches that can be employed to control and enhance the process. The present research work focused on the drying characteristics of apple slices treated with ultrasonic waves at two power levels, namely 60% and 90% and for 30, 45, and 60 min before drying in convective air at 60ºC and an air velocity of 0.5 m/s. The normalised mass loss over time was used as experimental data for the validation of the models, which could be used for drying and enhancing the methods.

The objective was firstly to investigate the enhancement due to ultrasonic pretreatment in reducing the drying time and to use AI to develop the drying model. The experiments' findings were that maximum moisture content was removed in the samples subjected to 90% amplitude for 45 minutes and that the mass of the control sample was reduced by more than 30% by the end of the drying period. According to the collected data, ANN and SVR models were proposed and trained with drying kinetics depending on the treatment parameters and time.

The models were highly accurate for prediction as all the models had R^2 above 0.98, which proved the suitability of the AI tools for the process improvement. As various cases are run and analysed, it is possible to suggest the best drying conditions without carrying out numerous physical experiments due to the effective use of software and computer technologies. Thus, it can be concluded that the simultaneous use of ultrasonic pretreatment and AI modeling may be considered as a practical approach to increasing the efficiency of convective drying in the food industry. Besides, it also helps to enhance quality employment in the products and support industries' objectives of practicing environmental conservation by extending innovation in food technology.

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Keywords: ultrasonic processing, drying, AI, optimisation

VALORIZATION OF SARDINE SIDE STREAMS: SUPERCRITICAL CO_2 EXTRACTION OF FISH OIL AND ITS EFFECT ON CACO-2 CELLS

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Abstract

Sardine side streams (heads, viscera, and backbones), are often regarded as waste materials. These materials are either discarded or converted into low-value products like animal feed, fish meal, or fertilizers, resulting in inadequate utilization of available resources. However, these side streams possess significant nutritional value and untapped potential for further exploitation. This study aims to extract fish oil from sardine processing waste using a novel green processing technology, supercritical fluid extraction (SC-CO_2), and evaluate its effects on human Caco-2 cells using the MTT assay to identify fish oil components with potential bioactivity.

The experimental results demonstrated that the oil yields from fish heads, bones, and viscera were 24.143±2.372%, 15.065±1.231%, and 31.239±1.223%, respectively, indicating that sardine side streams are excellent sources of fish oil. The MTT assay results revealed that all fish oil samples did not exhibit cytotoxic effects within the tested concentration range. On the contrary, high-concentration fish oil treatment groups (250, 500, and 1000 μg/mL) significantly promoted Caco-2 cell viability. Interestingly, the viability-promoting effects varied among fish oils from different sources, with head and bone oils showing superior activity compared to viscera oil. This suggests that other components in the fish oil may also contribute to the regulation of Caco-2 cell viability.

This study demonstrates that the bioactive substances in fish oil, such as ω-3 unsaturated fatty acids, facilitate cell viability. However, the varying composition of fish oils derived from different tissues and organs is likely responsible for their differential effects on Caco-2 cell activity. Further in-depth analyses are necessary to identify the key active components in fish oil and elucidate their mechanisms of action. This will aid in optimizing the utilization strategies for these byproducts and developing functional, high-value fish oil products. Future research should focus on detailed chemical composition analysis of fish oils, screening of key active substances, and elucidation of the molecular mechanisms underlying their effects, laying the foundation for the development of novel fish oil health products.

Keywords: SC-CO2, Sardine side streams, Caco-2 cells, Cell viability, nutrients

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ISOLATION AND PURIFICATION OF QUERCETIN FROM SUBCRITICAL WATER EXTRACT OF WASTE ONION PEELS

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Abstract

Agricultural byproducts are increasingly being used in food processing. A flavonoid called quercetin is occasionally added to nutraceuticals as a nutritional and antioxidant supplement. It is a yellow powder that tastes harsh and has a distinct fragrance. The amount of quercetin in the inedible portion of onions is over 77 times more than that in the edible portion. Quercetin is abundant in onion peels, although it can be difficult to separate and purify from onion extract. One environmentally friendly way to extract quercetin from onion peels is by aqueous extraction. However, because the extracted quercetin requires a lengthy purification process, its industrial application is restricted. Subcritical water's temperature- dependent selectivity, safety, high recovery efficiency, and reduced cost make it a viable substitute for organic solvent in the extraction of flavanol quercetin. This work examined the use of subcritical water extraction to extract quercetin from onion peels and assessed the impact of critical optimization parameters by adjusting the extraction period, temperature, and mixture ratio of onion skin and double distilled water under high pressure. It was observed that the maximum extraction yield of quercetin from dry scales of onion was obtained by using subcritical water extraction. The dependency of extraction yield on the optimization parameters was clearly seen. Optimization reduces solvent usage and increases quercetin yield by 9-fold as compared to CC and 2-fold as compared to LLE (Soxhlet extract) for the purification of quercetin from aqueous extract of waste onion peels. In this study, a simple one-step liquid-liquid extraction method was developed for the efficient purification of quercetin from aqueous solution by using a solvent mixture of ethyl acetate and hexane. Crucially, for every milligram of pure quercetin, the optimum solvent needed for LLE was more than 600 times smaller than that needed for CC. The LLE approach used here is more sustainable and simpler to scale up. The one-step purification method developed in this study has the potential for large-scale production of pure quercetin from onion extract for various applications in the food, pharmaceutical, and cosmetic industries.

Keywords: Quercetin, waste onion peels, subcritical water extraction, purification, liquid-liquid extraction, extraction yield.

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SUPERCRITICAL FLUID AND PRESSURIZED LIQUID EXTRACTION AS ADVANCED STRATEGIES FOR PHENOLIC RECOVERY AND MYCOTOXIN ASSESSMENT IN OLIVE MILL WASTEWATER SLUDGE

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Abstract

This study evaluated innovative extraction technologies to recover phenolic compounds from olive mill wastewater (OMW) sludge in abandoned evaporation ponds in Spain, while analyzing contaminants. Four sludge types were selected for their high phenolic content to obtain extracts rich in secoiridoids and low in contaminants. A sequential SFE and PLE treatment was applied to obtain extracts for further analysis. Total phenolic content (TPC) was determined using the Folin-Ciocalteu method, with results expressed as gallic acid equivalents (GAE). Mycotoxins were extracted by QuEChERS and quantified by UHPLC-MS/MS. PLE emerged as the most efficient method for phenolic recovery, achieving TPC values of 244.28 mg GAE/g in TED-16 (from Toledo) and 188.50 mg GAE/g in TED-22 (from Córdoba), attributed to its high-pressure and high-temperature conditions. Conventional extraction showed intermediate TPC values (43.60-96.18 mg GAE/g), but showed a large pond-dependent variability, which limited reproducibility. The SFE treatment effectively produced a dry, granular residue with limited extraction of phenolic compounds, as reflected by the low TPC values (7.38–18.46 mg GAE/g). Enniatins (ENB1, ENA2, and ENA) were detected in fresh OMW and SFE-cakes, while other mycotoxins were absent. Notably, ponds with higher phenolic content (TED-16, TED-20, TED-22) showed lower enniatin levels. These results support the sustainable valorization of OMW sludge by using greeen extraction technologies for the recovery of bioactive compounds, highlighting the use of PLE for the obtention of phenolic-rich extracts.

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Keywords: OMW, sludge, phenolic compounds, SFE, PLE, mycotoxins

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