8th IMEKO FOODS

Food Safety and Traceability for a Sustainable Future

22 – 24 September 2025 • Grand Hotel Union, Ljubljana, Slovenia

BOOK OF ABSTRACTS

INTERNATIONAL MEASURMENT CONFEDERATION
TC23 "Metrology in Foods and Nutrition"

Jožef Stefan Institute

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22-24 September 2025, Ljubljana, Slovenia

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Welcome

Dear readers and delegates, it is a pleasure to present you with this Book of Abstracts consisting of contributions to the 8th IMEKOFOOD conference *"Food Safety and Traceability for a Sustainable Future"*. The conference organized by Jožef Stefan Institute is scheduled to take place at the Grand Hotel Union in Ljubljana, the capital city of Slovenia.

The increasing globalization of food trade, rapid changes in food systems, the pressures of climate change, and the demands of a growing world population are profoundly influencing food safety, quality, and nutrition. These issues are closely tied to food security, malnutrition, and public health outcomes worldwide. Addressing them requires reliable, comparable, and metrologically sound food data that can underpin risk assessment, regulatory decisions, and innovative industry practices.

Food is an exceptionally complex biological matrix that contains thousands of organic and inorganic substances. Analytical sciences and food metrology face the ongoing challenge of developing and validating innovative methods that can accurately assess a wide range of chemical contaminants and nutritional components within these matrices. Such efforts are essential to strengthen consumer protection and to ensure confidence in food systems at both national and international levels.

In this context, the 8th International IMEKOFOODS Conference (22–24 September 2025) will convene scientists, researchers, and practitioners from diverse fields—including food chemistry and metrology, nutrition, food safety and quality, risk assessment, and food authenticity. The conference will serve as a platform for the exchange of knowledge, the presentation of cutting-edge research, and the establishment of collaborative networks.

The program is structured around seven thematic areas, covering:
- Novel analytical and metrological approaches for food analysis.
- Methods for detecting and quantifying chemical contaminants and residues.
- Advances in nutritional analysis and food quality assessment.
- Risk assessment strategies supported by reliable measurement data.
- Food authenticity, traceability, and fraud detection.
- Interdisciplinary approaches linking food safety, nutrition, and public health.
- Contributions to sustainable and resilient global food systems.

We are especially committed to supporting early-career researchers, encouraging their participation, and fostering the next generation of experts who will carry forward the spirit of IMEKOFOODS.

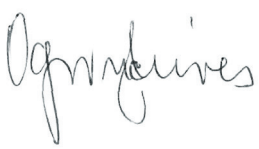
This year's scientific program includes 8 invited speakers, 61 oral presentations, and 40 poster presentations, featuring contributions from 17 countries across Europe and beyond. The conference opens with two dedicated workshops:
- AI in Food Science – Exploring artificial intelligence applications in food research and industry
- Soft Skills for Students: Project Writing – A practical guide to writing successful research and project proposals

In addition, a Cluster Workshop on the EU Cluster for Food Traceability & Trust will bring together several major EU projects (WATSON, ALIANCE, THEROS, FishEUTrust, Drag4FOOD) to explore innovation, synergies, and collaboration in building trustworthy and transparent food systems.

We warmly thank all participants—invited speakers, presenters, moderators, and sponsors—for their valuable contributions. Our sincere gratitude also goes to the organizing and scientific committees, whose dedication has made this conference possible.

Dear participants, we hope that the wide range of sessions, workshops, and networking opportunities will inspire you, deepen your knowledge, and strengthen your collaborations. May this conference be an exciting, informative, and rewarding experience for all.

We look forward to a fruitful and engaging IMEKOFOODS 2025!



Prof. dr. Nives Ogrinc
Chair of the IMEKOFOODS Organising committee

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The organising committee is deeply appreciative of the sponsorship generously provided by the following companies:

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INVITED SPEAKERS

Prof. Michele Suman

Barilla Analytical Food Science, Parma, Italy & Catholic University of the Sacred Heart, Milan, Italy

Conference Title: Versatility of the GC-IMS technique: from the freshness of eggs, to oil fraud, to the origin of apples

Prof. Michele Suman is a Food Safety & Authenticity Research specialist with over two decades of experience leading innovative research and development within the agri-food sector, with a track record of method development for studying contaminants, adulterants, authenticity markers and their transformation along food processing, pioneering new technologies as well. He has expertise in coordinating complex, internationally funded projects, and is dedicated to mentoring the next generation of professionals. Through collaboration with private and public stakeholders, he actively fosters innovation and advances the field. Since 2003, Prof. Suman has served as the Food Safety & Authenticity Research Manager in Barilla Spa company. He is also an Adjunct Professor of AgriFood Authenticity at Catholic University Sacred Heart (Milan/Piacenza) and a Visiting Professor at University of Chemistry and Technology in Prague. Additionally, he chairs the Italian National Normative Organization (UNI) Food Authenticity Working Group and contributes as a member of several prestigious committees, including Joint FAO/WHO Expert Committee on Food Additives (JECFA), working groups for Biotoxins-Processing Contaminants-Food Authenticity in European Committee for Standardization (CEN), the ILSI Europe Scientific Advisory Committee, where he also serves as Vice Chair of the Food Contaminants Task Force, the Italian Cluster Agrifood Scientific Board, and the European Food Safety Platform Steering Committee. His scientific impact is reflected in his Google Scholar H-index 32 & i10-index 69, Scopus H-index 28, Research Gate index 30. His scientific production is documented by 6 book chapters, 2 books edited, 180 contributions at national and international conferences and 130 papers in international ISI journals.

Dr. Stefan van Leeuwen

Wageningen Food Safety Research (WFSR), part of Wageningen University & Research, Wageningen, The Netherlands

Conference Title: The analytical toolbox for detection and identification of legacy and emerging PFAS in food production chains

Dr. Stefan van Leeuwen is a senior scientist at Wageningen Food Safety Research, with expertise in analytical and environmental chemistry. Driven by a passion for enhancing food safety, he specializes in developing state-of-the-art chromatography-mass spectrometry approaches to detect trace levels of environmental pollutants like PFASs, chlorinated and brominated pollutants. Dr. van Leeuwen is also at the forefront of innovation in identifying unknown contaminants, including novel PFAS compounds, by creating a comprehensive analytical toolkit. His current research explores emerging food safety challenges in circular food production, assessing how potential pollutants could pose risks when waste- and by-products are repurposed in food production systems. Through his work, Dr. van Leeuwen is helping to pave the way for a more sustainable and safer future in global food production. He is a co-chair of the biannually organised conference series Recent Advances in Food Analysis. He is co-chair of the Core Working Group on PFASs of the European Reference laboratory on POPs.

Prof. Amadeo Rodríguez Fernández-Alba

European Union Reference Laboratory for Pesticide Residues in Fruit & Vegetables, University of Almería, Spain

Conference Title: New trend in Multiresidue Methods: Achieving the maximum with the minimum

Prof. Amadeo is a founder of The Pesticide Residues Group AGR159 created in 1995, recognized as a center of excellence by the Plan Andaluz de Investigación in Spain. He has coordinated 30 national/regional projects, over 60 research contracts with national and international companies, and participated in 16 European projects. His research has produced over 370 ISI-JCR articles (35,000+ citations, h-index 105) and 5 patents, along with 6 edited books, 17 book chapters, and supervision of 28 PhD theses. His work focuses on chemical evaluations using mass spectrometry to identify contamination hotspots, predict trends, optimize remediation technologies, improve legislation, and design control systems. Current research includes microplastic evaluation in the atmosphere using passive samplers on beehives and the reuse of reclaimed water in greenhouse crop production. He also leads studies on balancing food production with minimizing environmental impact, assessing contaminants from pesticides, fertilizers, pharmaceuticals, and plastics, and developing advanced oxidation processes for water and plastic waste treatment. Since 2006, he has been Director of the EU Reference Laboratory for Pesticide Residues in Fruits & Vegetables, contributing to European legislation on pesticide use and control, including the EU's New Green Deal. Recognizing the laboratory's contribution to agronomic activities, biodiversity, and ecosystem sustainability, his team has also established a new line of work on the impact of contaminants on declining honeybees populations, participating in Spain's National Plans for chemical analysis.

Prof. María Dolores Hernando Guil

CSIC, The Spanish National Research Council, EEZA Experimental Station of Arid Zones

Conference Title: Microplastics: A New Hidden Threat in Our Food?

Prof. María Dolores Hernando Guil has participated in multiple national and international research projects, including 10 under the Spanish National R&D Plan, 3 European projects and 1 EU-Latin America cooperation project. Her work focuses on environmental contamination, pollutant behavior, and food safety, with emphasis on Persistent, Bioaccumulative, and Toxic (PBT) chemicals, Persistent Organic Pollutants (POPs), emerging contaminants, and microplastics. She has contributed to risk assessments, pollution control strategies, and conservation efforts, particularly in arid regions. She has co-authored 105 JCR journal articles (h-index: 46, 8,000+ citations), 6 book chapters, and the HERWE risk screening tool for chemical pollutants in wastewater effluents. She has also contributed to UN and EU technical reports on chemical risk management and served as Coordinator of Spain's National Reference Centers for the implementation of the EU REACH Regulation, the Global Harmonized System of Classification, and National Reference Center on Persistent Organic Pollutants (2007–2011). Since 2023, she has been Head of the Department of Desertification and Geo-ecology at the Spanish National Research Council (CSIC). She has participated in more than 150 international conferences, 30 seminars for national business confederations, and supervised 8 PhD theses (with 5 ongoing). She also teaches in Ph.D., Master's, and technical training programs at several Spanish universities.

Dr. Marta Dabrio Ramos

European Commission's Joint Research Centre

Conference Title: The Future of Food Analysis: Current Advances and Next-Generation Reference Materials

Dr. Dabrio Ramos holds a PhD in Analytical Chemistry from the Autónoma University of Madrid (UAM), Spain, followed by a postdoctoral stay at the Karolinska Institute in Stockholm, Sweden. After a brief period in the private sector, she has been part of the European Commission's Joint Research Centre for over 20 years. She has worked on the production of Certified Reference Materials, initially as Head of the Laboratory for Small Molecules, and currently serves as Team Leader for Reference Materials for Food Analysis.

Séverine Goscinny MSc

Department of Chemical and Physical Health Risks, Sciensano, Belgium

Conference Title: From concept to laboratory work: challenges and innovation in method validation for food additives.

Séverine Goscinny is a Senior Researcher at Sciensano in Brussels, where she has committed 18 years to the Department of Chemical and Physical Health Risks. Her research focuses on the safety and thorough analysis of chemical substances within the food chain, especially flavourings and additives. This involves developing and validating advanced analytical methodologies for their precise detection and accurate quantification in food. Additionally, she carries out chemical analyses to identify and measure various chemicals, which helps refine dietary exposure studies. A key part of her role is risk assessment, where she carefully evaluates the potential risks linked to these chemicals in our food. She is also active in European food safety networks, promoting collaboration and knowledge sharing among colleagues across the continent.

Prof. Dr. Michael Rychlik

Chair of Analytical Food Chemistry, Technical University of Munich, Germany

Conference Title: Stable isotope dilution assays for mycotoxins help assess the risk of plant-based meat alternatives

Prof. Dr. Michael Rychlik is heading the Chair of Analytical Food Chemistry at the Technical University of Munich, Germany (TUM). He graduated in food chemistry at the University of Kaiserslautern in 1988. His PhD studies on the flavour of bread were completed in 1996 and he was appointed full professor at the TUM in 2010. In 2015 he served as a Visiting Professor at the University of Queensland (UQ), Australia and in 2016 he was appointed an Honorary Professor at the latter University. In the last years he was also active as a Visiting Professor in 2016 at the National University of Singapore (NUS) and been teaching also in 2018 at the University of Hong Kong. In 2023 he was appointed a Visiting Professor at the University of Chemistry and Technology Prague. His group has been working for 25 years in the field of developing analytical methods for bioactive food components, in particular for vitamins, mycotoxins, odorants and lipids. Since 2014 he serves as the Head of the "Committee on Contaminants in the Food Chain" at the Federal Institute for Risk Assessment, Berlin, Germany.

Dr. Frans Verstraete

Official, European Commission DG Health and Food Safety

Conference Title: EU policy on contaminants in food: Recent developments, outlook and challenges.

Dr. Frans Verstraete graduated in 1985 as agricultural engineer at the University of Ghent (Belgium). After his studies he held positions at the University of Ghent and thereafter at the Belgian Ministry of Agriculture and he was for a period technical adviser of the Belgian Minister of Agriculture. He is working for the European Commission since 1997. In the European Commission he is working at the Directorate General Health and Food Safety. He is responsible for the elaboration, development and management of the EU-legislation on certain contaminants in feed and food.

PROGRAMME

MONDAY, 22. 9. 2025

9:30–11:30	**Workshop:** AI in Food Science – Exploring artificial intelligence applications in food research and industry	
	Workshop: Soft Skills for Students: Project Writing – A practical guide to writing successful research and project proposals	
12:00–13:30	**Lunch**	
13:30–13:50	**Opening ceremony** **Welcome word of the symposium - Nives Ogrinc (JSI), conference chair** **Welcome word of IMEKO - Joris Van Loco (SCIENSANO), IMEKO TC23 chair**	
	Invited speakers (Moderator: Nives Ogrinc)	
13:50–14:20	M. Suman: Versatility of the GC-IMS technique: from the freshness of eggs, to oil fraud, to the origin of apples	
14:20–14:50	M. Dabrio Ramos: The Future of Food Analysis: Current Advances and Next-Generation Reference Materials	
14:50–15:20	F. Verstraete: EU policy on contaminants in food: Recent developments, outlook and challenges	
15:20–15:50	**Coffee break**	
	FOOD AUTHENTICITY AND TRACEABILITY Moderators: Dimitra A. Lambropoulou, Michele Suman	**METROLOGY IN FOOD** Moderators: Lidija Fras Zemljič, Karl Presser
15:50–16:10	M. Z. Tsimidou: Building a quality characteristics database in support of the geographical indications for the Greek saffron "Krokos Kozanis"	A. Rossi: European Metrological Network for Safe and Sustainable Food: Coordinating Metrology and Research at European Level
16:10–16:30	R. Ofano: Isotopic fingerprinting of PDO tomatoes: a tool for authentication and traceability	N. Waegeneers: PFAS exposure in Belgium: safe for now, but are we looking at the whole picture?
16:30–16:50	G. Squeo: A comparison between FT-IR, NIR, and total fluorescence performance in honey adulteration detection	A. Bevivino: Food Side Stream-Derived Soil Improvers and Microbiome-Based Solutions for boosting soil health and food quality
16:50–17:10	F. Romaniello: Isotopic profiling as a tool for authenticating PDO extra virgin olive oils from Sicily and Apulia	M. Korošec: Nutritional and Sensory Impact of Cricket and Mealworm Meals Inclusion in Sourdough Bread
17:10–17:30	M. David: Authentication of local traditional Romanian meat products	L. A. Pérez Díaz: WDXRF as a tool for the characterisation of a candidate MRC for major and minor elements in rice flour
17:30–19:00	**Poster session**	
18:00	**Welcome party**	

TUESDAY, 23. 9. 2025

	Invited speakers (Moderator: Joris van Loco)	
9:00–9:30	M. Dolores Hernando Guil: Microplastics: A New Hidden Threat in Our Food?	
9:30–10:00	S. van Leeuwen: The analytical toolbox for detection and identification of legacy and emerging PFAS in food production chains	
	FOOD AUTHENTICITY AND TRACEABILITY Moderators: Maria Z. Tsimidou, Joris van Loco	**ADVANCES IN FOOD AND NUTRITION** Moderators: Monika Sabolova, Francesco Romaniello
10:00-10:20	A. Raluca Hategan: Data fusion of multi-source spectral data for the authentication of food and beverages	L. Kourimska: Nutritional Value of Edible Insects as Alternative Food and Feed Protein Sources in the Czech Republic
10:20–10:40	G. Puzo: Integrating Elemental and Isotopic Analysis for Wheat Authentication and Traceability	A. Rego: Comprehensive evaluation of the nutritional composition of chub mackerel (Scomber colias): Influence of cooking methods
10:40–11:00	C. Rossi: AGRITECH Project: integrated methodologies for geographical and varietal traceability of agricultural and food products	I. Khomenko: Real-Time VOC Profiling of Microalgae Fermented with Kefir Starters Using PTR-ToF-MS
11:00–11:30	**Coffee break**	
	FOOD DATA ANALYSIS Moderators: Maria Z. Tsimidou, Joris van Loco	**ADVANCES IN FOOD AND NUTRITION** Moderators: Jens Jørgen Sloth, Lenka Kourimska
11:30–11:50	C. Zoani: FAIR principles and metrological approaches for food integrity: data accuracy, availability, and privacy in the supply chain	M. Sabolova: Alcohol Consumption During Breastfeeding: A Questionnaire Survey Among Czech Women
11:50–12:10	M. Vankoningsloo: Automated AI-based classification of food products into the EFSA FoodEx2 system for standardized data integration	F. Sevi: Elemental and Metabolomic Characterization of Coffee Plant By-Products for Functional Beverage Development.
12:10–12:30	K. Presser: Interview Tool as a New Platform for High Quality Dietary Data Collection	V. Bunesova: Modulation of newborn and infant microbiota with prebiotics and probiotics
12:30–12:50	M. Ogrinc: NutriBase: A Web-Based System for Integration and Interoperability of Food Composition Data and Knowledge	L. Butinar: Microbial Spoilage Risks in Teran Wine: Tracking Brettanomyces and Biogenic Amines During Malolactic Fermentation
12:50–14:00	**Lunch**	
	Invited speaker (Moderator: Nives Ogrinc)	
14:00–14:30	S. Goscinny: From concept to laboratory work: challenges and innovation in method validation for food additives	

	FOOD DATA ANALYSIS & FOOD PROCESSING Moderators: Dolores M. Hernando Guil, Stefan van Leeuwen	**ADVANCES IN FOOD AND NUTRITION** Moderators: Gabriel Mustatea, Lenka Kourimska
14:30–14:50	G. Serafini: Co- Creation, the responsibility to be innovative: the METROFOOD-IT case	M. Costanzo: Multi-omics approach of wheat varieties, agronomic practices and functional microbiome for sustainable precision agriculture
14:50–15:10	L. Coppola: AI-Driven Robotic Arm Guidance and Control for Agrifood: Enabling Smart, Zero-Touch and Safe Food Automation	P. Kourimsky: Sensory properties and nutritional composition of cookies with added insect meal
15:10–15:30	M. Zampano: Toward Sustainable Mozzarella di Bufala Campana:LoRaWAN-Based Monitoring of Greenhouse Gases to Quantify and Reduce Emissions	N. Modrackova: Bifidogenic effect of prebiotics: a nutritional strategy for gut microbiome modulation
15:30–15:50	M. Magarelli: Explainable Machine Learning on SWIR Hyperspectral Data for Origin-Based Classification of Wheat Grains and Flours	A. Bernardini: Use of by-products in sourdough bread: Integrating analytical and technological services for sustainable food innovation
15:50–16:10	E. Bešter: Comparative analysis of volatile compounds and sensory assessment of olive oils	I. Bastardo-Fernandez: Application of ICP-MS for the determination of trace elements in side-streams in view of production of new food concepts
16:10–16:30	E. Abdullajeva: Comprehensive analysis of volatile compounds released during the heat-treatment of highly processed plant-based alternatives	D. A. Lambropoulou: Screening of pesticides in peaches using liquid chromatography high resolution mass spectrometry
16:30–18:00	Poster session & Coffee break	
	17:00–18:30 **IMEKO TC 23 (members only)**	
19:30	**Gala Dinner**	

WEDNESDAY, 24. 9. 2025

	Invited speakers (Moderator: Claudia Zoani)	
9:00–9:30	A. Rodríguez Fernández-Alba: New trend in Multiresidue Methods: Achieving the maximum with the minimum	
9:30–10:00	M. Rychlik: Stable isotope dilution assays for mycotoxins help assess the risk of plant-based meat alternatives	
	Workshop: CLUSTERING Moderator: Jon Switters	**ANALYTICAL APPROACHES IN FOOD CONTAMINANTS** Moderators: Michael Rychlik, Chiara Portesi
10:00-10:20	K. Jakobsen: Building trust in the whitefish value chain: Organisational and technical dimensions of a traceability pilot	J. Sloth: Exploitation of seaweed for food and feed applications – the need for elemental analysis for assessment of safety
10:20–10:40	S. Sadrmousavigargari: Consumer Purchase Intentions for Blockchain-Tracked Olive Oil and Feta Cheese	M. Torrelli: Development of an UHPLC-MS/MS method for determination of ultra-short PFAS in vegetable samples
10:40–11:00	K. Choumas: Blockchain based supply chain for PDO Feta Cheese: The ALLIANCE approach	M. Novak: Chemopreventive Effects of Rosmarinic Acid against the Carcinogenic Food Contaminant Aflatoxin B1
11:00–11:30	**Coffee break**	
	Workshop: CLUSTERING Moderator: Jon Switters	**ANALYTICAL APPROACHES IN FOOD CONTAMINANTS** Moderators: Andrea Rossi, Erika Bešter
11:00–11:50	P. Lappas: Securing Agri-Food Supply Chains with AI for Early Warning, Fraud Detection, and Decision Support	J. Van Loco: METROFOOD-BE service provision to support circular economy, food safety and sustainable solutions for food packaging
	11:50–12:50 **Round table discussion**	**11:50–12:10** E. Andreasidou: Assessing the Uptake and Risk of Contaminants of Emerging Concern in Tomato Cultivation Using Treated Wastewater and Sludge
		12:10–12:30 L. Coenegrachts: Broadening Arsenic Speciation: Inclusion of Small Organoarsenic Species in Standard Food Testing Methods
		12:30–12:50 B. Clerc: Large-scale biomonitoring of bisphenols in the Swiss adult population
12:50–14:30	**Lunch**	

	FOOD PACKAGING & NANOMATERIALS Moderators: Claudia Zoani, Marjeta Mencin	**ANALYTICAL APPROACHES IN FOOD CONTAMINANTS** Moderators: Isabel Bastardo-Fernandez, Mojca Milavec
14:30–14:50	A. Rossi: Lactose Tablets as suitable Microplastics Reference Material to support validation studies and food quality control	T. Hamitouche: Assessment of the impact of cooking on the fate of potentially toxic elements and nutrients in foodstuff
14:50–15:10	C. Portesi: The ScreenFood project: Metrology for food safety in the circular economy	G. Goderdzishvili: Oxidative Stress and Inflammation Dynamics in Type 2 Diabetes: Effects of the SGLT2 Inhibitor Empagliflozin
15:10–15:30	V. Poscente: Antimicrobial Packaging Innovation for Fresh Strawberries	A. Vehar: Quality of tomatoes grown in sludge containing contaminants of emerging concern
15:30–15:50		R. Esposito: Natural actives for ecofriendly/sustainable alternative disinfection strategies for agricultural products
16:00	**Closing remarks**	

POSTER SESSION, Monday 22. 9. 2025

ADVANCES IN FOOD AND NUTRITION

P1 D. A. Alexandra: Antimicrobial profile of sourdough lactic acid bacteria against pathogen bacteria and molds

P2 Z. Koziara: The histaminergic system as a potential target in the treatment of binge eating behaviour in an animal model

P3 L. Morales Erazo: Recovery and Green Purification of Methylxanthines and Flavan-3-ols from Cocoa Husk Agro-Waste

P4 M. Korošec: Dietary Potassium Reduction in Fruits and Vegetables: A Study on the Efficacy of Ultrasonic Soaking and Thermal Processing

P5 A. Culetu: Evaluation of side-streams from sea buckthorn oil production

P6 A. Culetu: Exploring the amino acid profile of various legumes for optimal nutrition

P7 C. Zoani: Co-creation from University-based Living Labs: the case of the FUSTO Programme

FOOD AUTHENTICITY & TRACEABILITY

P8 C. Terro: Multi-Analytical Assessment of Paprika and Cinnamon Authenticity and Quality in the Slovenian Market

P9 Z. Sel: Analytical Characterisation of Emerging High-Value Seed Oils in Slovenia

P10 M. Mencin: Impact of Climate Change on Fatty Acid Composition and $\delta^{13}C$ Signatures in Slovenian Extra Virgin Olive Oil: A Long-Term Study

P11 N. Poklar Ulrih: Quality Assessment and Adulteration Detection of Rosemary and Laurel Essential Oils Using GC-C-IRMS

P12 G. Puzo: Integrated Multi-Method Approaches to ensure Olive Oil Authenticity and Traceability

P13 A. Bernardini: Territorial origin determination of wheat flour by NMR profiling: a case study

P14 L. Kpattah: Tracing the Sources of Adulteration along the Ghanaian Food Supply Chain using Isotopic and Chromatographic Techniques: Implications for Food Authenticity

FOOD DATA ANALYSIS

P15 G. Mustatea: AI-Driven Review of Analytical Methods for Micro- and Nanoplastics Analysis

P16 M. Zampano: Real-time AI-based monitoring system for microbiological safety of drinking water

METROLOGY IN FOOD

P17 M. Z. Tsimidou: METROFOOD-RI integrated analytical services: Phenol determination in agro-industrial by-products and derived formulations

P18 M. Khayrullaev: The Impact of Equipment Conformity Assessment in Ensuring the validity of Food Testing: A Comparison of Laboratory Practices

P19 C. Vansnick: Metal impurities in food additives: Do they contribute to dietary metal exposure?

P20 A. Bogožalec Košir: Standardizing Plant Pathogen Detection using dPCR as a Reference Method for Xylella fastidiosa

P21 P. Marinček: Development and validation of control materials for molecular detection of Listeria monocytogenes in milk

P22 O. Shcherbakova: Grain moisture determination. Using of standard addition method

P23 D. Chupis: Metrology for the phosphorus content measurements in vegetable oils in support of European and international food safety

POSTER SESSION, Tuesday 23. 9. 2025

FOOD PACKAGING

P1 M. Di Mario: What is the future of FCM after the ban on single-use plastic articles? A deep dive into alternative materials in Belgium.

P2 F. Romaniello: Enhanced untargeted method to detect organic and inorganic contaminants in biobased and recycled food contact materials

P3 T. Šaula: Microplastics on the Surface of Packaged Chicken Meat: Method Optimization for Detection, Isolation, and Characterization

P4 A. John: Poly (lactic acid)–Poly (L-lactide-co-ethylene adipate) Hybrid Films: A Promising Approach for Sustainable Food Packaging

FOOD PROCESSING

P5 L. Kourimska: Food Processing Workshops in the RURBANIVE Project: Helping Local Producers Shorten the Supply Chain

P6 T. Šaula: Antibacterial Potency of Slovenian Honeys against Foodborne Pathogens

P7 I. Petrignani: Rapid and non-destructive assessment of cultivars and geographical origin of durum wheat flour using Raman spectroscopy

NANOPARTICLES IN FOODSTUFFS

P8 U. Rozman: Microplastics in food: literature review

P9 N. Renier: Identifying Technological Needs in Micro- and Nanoplastics Research: A FHERITALE Perspective

ANALYTICAL APPROACHES IN FOOD CONTAMINANTS

P10 H. Baša Česnik: Multiresidual GC-MS/MS method for determination of pesticide residues in fruits

P11 H. Baša Česnik: Multiresidual GC-MS/MS method for determination of pesticide residues in vegetables

P12 M. L. Adriana: GC-MS/MS method for acrylamide determination in various food matrices from Romania

P13 M. L. Adriana: A quenchers-based protocol for analysis of polycyclic aromatic hydrocarbons (PAHs) in vegetable oils and their derivatives

P14 M. L. Adriana: Validation study according to commission regulation (EU) 2021/808 for determining PAHs in cereal derivatives by GC-MS/MS

P15 T. Radovanović Vukajlović: Fungal and Yeast Contaminants in Dried Fruits: Implications for Food Quality and Safety

P16 I. Bastardo-Fernandez: High content, low release: Exploring TiO2 nanoparticle migration from food packaging using APEX™-single particle ICP-MS/MS

P17 V. Alampanos: Trace-level determination of PFAS in water samples using LC-HRMS and a novel MOF sorbent in miniaturized SPE

CLUSTERING

P18 M. Pirc: Consumer Perspectives on Food Fraud Vulnerability and Traceability: Insights from a Cross-Country Survey

P19 L. Karapetsi: Galician mussel species identification via HRM analysis and ML for automated DNA Classification

P20 D. Kocman: User-centred pilot testing of tools for organic and geographical indication of food products

P21 Lorenzo Nolfi: Biosafety assessment of raw materials and soil improvers for a safe use in agriculture

Workshop: Traceability and Trust Solutions in EU Food Supply Chains

The EU Cluster for Food Traceability and Trust is a collaboration of currently 13 European research and innovation projects that share a common ambition: to make food systems more transparent, trustworthy, and resilient. The cluster brings together initiatives exploring how digital technologies such as blockchain and artificial intelligence, combined with improved organisational practices, can help address long-standing challenges of food fraud, safety, and consumer confidence. By joining forces, the projects seek not only to advance technical solutions but also to open dialogue across disciplines and stakeholders — from producers and retailers to policymakers and consumers — about what it truly takes to build trust in the food we eat.

This workshop offers participants a chance to hear about emerging solutions from across the cluster and to contribute to shaping their future direction. The morning begins with short research presentations on traceability pilots in the whitefish value chain, consumer attitudes towards blockchain-tracked olive oil and feta cheese, and a blockchain-based supply chain model for PDO feta. After a short break, the session shifts into a more interactive mode: solution "snapshots" from additional projects, breakout discussions on barriers and opportunities, and a plenary exchange to distil key insights.

The discussions will focus on real-world questions: What prevents blockchain and AI from being widely deployed in food systems? What kinds of evidence and data are needed to inspire trust among consumers and stakeholders? How can EU projects better connect their tools, knowledge, and datasets? And what kinds of policy frameworks or market incentives are missing for scaling these innovations?

Importantly, this workshop will bring together participants from WATSON, ALLIANCE, THEROS, FishEUTrust, and Drag4Food, ensuring a rich mix of perspectives from across the EU's food traceability innovation landscape.

Rather than producing only formal conclusions, the session is designed to generate collaborative outputs — ranging from shared perspectives and knowledge gaps to a joint workshop summary, a co-created brainstorming space, and even a short blog post co-authored with participants. By the end, we hope to leave not only with sharper questions but also with stronger connections across projects and stakeholders who care about trustworthy food supply chains in Europe.

Abstract presentations:

K. Jakobsen (WATSON): **Building trust in the whitefish value chain: Organisational and technical dimensions of a traceability pilot**

S. Sadrmousavigargari (ALLIANCE): **Consumer Purchase Intentions for Blockchain-Tracked Olive Oil and Feta Cheese**

K. Choumas (ALLIANCE): **Blockchain-based supply chain for PDO Feta Cheese: The Alliance approach**

P. Lappas (ALLIANCE): **Securing Agri-Food Supply Chains with AI for Early Warning, Fraud Detection, and Decision Support**

M. Pirc (WATSON): **Consumer Perspectives on Food Fraud Vulnerability and Traceability: Insights from a Cross-Country Survey**

L. Karapetsi (THEROS): **Galician Mussel Species Identification via HRM Analysis and ML for Automated DNA Classification**

D. Kocman (THEROS): **User-centred Pilot Testing of Tools for Organic and Geographical Indication of Food Products**

ORAL PRESENATIONS

Versatility of the GC-IMS technique: from the freshness of eggs, to oil fraud, to the origin of apples

Michele Suman

Catholic University of Sacred Heart Milan-Piacenza, Italy

This presentation explores the versatility of Gas Chromatography–Ion Mobility Spectrometry (GC-IMS) as a rapid, sensitive, and cost-effective analytical tool for food quality control. Three case studies demonstrate its application across diverse food matrices: egg freshness, geographical origin of dehydrated apples, and authenticity of extra virgin olive oil (EVOO). In the first case, GC-IMS was employed to assess the freshness of egg products under various storage conditions. Identifying several volatile markers, the method proved more sensitive than official protocols and suitable for 100?tch screening in production environments. The second case focused on verifying the "100% Italiano" claim for dehydrated apples used in food industry. A comprehensive experimental design considered variables such as variety, peeling, dehydration, and harvest year. GC-IMS data, processed through PCA and OPLS-DA, enabled clear discrimination between Italian and non-Italian origins and the model achieved more than 90?curacy in validation sets. The third case addressed EVOO fraud detection, particularly the undeclared blending with soft-refined oils (SROOs). GC-IMS fingerprinting revealed distinct VOC profiles between authentic EVOOs and adulterated samples. SIMCA analyses confirmed the method's ability to detect subtle changes due to soft deodorization and deacidification. The technique demonstrated high repeatability and stability, making it ideal for industrial screening. Overall, GC-IMS offers a powerful, high-throughput solution for food authenticity and quality assurance, with minimal sample preparation and strong potential for broader implementation in quality control laboratories.

The Future of Food Analysis: Current Advances and Next-Generation Reference Materials

Marta Dabrio

European Commission, Joint Research Centre, Belgium

The food systems in Europe are complex and vulnerable to challenges such as climate change, food security and geopolitical tensions. In this context, to maintain the resilience and sustainability of the food system, the European Union's food legislation plays a crucial role in ensuring the safety and authenticity of the food supply chain. The EU's strict food safety and authenticity guidelines, such as those related to labelling, tracing and testing, are designed to protect consumers from contaminants, foodborne illnesses and deceptive practices, and to maintain trust in the food system. The food industry and food authorities control the food safety, quality, and authenticity by relevant food testing methods. The role of reference materials in ensuring the accuracy and reliability of food analysis has never been more critical. This presentation will explore the vital role of reference materials in modern food analysis, with some examples, highlighting their importance in ensuring the safety, quality, and authenticity of food products. The talk will cover the current state of reference materials in food analysis, including recent advances in their production, characterization, and application. The presentation will furthermore discuss the challenges and opportunities in the field, including the need for reliable reference materials in emerging areas, the development of new technologies and methods, and the importance of international collaborations and standardization efforts.

EU policy on contaminants in food: Recent developments, outlook and challenges

Frans Verstraete

European Commission, Belgium

The EU legislation on contaminants Council Regulation (EEC) No 315/93 of 8 February 1993 provides that food containing a contaminant in an amount which is unacceptable from the public health viewpoint shall not be placed on the market (food can only be placed on the market when it is safe). Furthermore, it is foreseen that contaminant levels shall be kept as low as can reasonably be achieved by following good practices at all stages of the production chain and in order to protect public health, maximum levels for specific contaminants shall be established where necessary. In recent years, regulatory levels for several contaminants have been established and updated and this to take account of the outcome of risk assessments performed by the European Food Safety Authority (EFSA). The maximum levels are established in Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006 (http://data.europa.eu/eli/reg/2023/915/2025-01-01). Despite frequent updates to the EU contaminants legislation, there is still a lot of work ahead! In the presentation, recent and future developments on EU legislation on contaminants in food shall be presented. Climate change, changes in dietary patterns, novel/new foods, circular economy etc. entail new challenges for the safety of the food chain. In addition, in order to continue to ensure a high level of food safety it is necessary not to address single contaminants individually but also pay more attention to the combined exposure to multiple contaminants. In addition, particular attention shall be paid to the analytical requirements and analytical challenges for an effective EU policy on contaminants in food. Indeed, for an effective risk management and enforcement, it is not only sufficient that a method of analysis is available, but the method of analysis must be able to be used for routine control, be reliable, sensitive, quick and preferably cheap.

Building a quality characteristics database in support of the geographical indications for the Greek saffron ″Krokos Kozanis″

Maria Z. Tsimidou, Stella Ordoudi

Aristotle University of Thessaloniki - AUTH , Greece

Saffron is the spice that comes from the drying of the red stigmas of Crocus sativus L. flower. This most expensive spice by weight in the world, is of great importance for the local community around the village Krokos (Kozani, Western Macedonia, Greece). This work presents the results of a systematic study on the compositional variability in Greek saffron in terms of three determinant criteria defined by international trade standards. A total of 547 samples (2022 harvest) were obtained from registered growers - members of the Cooperative of Kozani Saffron Growers. The administration and quality control managers of the Cooperative coordinated sample collection and direct shipment to our laboratory for analysis according to ISO 3632-2 test methods to assess moisture content, and also coloring, flavor and aroma strength indices. The analytical data were combined with metadata about individual member production quantity, processing practices, etc that helped overall interpretation and discussion. The results of the systematic study were used to start building a compositional database for the Protected Designation of Origin saffron "Krokos Kozanis". This database needs regular updating to serve not only the internal quality control management system of the Cooperative but also to provide robust documentation for official controls in support of the registered Geographical Indication that enhances consumer confidence in fair trade practices.

Acknowledgement: Part of this research is linked to the project ELKE/AUTH contract no 278709, financed by the Kozani Saffron Growers Cooperative. The project 'Dissemination and exploitation of the outcomes of the Laboratory of Food Chemistry and Technology' (AUTh Research Committee code 96677) is acknowledged for financial support of MZT participation.

Isotopic fingerprinting of PDO tomatoes: a tool for authentication and traceability

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The authentication and geographical traceability of agri-food products are essential strategies to ensure food safety and quality. These approaches not only safeguard the integrity of Protected Designation of Origin (PDO) products but also enhance their market competitiveness and prevent fraud. Soil, as the primary source of mineral elements for plants, influences the elemental and isotopic profile of agricultural products based on bioavailability and pedoclimatic conditions. In this study, stable isotope ratio analysis was employed to investigate the geographic provenance of soils and PDO tomatoes grown on the slopes of the Somma-Vesuvius volcanic complex, a small geographical area where unique pedoclimatic conditions influence their quality and organoleptic properties. Soil and tomato samples were collected from representative farms located both within and outside the PDO-designated area over four years (2021-2024). The isotopic ratios δ34S, δ15N, δ13C and S, N, C concentrations were measured by Isotope Ratio Mass Spectrometry (IRMS) in both tomato and soil samples. The resulting data were subjected to supervised multivariate discriminant analysis, specifically Linear Discriminant Analysis (LDA), to evaluate the discriminatory power of the isotopic parameters for geographic origin authentication. Statistical validation using leave-one-out cross-validation revealed that the highest classification accuracy was achieved when data from each year were analyzed independently, rather than as a combined dataset. Among the isotopic parameters considered, δ34S was the most discriminant markers across all individual years and in the combined dataset. The strong correlation observed between the isotopic profile of tomatoes and their corresponding soils confirms the robustness of this approach. These findings support the use of isotope ratio analysis as a reliable and effective analytical tool for food traceability, contributing to the protection and valorization of PDO products.

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A comparison between FT-IR, NIR, and total fluorescence performance in honey adulteration detection

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Honey is a natural, high value product, whose authenticity is often compromised by fraudulent practices, such as the addition of cheaper sugar syrups. Honey adulteration is one of the most widespread food frauds. This study evaluates the feasibility and performance of spectroscopic techniques to quantify the adulteration of citrus and wildflower honey. To this end, samples of authentic honey were adulterated with three different sugar syrups in increasing concentrations. FT-IR and NIR spectra, and fluorescence excitation-emission matrices (EEMs) were collected for pure honeys (n = 2), pure syrups (n = 3), and adulterated samples (n = 42). FT-IR and NIR spectra were explored by principal component analysis (PCA), then partial least squares (PLS) regression was used for quantify the level of adulteration. Considering NIR, a global PLS model showed promising predictive capacity of the level of adulteration, with an R2CV of 0.76 and an error in cross-validation (RMSECV) of 6%. However, the performance was affected by the type of adulterant. By splitting the dataset, the regression model improved significantly (R2CV 0.94; RMSECV 3%). PCA of FT-IR spectra highlighted differences in the samples according to the type of adulterant; nonetheless, the PLS model showed poor and insufficient predictive performance. Fluorescence EEMs revealed distinct bands in pure honeys while syrups had weaker signals. Parallel factor analysis (PARAFAC) identified two significant components, with Component 2 correlated with the level of adulteration. Linear regression based on Component 2 scores produced accurate estimates, but highlighted a bias between honey types. A second approach, based on NPLS trained on the whole dataset, provided interesting results (R2 0.92 in calibration, 0.90 in CV; RMSECV 4%). Overall, NIR and fluorescence spectroscopies, coupled with multivariate analysis, have proven to be suitable for honey authentication. NPLS applied on EEMs provided an effective global model for all the tested adulterants. In the other cases, it seems that a proper strategy rely on the development of adulterant-specific (NIR) or honey-specific (EEMs-PARAFAC based regression) models, which could be more challenging.

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Isotopic profiling as a tool for authenticating PDO extra virgin olive oils from Sicily and Apulia

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Extra virgin olive oil (EVOO) is a product of significant economic and cultural importance, yet its authenticity and geographical origin are often targeted by fraudulent practices. In this framework, the study of stable isotopes specifically carbon ($\delta^{13}C$), oxygen ($\delta^{18}O$), and hydrogen ($\delta^{2}H$) has proven to be a powerful tool for determining and confirming the regional origin of EVOO. The natural variation in isotopic ratios is strongly influenced by region-specific environmental and agricultural factors such as climate, altitude, water resources, and cultivation techniques. These isotopic "signatures" act as indicators that can distinguish oils from different geographical areas, thus aiding in the prevention of food fraud and the verification of authenticity. This research focuses on analyzing the isotopic profiles of carbon, oxygen, and hydrogen in 60 monovarietal EVOO samples collected from Sicily and Apulia—two prominent olive oil-producing regions in southern Italy, both recognized with EU Protected Designation of Origin (PDO) status. The main goal is to identify statistically significant links between the isotopic measurements and the oils declared origins. Furthermore, by applying Gas Chromatography–Isotope Ratio Mass Spectrometry (GC-IRMS), the $\delta^{13}C$ values of individual fatty acids will be determined. The collected isotopic data will be examined through multivariate statistical methods, such as Discriminant Analysis (DA) and Principal Component Analysis (PCA), to uncover patterns and clusters that reflect specific geographical origins. Predictive models will be developed based on these isotopic ratios to define unique regional profiles, providing a scientifically grounded and effective approach for verifying the traceability and authenticity of EVOO from these renowned southern Italian regions. The findings of this study aim to support the fight against food fraud in the olive oil sector by delivering a reliable analytical method for origin verification. The approach developed here could be adopted by regulatory bodies and analytical laboratories to help safeguard product integrity and consumer trust in the EVOO market.

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Authentication of local traditional Romanian meat products

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Meat constitutes a significant component of the human diet across a broad population. Moreover, traditionally produced products, often in small batches, hold strong appeal for consumers. In this context, the authentication of meat products is essential to ensure food quality, enable traceability, prevent fraudulent practices, and verify label claims associated with premium or specialty items. The present study analyzes the samples of pork tenderloin cuts and the obtained smoked meat products manufactured by local Romanian producers. In this regard, the isotopic and elemental profiles of the meat samples were obtained and employed to authenticate the environmental and geographical origin signature and the dietary regime. Specially, the elemental analysis followed the identification of the concentration of macroelements (Ca, K, Mg, and Na) and essential elements (Fe, Zn, and Co), while the stable isotope ratios of interest were 2H/1H, 18O/16O, 12C/13C, and 14N/15N. In order to obtain authentication models, multivariate analysis was used including principal component analysis (PCA), linear discriminant analysis (LDA), and partial least squares discriminant analysis (PLS-DA). Through the application of supervised feature selection methods, the significant markers capable to authenticate the pork tenderloins in regard to the region of production were identified and further analyzed. Notably, 13C values effectively revealed that the animals were raised on C3 plant-based diets. 15N values showed correlations with nitrogen sources and farming practices, while 18O and 2H isotopic ratios reflected environmental water sources and specific climatic conditions. Elemental profiles also varied significantly across samples, providing an additional discriminatory layer when paired with isotopic data. The combined use of macroelement and essential element concentrations with stable isotope analysis processed using multivariate analysis proved to be a robust approach for meat authentication, high classification accuracies being obtained. This integrated analytical approach aims at preserving the designations of origin of food products (PDO certificate), contributes to the improved transparency in the meat supply chain and can be instrumental in regulatory enforcement and consumer protection.

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European Metrological Network for Safe and Sustainable Food: Coordinating Metrology and Research at European Level

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The provision of safe, high-quality food is vital for human health, and innovation in the food sector is needed to protect the environment, ensure sustainability, and respond to future needs. EURAMET, the association of National Metrology Institutes (NMI) in Europe, approved in May 2022 the European Metrology Network (EMN) for Safe and Sustainable Food (EMN Food). The EMN Food aims to foster collaboration and coordination in the measurement science community to meet metrology needs along the food chain, working within the European Unions Farm to Fork Strategy. The network promotes a harmonised approach to food measurements, reference materials and standards, which will allow National Metrology Institutes (NMIs) and Designated Institutes (DIs) across Europe to respond to stakeholders and regulations with confidence and quality. This will afford greater protection to citizens and the environment and accelerate the response to emerging and future metrology needs. The EMN-Food has also promoted scientific activities related to metrological research in food safety and sustainability, and in the framework of national and European projects, for guaranteeing an adequate economical support of the EMN activities. A key objective of the EMN is the definition of a common approach for the production of Certified Reference Materials and Reference Materials for food and food-related matrices and analytesIn this presentation, the SRA and the EMN strategy for reference materials will be presented, together with the national and international projects involving the consortium and aligned with the scope of the EMN.

PFAS exposure in Belgium: safe for now, but are we looking at the whole picture?

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The latest EFSA evaluation on per- and polyfluoroalkyl substances (PFAS) resulted in a tolerable weekly intake (TWI) for the sum of PFOS, PFOA, PFHxS and PFNA (∑4PFAS) of 4.4 ng/kg bw/week [1]. Given that the last Belgian exposure assessment focused solely on PFOS and PFOA [2], a re-evaluation of the exposure and risk to PFAS was needed. A comprehensive sampling, reflecting all foods relevant for PFAS exposure and Belgian consumption habits, yielded 283 food samples. The study did not include homegrown food. The selection of 25 PFAS was based on Recommendation (EU) 2022/1431 and Regulation (EU) 2023/915. The samples were analysed using a validated method, involving a QuEChERS-based extraction, a two-step SPE purification process, and analysis by UHPLC-HRMS. Potential PFAS contaminations in the laboratory were minimised to achieve low quantification limits. The PFAS occurrence data [3] were combined with consumption data from the Belgian food consumption survey [4] to assess dietary exposure. The risk assessment for ∑4PFAS was conducted following the methodology used by EFSA [1]. Of the 25 targeted PFAS, a quantifiable exposure assessment could be conducted for 13. The exposure estimates were highest for PFBA, followed by a PFAS group with exposure estimates approximately ten times lower: PFPeA, PFOA, PFHxA, and PFOS. The exposure to the remaining PFAS was at least 30-fold lower. The middle-bound dietary exposure to PFOS in Belgium decreased 8-fold compared to the previous Belgian study from 2012, which may reflect the phase-out of PFOS in the EU since 2009. The exposure to PFOA, phased out since 2020, also decreased, but to a lesser extent. The mean exposure to the Σ4PFAS, assuming equal toxicity potencies, ranged from 0.93 ng/kg bw/week for adults to 1.7 ng/kg bw/week for children. The TWI was not exceeded for adolescent and adult populations and was only marginally exceeded by a minor fraction of the children's population. Hence, if solely dietary exposure to ∑4PFAS is considered, no health concerns are expected for the Belgian population. Nonetheless, exposure to PFAS extends beyond these four compounds and is not restricted to food alone.

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Food Side Stream-Derived Soil Improvers and Microbiome-Based Solutions for boosting soil health and food quality

Annamaria Bevivino[1], Lorenzo Nolfi[2], Arianna Bindo[3], Tapio Salo[4], Minna Sarvi[4], Minna Kahala[4], Avelino Álvarez Ordóñez[5], Patricia Oliveira[5], Andrea Visca[1], Silvia Tabacchioni[1], Luciana Di Gregorio[1], Manuela Costanzo[1], Elisa Clagnan[6], Nicola Colonna[1], Andrea Brunori[1], Roberta Bernini[2], Marina Caldara[7], Sara Graziano[7], Caterina Agrimonti[7], Ansa Palojärvi[8], Nelson Marmiroli[9]

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There is an urgent need to develop new approaches for improving the sustainability of the food systems and enhancing soil health. This study explores the impact soil improvers derived from food processing side streams along with microbiome-based solutions on soil health and plant performance, with the final aim to reduce reliance on chemical inputs within a circular bioeconomic framework. A data mining approach was first used to assess the effect of soil improvers and biofertilizers on soil health and biodiversity, with the target to explore their ecological role in the soil ecosystem and identify the driving factors behind their effectiveness. Next, innovative and locally produced soil improvers from the food industry, previously evaluated for biosafety assessment, were tested in greenhouse conditions on spring wheat, alone and combined with a synthetic microbial community (SynCom) composed of plant growth-promoting microorganisms (PGPMs), while biochar derived from food processing residues was applied in field trials on tomato, in combination with different types of commercial biostimulants (Rhizophagus intraradices, Micosat F and Rhizovital). Plant growth parameters were monitored, and soil samples were collected for biological and chemical analysis. The collection and an in-depth analysis of available data from EU projects and long-term field experiments through a Python script, along with VOSviewer, permitted to define the main driver factors influencing soil health, thus providing the basis for the development of strategies and policies aimed at promoting sustainable agricultural practices. The application of biochar, compost, and digestate and other soil improvers has demonstrated significant improvements in soil health metrics, crop yields, and environmental sustainability. Whole-genome sequencing of SynCom members confirmed the absence of pathogenic traits and identified a wide range of plant growth-promoting features, supporting their broader application in sustainable agriculture. Ongoing analyses of rhizospheric soil samples and agronomic outcomes from greenhouse and field experiments will permit to identify novel biomarkers of soil health and determine the most effective combinations of soil improvers and microbiome-based tools for field application. Our study permits to assess how soil improvers and microbiome-based solution influence soil health, enabling more targeted recommendations for sustainable soil management. It highlights the critical role of scientifically validated

microbiological indicators in fostering resilient food systems and supporting a robust 'farm to fork' strategy.

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Nutritional and Sensory Impact of Cricket and Mealworm Meals Inclusion in Sourdough Bread

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Edible insects are emerging as a sustainable food source, recognized for their high-quality proteins, fats, minerals, and bioactive compounds, offering a viable strategy for protein diversification. Despite their nutritional potential, regulatory status as novel foods (EU) and consumer acceptance remain significant challenges. This study investigated the nutritional and sensory implications of incorporating ground dry cricket (Acheta domesticus) and mealworm (Tenebrio molitor) meals into sourdough bread. Wheat flour was partially substituted at 5% and 10% (w/w). Chemical analyses revealed that insect inclusion significantly increased bread protein content by 10-25%, dietary fibre by approximately 2%, and ash by 2-8%, while concomitantly reducing available carbohydrates by up to 7%. Notably, the 10% mealworm meal substitution nearly doubled the bread's fat content. A professional sensory panel observed that higher insect meal concentrations (10%) negatively impacted bread characteristics, leading to uneven crumb structure, irregular loaf shape, gritty texture, and undesirable earthy/animal-like flavours, particularly in cricket-enriched samples. Conversely, breads with 5% insect meal exhibited more favourable sensory profiles, though slightly inferior to the 100% wheat flour control. These findings indicate that a moderate inclusion (5%) of ground mealworms and crickets can effectively enhance the nutritional value of sourdough bread without severely compromising sensory quality, representing a promising step toward developing sustainable and nutritionally superior food products. However, the intrinsic aroma of insect meals within the bread matrix necessitates further research into consumer acceptability.

WDXRF as a tool for the characterisation of a candidate MRC for major and minor elements in rice flour

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The development of a Certified Reference Material (CRM) for elemental analysis of rice is essential to ensure food quality and safety. Currently, few National Metrology Institutes (NMIs) have CRMs for major and minor elements in the rice matrix, with the most recognized being SRM 1568b from the U.S. National Institute of Standards and Technology (NIST). This highlighted the need to produce a national CRM to improve accessibility within the country. Additionally, only a limited number of national laboratories are accredited under the NTC/ISO 17025:2017 standard for measuring elements in rice, underscoring the importance of promoting accreditation to guarantee reliable results. Commonly used analytical techniques—atomic absorption, ICP-MS, and ICP-OES—are accurate but costly and destructive. In contrast, X-ray fluorescence (XRF) is a more economical, non-destructive technique with minimal sample preparation, but it remains underutilized due to the lack of accredited laboratories. To address this situation, a candidate rice flour CRM was prepared and characterized using wavelength-dispersive X-ray fluorescence spectrometry (WDXRF) for the simultaneous determination of major (Mg, Ca, Na, P, S, K) and minor (Mn, Zn, Cu, Fe) elements. Calibration curves were established using NIST-certified reference materials of organic matrices, while other CRMs were used to validate the method. Samples were dried according to the conditions stated in each CRM certificate and prepared as pressed pellets (1 g sample with 0.11 g wax, pressed at 20 tons for 120 seconds). The developed method proved to be selective, precise (with relative standard deviations below the Horwitz coefficient), and accurate, as biases were within the limits defined by the standard uncertainty of each CRM and the experimental standard deviation. Therefore, the observed bias was considered statistically insignificant. Final characterization of the reference material INM-027-1 by WDXRF yielded the following mass fraction values: Ca (85.30 mg/kg), Cu (3.21), Fe (13.37), K (2875.55), Mg (1672.51), Mn (28.78), P (3751.75), Zn (20.89), and S (1275.26), with relative uncertainties ranging from 0.2% to 19.4%, depending on the element.

Revealing metabolic alterations in plants induced by nano- and microplastic exposure by high-resolution mass spectrometry

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This study represents a novel comprehensive assessment of metabolic perturbations elicited by nano and microplastics (NMPs) in plant systems, employing Lactuca sativa as a model organism. It was accomplished through controlled hydroponic exposure assays with high resolution mass spectrometry. It was found that plastic nanoparticles disrupt metabolic pathways by altering levels and activities of polyunsaturated fatty acids (PUFAs), revealing a previously unrecognized interaction between NMPs and plant biochemistry. Particle size proved critical: the smallest nanoparticles (100 nm and 200 nm) produced the most pronounced metabolic disturbances, with 100 nm particles causing the greatest shifts in PUFA-associated molecular masses, as evidenced by significant changes in chromatographic peak areas. Specifically, the molecular ion at m/z 293.2469—tentatively identified as the methanol adduct of glycerolipid (6Z,9Z,12Z,15Z)-octadeca-6,9,12,15-tetraenal—was most significantly affected at 100 nm. Two additional ions, m/z 307.2264 and 309.2415, also exhibited heightened sensitivity to smaller particles, underscoring the size-dependent nature of these interactions. By contrast, the methanol adduct of α-linolenic acid (m/z 311.2575) responded more gradually across particle sizes, suggesting a distinct interaction mechanism. Larger particles (500 nm and 1000 nm) had markedly weaker effects, confirming that smaller nanoparticles are the primary drivers of PUFA downregulation. These findings demonstrate the power of precise-mass metabolomics for reliable data generation when assessing NMPs impacts and provide crucial insights into their potential implications for plant health and food quality.

The Knowns And The Unknowns: The Analytical Toolbox To Tackle The PFAS Challenge

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PFAS pollution has evolved to an unprecedented societal challenge. PFASs are found everywhere in our environment and foods, the number of compounds is continuously expanding, and already at low levels exposure may be exceeding the safe levels. Food and drinking water are important vectors for human exposure, and a diversity of analytical tools are needed to unravel the PFAS problem in food. The toolbox consists of 3 elements, that allow the investigation of the following: - Mass balance analysis, i.e. the determination of the total PFAS amount in foods - Targeted analysis, i.e. the (sub) pg/g level determination of PFASs in foods and feeds - Unknowns identification, i.e. the screening and identification of (yet) unknown PFASs in foods. Highly sensitive targeted approaches for reliable, ultrasensitive (low/sub pg/g level) are developed for carboxylic acids, sulfonates, telomer sulfonates, telomer alcohols, sulfonamides, ultrashort-chain PFAS etc. This provides robust data for the purpose of e.g. monitoring, compliance testing and exposure assessment. The mass balance approach we applied on freshwater fish samples, showing that over 50% of the extracted organic fluorine could not be attributed to the know PFASs (as determined by targeted approaches). This means that a substantial amount of yet unknown PFASs are present in these samples. A Thermo Scientific Orbitrap IQ-X Tribrid HRMS is used to identify the unknown PFASs causing this missing proportion of extracted organic fluorine. For that purpose, we have developed a workflow to screen for suspects in sample extracts. In addition, advanced acquisition modes were developed combined with specific data filtering tools (i.e. Kaufman approach, Kedrick mass defect) are applied to elucidate unknown PFAS signals in food extracts, which the need further confirmation by (ideally) Level 1 identification using reference standards. Altogether, this toolbox allows for unravelling the PFAS complexity in foods and environmental samples, as it provides insights into PFASs contamination from different angles. Next to current state-of-the-art, analytical challenges will be addressed, as well as the needs to advance this field further in the future.

Data fusion of multi-source spectral data for the authentication of food and beverages

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Owing to their high market value, wine and honey represent agri-food products that are frequently subjected to fraud, particularly in regard to their geographical and botanical origin, as well as harvesting year. As conventional authentication techniques such as stable isotope ratio analysis often present limitations in terms of costs, destructive nature, or sample preparation and analysis time, there has been growing interest in employing spectroscopic methods coupled with advanced data processing tools for the development of reliable recognition models. More recently, the integration of multiple spectroscopic data sources through data fusion approaches has emerged as a powerful approach for improving the accuracy and reliability of authenticity assessments. Against this background, the present study explores the application of data fusion strategies combining 1H NMR and Raman spectroscopies for wine and two complementary vibrational techniques, Attenuated Total Reflection Fourier Transform Infrared (ATR FT-IR) and Fourier Transform Raman (FT-Raman) spectroscopies, for honey recognition. For wine, a dataset of more than 50 authentic white wine samples from Romania, encompassing four cultivars across three viticultural regions over five vintages, was analyzed. Given the high dimensionality of the fused spectral data, a supervised feature selection based on Partial Least Squares (PLS) regression was applied to identify the most discriminative markers. The resulting models demonstrated outstanding classification performances, achieving up to 100?curacy in both cross-validation and external testing, with the fused data outperforming single-technique inputs, especially in varietal discrimination. Similarly, in the case of honey authentication, low-level data fusion coupled with a subsequent supervised feature selection step allowed for enhanced recognition of honey botanical origin and harvesting year. The obtained results underscore the potential given by the association of multi-source spectroscopic data for the authentication of complex food matrices such as wine and honey, which not only enhances model performance but also contributes to the construction of more comprehensive and reliable food and beverages authentication models.

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Integrating Elemental and Isotopic Analysis for Wheat Authentication and Traceability

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Wheat is a strategic crop in the global food system, as it is one of the most widely cultivated crops worldwide and serves as a primary source of calories and nutrients for a large portion of the global population. Due to its economic and nutritional importance, ensuring the authenticity and traceability of wheat throughout the supply chain is becoming increasingly important, not only for food safety and consumer protection, but also to prevent fraud, ensure product quality, and promote sustainable agricultural practices [1]. Moreover, in a context of growing global trade and complex supply chains, the ability to verify the geographical origin and production practices of wheat is essential to support fair competition, reinforce labeling systems, and comply with international food standards. This study aims to evaluate the application of integrated chemical-analytical techniques for the discrimination and authentication of wheat samples, emphasizing their potential to enhance quality, safety, traceability, and transparency across the entire supply chain. Samples of Triticum turgidum subsp. durum (durum wheat) and Triticum aestivum L. (soft wheat) were characterised for mineral nutrient composition, the presence of toxic and potentially toxic elements, and stable isotope ratios. In parallel, stable isotope ratio analyses were conducted to investigate variations in isotopic composition associated with the chemical-physical fractionation of elements. The results suggest that integrating multiple chemical-analytical techniques is essential to establish a comprehensive profile in terms of authenticity and geographic traceability. This combined approach provides detailed insights into nutrients and contaminant levels, as well as natural isotopic signatures, ultimately contributing to greater transparency, increased consumer trust, and the valorisation of high-quality wheat products in global markets.

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AGRITECH Project: integrated methodologies for geographical and varietal traceability of agricultural and food products

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Geographical and varietal traceability of food products plays a crucial role in ensuring their authenticity, quality, and safety—both for agricultural raw materials and final food products. In the global food market, consumers and producers alike are increasingly interested in knowing the geographical origin and the variety of products for purposes of valorization and authentication. This is especially important for high-value products such as wines and extra-virgin olive oils, but also cereals, fruits, vegetables, and dairy products, where origin and variety can significantly influence quality and market value. To achieve reliable and accurate traceability, we employed a combined approach that integrates physical/chemical and genetic analyses. Advanced experimental spectroscopic and spectrometric methods are applied, including hyphenated chromatographic/mass spectrometry, fluorescence spectroscopy, nuclear magnetic resonance (NMR), and electron paramagnetic resonance (EPR). These cutting-edge tools analyze the elemental, isotopic, and metabolomic characteristics of samples, providing specific fingerprints that can be linked to particular geographic regions or varieties. Genetic analysis also plays a key role in traceability by identifying different varieties within the same species and tracking a specific variety throughout the food production chain. This is achieved using molecular microsatellite markers, which differentiate genotypes based on the number of repeat sequences. These data serve as indicators, helping to verify the authenticity of products and distinguish genuine items from counterfeits or adulterated ones. The data obtained from multiple techniques are then integrated through multivariate statistical methods, including data fusion approaches. This integration enables the development of models capable of interpreting complex datasets and extracting meaningful patterns and correlations. These comprehensive approaches represent a significant advancement in food authentication and valorization, providing stronger tools for consumer protection, quality certification, and the fight against food fraud.

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Nutritional Value of Edible Insects as Alternative Food and Feed Protein Sources in the Czech Republic

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The nutritional value of edible insects depends on many factors, including insect species, rearing conditions, and processing methods—including the way of killing. This study aimed to comprehensively monitor key nutritional parameters of six insect species collected from 13 rearing facilities in the Czech Republic. A total of six sampling rounds were conducted at approximately quarterly intervals to cover seasonal variation (2023: March, July, November; 2024: February, May, November). Altogether, 83 insect samples with a total fresh weight of 28.3 kg were obtained. The analysed species (Tenebrio molitor, Zophobas morio, Acheta domesticus, Alphitobius diaperinus, Gryllus assimilis, and Blaptica dubia) were killed either by freezing (-18 °C) or by blanching in boiling water for 5 minutes. In lyophilized samples, the following parameters were determined: dry matter and ash content (gravimetrically), total lipids (Soxhlet extraction), and crude protein content (Kjeldahl method with a nitrogen-to-protein conversion factor of 6.25). Nutritional values varied most significantly by insect species. Observed ranges were dry matter 16.3–41.0 g/100 g, ash 0.59–6.44 g/100 g of fresh weight (FW), fat 1.6–16.9 g/100 g FW, and crude protein 10.0–26.3 g/100 g FW. The way of killing had no significant effect on nutritional composition. However, significant differences in lipid, protein, and ash content were observed within individual insect species, depending on the season and rearing facility (rearing conditions including feed). Therefore, when using insects as food or feed, it is essential to assess their specific nutritional profile from each supplier. Additionally, the way of killing should also be recorded and considered.

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Comprehensive evaluation of the nutritional composition of chub mackerel (Scomber colias): Influence of cooking methods

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Aim: Chub mackerel (Scomber colias) is an abundant but underutilized fish species in the Atlantic, increasingly recognized for its nutritional benefits, including significant contents of omega-3 fatty acids (EPA and DHA). However, comprehensive data on its nutritional profile, especially the impact of cooking methods on nutrient retention, remains scarce. This study aimed to evaluate the nutritional composition of chub mackerel, focusing on moisture, total fat, protein, ash, fatty acid profiles, vitamin B12, and amino acids (AA), comparing raw versus cooked (boiled and grilled) samples.

Methods: Chub mackerel from Portuguese Atlantic waters were sampled, and fish dimensions and weights were recorded. A subset was cooked by boiling and grilling. Nutritional analyses included moisture (oven drying to constant weight), ash (incineration at 525 °C), protein (Kjeldahl), and total fat (acid hydrolysis and extraction). The fatty acid profile was assessed by gas chromatography. Additionally, vitamin B12 was analyzed using ultra-performance liquid chromatography coupled with triple quadrupole mass spectrometry, and AA were analyzed via ultra-performance liquid chromatography with photodiode array detection.

Results: The protein content remained consistently high across all preparations. It also presents all essential AA, each with a score above 1.0, indicating a protein of high biological value. The total fat content varied, with lower levels observed in grilled samples due to fat loss during the cooking process. Total mineral content was relatively stable. The fatty acid profile revealed significant amounts of EPA and DHA. Calculating the retention factor after cooking reveals that the fatty acid content does not vary with processing. Vitamin B12 content increased in cooked samples, from 27.8 µg/100 g in raw to 35.8 µg/100 g (boiled) and 38.1 µg/100 g (grilled). Consuming 100 g of chub mackerel provides more than 100% of the recommended daily intake.

Discussion: The results highlight the nutritional robustness of chub mackerel across various culinary methods, particularly in terms of protein and omega-3 fatty acids. The apparent increase in vitamin B12 content after cooking is likely due to water loss, concentrating the nutrient, and enhanced extraction efficiency resulting from protein denaturation. Most AA, particularly essential ones, remain stable during moderate cooking processes. These findings highlight the significance of this species as a valuable source of high-quality nutrients.

Conclusion: Chub mackerel is a nutritionally rich and resilient food source, maintaining high-quality nutrient profiles through various cooking processes. Its exceptional content of vitamin B12 and omega-3 fatty acids supports its inclusion in strategies for improving dietary quality and promoting sustainable nutrition.

Real-Time VOC Profiling of Microalgae Fermented with Kefir Starters using PTR-ToF-MS

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Microalgae play an important role in future food industry due to their high protein and bioactive content. However, using the microalgae as a food ingredient has two main problems such as characteristic fishy off flavours and poor accessibility of nutrients due to the thick cell walls. That is why their fermentation should help improve nutritional, sensory, and bioactive properties. For the optimization of the microalgae fermentation process the online and non invasive monitoring of volatile organic compounds (VOCs) is necessary. Proton Transfer Reaction Mass Spectrometry coupled to Time of Flight mass spectrometer (PTR-ToF-MS) as a direct injection mass spectrometry technique is a good option for this task and it showed successful results for monitoring of different fermentations. Three microalgae species: Chlorella vulgaris, Arthrospira platensis (Spirulina), and Galdieria sulphuraria were selected for this study. Two commercial starters of milk kefir and water kefir (Bionova, Italy) were used for the 48h fermentation at 27°C of 1% and 10% of each alga in water without additional nutrients. A commercial PTR-ToF-MS 8000 instrument (Ionicon Analytik GmbH, Innsbruck, Austria) coupled to a multipurpose head-space automated sampler (Gerstel GmbH, Mulheim am Ruhr, Germany) and a SHS module were used for the automatic measurements of each sample every 4 h for 48 h. SPME-GC-MS analysis was performed on all samples at 0h and 48h time points for the purposes of compound identification and confirmation of the results. Univariate and multivariate statistical analysis showed the time-dependent trends in VOC production. Similar temporal trends for the majority of VOCs release were observed across for both 1% and 10% algal load with the higher concentration in the latter one. Moreover, the influence of microalgae species and starter culture was observed as well. Different alcohols such as ethanol, butanol, methyl butanol were produced during the fermentation with water kefir starter with the higher abundance of yeasts in comparison with milk kefir one. Their time evolution curves were microalgae dependent. The milk kefir fermentation produced elevated levels of 2,3-butanedione, a characteristic compound of milk fermentation. Spirulina fermentations, particularly towards the end, were notably rich in sulfur-containing compounds. These outcomes suggest that PTR-ToF-MS is a powerful tool for optimization of plant-based fermented foods.

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FAIR principles and metrological approaches for food integrity: data accuracy, availability, and privacy in the supply chain

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Metrology in this digital era continues to support the implementation of new methods, technologies, and standards. Reliable and precise measurements and data are critical for ensuring food integrity along the food supply chain. On the other hand, access to data according to the FAIR data principles allows statistics to be obtained on all stages of the food supply chain (primary production, processing, distribution, and storage). This is essential to creating a more sustainable and resilient food system and to enable policymakers to make informed decisions. In the global food production landscape, the lack of standardization makes harmonizing food production statistics difficult, while restricted data availability, lack of transparency, and data privacy issues, further complicate challenges of accessibility and interoperability. Emerging digital technologies, such as satellite remote sensing, Internet of Things (IoT) sensors, real-time monitoring systems, artificial intelligence (AI) and machine learning algorithms, offer new opportunities for improving data collection, processing, and predictive models. Their deployment also introduces new ethical, legal, and social dilemmas, particularly regarding data privacy, algorithmic bias, and governance policies. Furthermore, the exchange and integration of food production data between countries and institutions are frequently delayed by heterogeneous regulatory frameworks, incompatible platforms, and inconsistent data governance protocols. This complexity is further exacerbated by fragmented data ownership, inconsistent data privacy protocols, and limited international coordination. Successfully addressing all these challenges of the agrifood supply chain with a metrological approach, supported by structured data sharing mechanisms and appropriate policies, will represent a fundamental step towards realizing the full potential of food systems for the achievement of sustainability and resilience goals. To overcome these barriers, collaborative international efforts are needed, aimed at establishing unified standards and protocols that promote data sharing while respecting privacy concerns. This can be achieved by fostering partnerships between governments, industry stakeholders, and research institutions. The implementation of these best practices in data governance, through the integration of metrological principles with cutting-edge technology, can pave the way for a more transparent, efficient, and sustainable global food supply chain.

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Automated AI-based classification of food products into the EFSA FoodEx2 system for standardized data integration

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Standardized classification of food products is critical for food safety monitoring, dietary exposure assessments, and regulatory compliance. The EFSA FoodEx2 system provides a comprehensive hierarchical framework to categorize foods, from main food categories down to specific subtypes categories. However, manual assignment of products to these categories, especially at scale, is resource-intensive and prone to inconsistencies. To address these challenges, we developed an automated AI-based classification approach that uses large language models (LLMs) to assign food products to FoodEx2 categories with high accuracy and minimal human intervention. The step-wise classification algorithm was applied to a web-scraped dataset of over 60,000 unique retail food products, using both product names and associated images. It demonstrated good performance, achieving up to 95% classification accuracy for main food categories. The method is generalizable and can be used with minimal input information, making it applicable to a wide variety of datasets, including national food consumption databases, retail inventories, and consumer-facing platforms. Its modular and reproducible structure ensures consistent classification over time and across projects. This makes it well suited for integration into research infrastructures and data platforms that require harmonized food data. This AI-assisted classification is part of a broader toolset that enables downstream data exploitation. Using ingredient lists, it supports food additive identification, ingredient frequency analysis, and nutritional profiling. Moreover, the classification logic can be adapted to other regulatory systems, such as the EC 1333/2008 classification for food additives, allowing the approach to contribute to broader regulatory science workflows and interoperability. In conclusion, this AI-assisted method offers a scalable, standardized, and high-throughput solution for food product classification, enhancing the reliability and efficiency of data integration across food safety, public health, and regulatory domains. Its adaptability and performance make it a valuable component in the transition toward more intelligent and automated data pipelines in the food and health sectors.

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Interview Tool as a New Platform for High Quality Dietary Data Collection

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Accurate and reliable dietary assessment is essential for understanding nutrition trends, informing public health policies, and advancing research on diet-disease relationships. One widely used method is the 24h dietary recall, where individuals report all foods and beverages consumed the previous day. GloboDIET, developed by the International Agency for Research on Cancer (IARC), is a software tool designed to support interviewers in collecting such data systematically, based on a structured and validated methodology [1]. While GloboDIET has been successfully implemented in multiple countries and contexts, its development and maintenance have been discontinued, and it no longer meets modern usability or technological requirements. To address this gap, we present the Interview Tool - a new dietary assessment platform that builds upon the validated GloboDIET framework while integrating the latest advances in user experience, design, software architecture, and technology. The Interview Tool supports both guided interviews and self-interviews, offering flexibility for large scale population studies and individual level data collection. At the core of the software are the three validated steps of consumption measurement: - Food Identification - users are guided through user-friendly search and selection interfaces that allow them to accurately report the foods they have consumed. - Food Description - the system gathers detailed descriptors for each food item, including preparation method, brand, and origin, through tailored follow-up questions designed to enhance user experience and improve data quality. - Food Quantification - users estimate portion sizes using visual tools, household measures, and standard references. The application is developed with modern software architecture and prioritizes user-centered design, accessibility, and data protection. It incorporates input from multidisciplinary experts in nutrition, measurement, data management, and legal compliance to ensure methodological robustness and data security. By integrating validated scientific approaches with technological innovation, the Interview Tool represents a significant step forward in harmonizing and modernizing dietary data collection across Europe and beyond.

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NutriBase: A Web-Based System for Integration and Interoperability of Food Composition Data and Knowledge

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High-quality food composition data and related nutritional knowledge are fundamental for research and public health, yet such data often remains fragmented across multiple databases and formats. NutriBase is a web-based database and knowledge management system developed by researchers at JSI to address this challenge by enabling seamless integration and interoperability of food composition datasets (FCDBs) and knowledge bases. It adheres to EuroFIR (European Food Information Resource) standards for data quality and exchange, allowing data from various national and international sources to be linked and harmonized within a single, unified platform. To address the common issue of missing nutrient values, NutriBase implements a semi-automatic imputation mechanism. Users can compare data gaps in their databases against trusted external sources, with the system transparently recording the source of each borrowed value. This approach maintains data integrity and traceability essential for reliable research and applications. Currently, NutriBase hosts Slovenian FCDB with approximately 1,200 generic food items with analytical nutrient values and around 54,000 branded food products. Over 31,000 of these branded products have been validated and are accessible via an Application Programming Interface (API), which is available exclusively to approved applications upon request, ensuring them access to up-to-date food composition data. NutriBase is designed for the seamless management of any FCDB that complies with EuroFIR standards. Recently, it has been localized for the Australian region, demonstrating its adaptability. In addition, NutriBase can be easily integrated with various applications, such as mobile food-related apps (e.g. VešKajJeš) or web-based research portals (e.g. IsoFoodTrack), to deliver or exchange reliable data and knowledge. Additionally, NutriBase provides tools to add, update, and curate food composition data and related knowledge in a user-friendly environment. It promotes standardization with validation and by using common vocabularies and formats, which makes it easier to share data across projects and countries. NutriBase enhances the overall utility of food composition information for scientific research and future dietary planning.

Alcohol Consumption During Breastfeeding: A Questionnaire Survey Among Czech Women

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Expert opinions and institutional guidelines regarding alcohol consumption while breastfeeding vary; however, the World Health Organization recommends abstaining from alcohol during this period. This study aimed to assess the prevalence and context of alcohol use among breastfeeding women in the Czech Republic. Data were collected through a questionnaire survey completed by 468 women. Although 84% of respondents believed that alcohol should not be consumed during breastfeeding, 66% of breastfeeding women reported having consumed alcohol at least once during this time. Among them, 75% stated that the amount of alcohol consumed corresponded to a small beer, one shot of spirits, or one deciliter of wine (i.e., approximately 10 grams of alcohol). Wine and beer were the most frequently consumed types of alcohol. The main reasons for alcohol consumption during breastfeeding included social events, nice weather (summer), the desire to relax, and a craving for alcohol. The findings suggest that, despite general awareness of recommendations, alcohol use during breastfeeding remains relatively common. Therefore, it is essential to improve public health education and provide breastfeeding women with accurate information about the potential risks of alcohol consumption during this critical period.

Elemental and Metabolomic Characterization of Coffee Plant By-Products for Functional Beverage Development

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Coffee is one of the most widely consumed beverages worldwide. Currently, only the beans are commercially exploited in the food industry, making them the sole source of income for coffee growers. This limited use is critical in terms of sustainability, as the entire coffee production chain is associated with a significant environmental footprint, largely due to the intensive use of water, land, fertilizers, pesticides, and fossil energy. The production process also generates substantial amounts of waste: it is estimated that approximately 0.9 kg of waste is produced for every kilogram of harvested coffee cherries. Among the various by-products are residues from plant pruning and the extraction of bean from the berry. In this context, the valorization of coffee by-products within a circular economy framework is essential for reducing environmental impact. Consequently, in the present study, through chemical and metabolomic approaches, freeze-dried leaves and fruit skins derived from two Caturra varieties (Rojo and Amarillo) of Coffea arabica were analyzed, in order to assess their content of essential nutrients (macro- and microelements) and the presence of potential bioactive compounds for the development of functional beverages. More in detail, elemental analysis using inductively coupled plasma atomic emission spectroscopy (ICP-AES) revealed a comparable elemental profile across both tissues and varieties. In parallel, liquid chromatography coupled to high resolution mass spectrometry (LC-HRMS) metabolomic analysis on the polar fraction was performed using both targeted and untargeted approaches, with methanolic and aqueous extractions to simulate the overall biochemical profile and the brewing process, respectively. Thus, a better understanding of the elemental profile and presence of phytochemical constituents could provide valuable insights into processing and extraction methods in order to preserve these compounds to better enhance the use of coffee leaves and berries in the formulation of new functional beverages.

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Modulation of newborn and infant microbiota with prebiotics and probiotics

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Prebiotics and probiotics are now quite established terms that are associated with a beneficial effect on human health. But since when do they naturally become a part of our diet? Since when should we consider their supplementation? Moreover, it is necessary to consider not only their potential independent or synbiotic benefits, but also the interaction at the level of the host microbiota, which may be very individual. The aim of our work is to focus on the choice of suitable prebiotics and probiotics during the initial colonization of the newborn's intestine, or rather the infant, with regard to gestational age, mode of delivery, and the initial period of nutrition, i.e., liquid food diet. Therefore, we longitudinally monitored an infant, combining both cultivation and molecular genetic approaches, to determine microbiota development and evaluate prebiotic and probiotic interventions. It is desirable to underscore the importance of targeted prebiotic and probiotic interventions during critical developmental periods, not only for their direct effects on specific microbial populations but also for their potential to modulate overall microbial interactions. Human milk is a unique source of oligosaccharides, which, however, despite the best efforts, cannot be fully synthesized, and therefore, we are looking for alternatives whose use has clear justifications. As well as including probiotics in the diet of newborns born out of right gestational age, surgically instead of vaginally, or whose microbial colonization is not standard and suffers e.g., from colic. These are just a few examples for considering the supplementation of prebiotics and probiotics. Moreover, the effect does not end with their application; it extends to the further development of the individual. Our findings highlight the importance of considering probiotic and prebiotic supplementation in newborns whose early microbial colonization may be suboptimal, such as those born via cesarean section, prematurely, or not breastfed. While breastfeeding remains the gold standard due to its unique oligosaccharide content, our results demonstrate that targeted microbiota modulation can have meaningful and lasting effects on infant development.

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Microbial Spoilage Risks in Teran Wine: Tracking Brettanomyces and Biogenic Amines During Malolactic Fermentation

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Yeasts and lactic acid bacteria (LAB) are the main microorganisms involved in wine production, responsible for alcoholic fermentation and malolactic fermentation (MLF), respectively. During MLF, LAB convert L-malic acid into L-lactic acid, which primarily leads to biological deacidification but also results in changes in the wine's aroma and microbiological stability. While LAB generally improves wine quality, certain strains can cause spoilage and are linked to the production of biogenic amines (BAs), which are nitrogenous compounds such as histamine, tyramine, and putrescine. Elevated levels of BAs may pose health risks, especially in sensitive individuals, potentially causing headaches, hypertension, and digestive issues. Similarly, the yeast Dekkera/Brettanomyces bruxellensis is considered a spoilage organism because of its ability to produce volatile phenolic compounds (e.g., 4-ethylguaiacol and 4-ethylphenol), which impart off-flavors resembling bandages, sweat, and smoke. As part of the AGROTUR+ project, we monitored LAB and B. bruxellensis populations, as well as BA and volatile phenol content, during MLF in Teran, a protected wine made from Refošk grapes in the Karst wine-producing region. The goal was to assess the presence of spoilage-related compounds and support improvements in the microbiological quality of this traditional wine. A total of 48 Teran wine samples from the 2023 and 2024 vintages were analyzed in this study. Volatile phenols were analyzed using HS-SPME-GC-MS, and BAs were determined via HPLC–UV following sample derivatization. The basic physicochemical parameters were determined using standard methods. LAB community and composition were analyzed through plating, 16S rRNA amplicon sequencing, and flow cytometry was used for LAB quantification in 2024 samples. In vintage 2024, B. bruxellensis was quantified in wine samples using plating and flow cytometry. Histamine was the most abundant BA (average 11.9 mg/L), followed by cadaverine (2.8 mg/L) and by putrescine (2.6 mg/L). There were differences between the vintages. No correlation was observed between total LAB counts and BA levels, indicating the need for further analysis of the LAB strain composition. For volatile phenols, 4-ethylphenol was primarily found at concentrations below its sensory threshold (600 µg/L), with only one sample exceeding this threshold. In contrast, 4-ethylguaiacol exceeded its threshold (110 µg/L) in four of the samples. B. bruxellensis was detected using the CyFlow™ BrettCount flow cytometry kit (Sysmex Partec), although no colonies were observed on the selective Dekkera/Brettanomyces differential medium (DBDM). Flow cytometry has proven to be a rapid and specific method for detecting spoilage yeasts, such as B. bruxellensis, with strong potential for early intervention and spoilage prevention in winemaking.

From concept to laboratory work: challenges and innovation in method validation for food additives

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Validation of analytical methods is paramount to demonstrating their fitness for purpose. In the critical field of food additive analysis, this data underpins regulatory compliance, market surveillance, and public health risk assessments. The discipline is profoundly challenging, demanding that a single method be applicable across various food matrices, from simple beverages to complex food products. Concentrations of additives fluctuate dramatically, not only between different substances but also for the same additive across different food categories. Furthermore, the substances possess a broad and diverse range of physico-chemical properties (e.g. organic, inorganic, ionic, polar, and non-polar) requiring analysts to apply an exceptionally high level of technical skill to achieve methods with minimal variability and ensure data integrity. The rigorous validation process introduces further significant hurdles, including matrix coverage, broad concentration ranges, and substance stability. Failing to assess these factors properly threatens the reliability of the data. While validation is known to be costly and time-consuming, not doing it correctly risks wasting valuable time, money, and resources. To overcome these obstacles, we have developed a proactive and innovative approach. This strategic framework directly addresses food additive specificities, including the need for full matrix coverage and the use of additive blends (e.g. sweeteners, antioxidants and preservatives) which critically impact the required concentration range and limit of quantification. This novel methodology streamlines the validation process, significantly enhancing its efficiency without compromising the accuracy or reliability of routine data. Our presentation will detail this approach and its application to specific food additive classes, proving that innovation can thrive within the most stringent processes.

Co-Creation, the responsibility to be innovative: the METROFOOD-IT case

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The term "co-creation" refers to the collaborative efforts of various stakeholders—including businesses, universities, policymakers, and the general public—within innovation processes.[1]. In recent years, this approach has emerged as a response to a range of societal challenges, including environmental degradation, sustainability of industrial production, and issues related to food safety and food security. At the same time, co-creation is also increasingly recognised as an opportunity for making innovation processes more socially inclusive and responsible. Involving end-users, researchers, and stakeholders in the research process enhances project outcomes, aligning them more closely with societal needs and expectations, as emphasized by Horizon Europe's First Pillar. This alignment boosts real-world applications and helps translate research findings into effective policy and practice. In fact, the so called "independent science", when detached from its political and social context, often fails to provide valid solutions to tackle the complex problems faced by our society. Therefore, an engaging collaboration among researchers, policymakers, and citizens becomes essential because "by working together on the structuring of the problem definition after which a shared knowledge (shared reality') can be achieved"[2,3]. The aim of this work is to explore the concept of co-creation within the European research landscape and to examine its transformative potential in shaping research and innovation. The goal is not only to highlight the benefits of co-creation, but also to propose a different perspective: to consider such a research approach as a responsibility rather than merely a strategic tool. To this end, the experiences developed within the METROFOOD-IT research infrastructure are presented, including co-creation strategies and initiatives undertaked so far. A focus is given on the role of Living Labs and Training & Education activities, which are crucial enablers for an inclusive and impactful research.

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AI-Driven Robotic Arm Guidance and Control for Agrifood: Enabling Smart, Zero-Touch and Safe Food Automation

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Digital technologies, particularly those involving artificial intelligence, robotics and advanced sensing, offer concrete solutions to enabling smart, zero-touch and safe food automation, especially in sensitive production environments where hygiene and precision are paramount. In this context, the SCENARIO project (Advanced Robotic Solutions for the Agri-Food Industry) aims to design and validate intelligent technologies for advanced automation in the food and drink industry. The project core involves developing a smart robotic system for preparing baccalà (salt cod) batter. This system is designed to operate in controlled contamination environments and can consistently replicate a traditional process that is highly valued for its gastronomic qualities. Based on a multi-axis arm controlled by AI algorithms, the robot integrates computer vision and smart sensors to monitor critical parameters such as the position, attitude, appearance of the fish piece as well as viscosity of the batter in real time. The entire process — from mixing the ingredients to quality control — is automated thus lowing also to implement a zero-touch logic to minimize contamination risks and ensure the highest hygiene standards. Through a dedicated human-machine interface (HMI), operators can select recipes, program sequences and monitor system status. Environmental and process data collected by the sensors feed predictive modules that optimize operational efficiency by dynamically adjusting the robot's behavior to real-world conditions. The SCENARIO project demonstrates how collaborative robotics can enhance tradition through technological innovation when applied to a typical food process such as baccalà batter production. The system is designed to be scalable and replicable for use in both small-scale local production and industrial lines. It is a concrete example of how digitalisation and automation can coexist with the cultural identity of quality food products.

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Toward Sustainable Mozzarella di Bufala Campana:LoRaWAN-Based Monitoring of Greenhouse Gases to Quantify and Reduce Emissions

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The production of Mozzarella di Bufala Campana, a PDO-certified excellence of Southern Italy, is deeply rooted in centuries-old farming practices and a unique territorial heritage. Within this framework, ensuring animal welfare, environmental sustainability, and food safety has become essential. With increasing consumer demand for transparency and eco-responsibility, the implementation of technological solutions to ensure traceability and cutting emissions is essential [1]. This study introduces a wireless sensor network based on the LoRaWAN protocol [2], engineered for real-time monitoring of greenhouse gases—specifically carbon dioxide (CO_2) and ammonia (NH_3)—in buffalo barns. These gases are critical indicators of air quality, with direct implications for animal health, worker safety, and overall compliance. Long-term exposure to excessive concentrations can reduce productivity and compromise milk quality. Each sensor node integrates commercial electrochemical sensors (DOL-119 for CO_2 and DOL-53 for NH_3), a low-power STM32 microcontroller, and an I-NUCLEO-LRWAN1 shield. The system operates autonomously, transmitting data at 10-second intervals to a central LoRaWAN gateway. Information is then processed via MQTT and visualized in Node-RED for real-time and historical tracking. The solution is designed for rural contexts, ensuring reliable transmission even in harsh barn environments lacking Wi-Fi or cellular infrastructure. The architecture was validated in a working buffalo dairy. Results confirmed stable communication and consistent data acquisition across all deployed nodes. Gas peaks were detected promptly, enabling timely ventilation. This improved environmental conditions and supported welfare and product quality. This work highlights how IoT technologies, integrated with Precision Livestock Farming practices, can modernize traditional dairy operations and help achieve European sustainability and food safety goals.

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Explainable Machine Learning on SWIR Hyperspectral Data for Origin-Based Classification of Wheat Grains and Flours

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The authentication and traceability of agro-food products are increasingly critical for ensuring food quality, combating fraud, and promoting transparency in supply chains. In the case of durum wheat—a staple crop with strong geographical and varietal identity—traditional analytical methods are often limited in throughput, scalability, and interpretability. In this study, we propose a novel approach that integrates short-wave infrared (SWIR) hyperspectral imaging (900–1700 nm) with machine learning (ML) and explainable artificial intelligence (XAI) to classify durum wheat samples by geographical origin and variety. A total of 16 wheat samples were collected from multiple Italian regions and cultivars. Each sample was analyzed in both whole-grain and flour form using the NIREOS HERA SWIR-2 hyperspectral system. The resulting high-dimensional data were normalized and preprocessed to extract meaningful spectral features. We then applied supervised ML algorithms—including Support Vector Machines (SVM), Random Forest (RF), and Partial Least Squares Discriminant Analysis (PLS-DA)—to classify the samples. To move beyond black-box predictions, we incorporated explainable AI techniques, primarily SHapley Additive exPlanations (SHAP), to uncover the most influential wavelengths and spectral intervals contributing to the model's decisions. These insights not only confirmed known chemical-spectral associations but also revealed novel discriminative features relevant to wheat origin. The proposed pipeline achieved high classification accuracy and provided interpretable models that support the development of AI-based tools for rapid, non-destructive screening in cereal quality control. This study highlights the potential of combining hyperspectral imaging with interpretable machine learning as a robust solution for real-time food authentication, aligning with the goals of infrastructures like METROFOOD-IT and the broader vision of open, data-driven agro-food systems.

Comparative analysis of volatile compounds and sensory assessment of olive oils

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The accurate detection of volatile compounds (VOCs) and sensory defects in virgin olive oil is very important for characterisation of virgin olive oil as well as to support olive oil classification according to Commission Delegated Regulation (EU) 2022/2104. This study is aimed to validate methods for determination of VOCs and to determine which of the two used methods is more reliable for individual marker. A set of 18 VOCs was set based on previous studies which demonstrated that these 18 compounds showed the strongest correlation with sensory defects. In this study, 20 virgin olive oil samples were determined by SPME-GC-MS and by SPME-GC-FID and compared with sensory analyses. Despite progress in analytical instrumentation, inter-laboratory variability and mismatches with sensory evaluation persist. VOC data, z-scores, and classification values from all panels were assessed. Bias, standard deviation, and failure rates were explored, and the most divergent compounds were compared against established sensory defect markers. The performance of our sensory panel in the interlaboratory comparison was excellent. Comparison of VOCs assessment results showed that our laboratory's results for certain parameters, such as ethyl acetate, were in close agreement with consensus values. On the other hand, some other parameters, such as aldehydes and acids, that correlate with rancid and musty defects, were underestimated. It turned out that for some markers, SPME-GC-MS method provided better results, while for other markers, the SPME-GS-FID method was more suitable. Ultimately, our findings support the implementation of enhanced methods for sensory defect-related VOCs.

Comprehensive analysis of volatile compounds released during the heat-treatment of highly processed plant-based alternatives

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Plant-based alternatives is a relatively new group of products with a diverse composition and varying degrees of processing. While the presence of these products on the market has been steadily growing, there is still limited information on the composition of chemical profiles of these products, especially the ones generated through heat-treatment. In this study, we aim to describe the chemical profiles of volatile organic compounds released during heat-treatment of plant-based meat and cheese alternatives. The extraction strategy was based on three distinct approaches: (1) solvent extraction (SE) using acetonitrile followed by a QuEChERs-based clean-up, (2) headspace-solid phase microextraction (HS-SPME) using a CAR/PDMS/DVB fiber, and (3) dynamic headspace with sorbent trapping followed by thermal desorption (DHS-TD), which is less commonly applied in food studies. For the latter method, two DHS-TD tube types were compared: TenaxTA and a two-phase Bio-monitoring sorbent tube (non-disclosed composition, produced by Markes International). Additionally, two different volatile phases were sampled: i) the one released during the processing (150°C, 20 min) and ii) a post-processing phase (50°C, 30 min). In all cases, the analysis was performed on GC-QOrbitrap hyphenated with TD100-xr system for thermal desorption, followed by the processing with a non-target workflow (Compound Discoverer, version 3.3.3). Volatile phases collected using sorbent tubes (during and post-processing) were compared with the chemical composition found using SE and SPME [1]. Regarding DHS-TD, TenaxTA and Bio-monitoring sorbents yielded similar profiles, though better reproducibility was observed using TenaxTA (94 versus 79 features with RSD<20%). The principal component analysis (PCA) of TenaxTA data showed clear separation between during- and post-processing phases, with greater variability in triplicates during processing. Volatile profiles released during processing were mostly comprised of O-containing aromatic and cyclic compounds, followed by N-containing compounds post-processing. As for the other techniques, SE revealed more features overall, but SPME highlighted the heterogenicity of volatiles released by different plant-based and cheese alternative matrices. Both techniques showed good reproducibility and will be used in the future as complementary approaches to DHS-TD extraction using TenaxTA sorbent tubes for analysis of commercially available products.

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Multi-omics approach of wheat varieties, agronomic practices and functional microbiome for sustainable precision agriculture

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The soil and rhizosphere microbiome are essential for plant health and agroecosystem sustainability, regulating nutrient cycling, stress resistance, and crop yeld. In wheat, microbial composition and function are strongly influenced by both varietal genetics and agronomic practices, including fertilization and crop protection measures. This study assessed how geography, agronomic practices, and wheat cultivars (Triticum durum and T. aestivum) influence soil microbial communities. Soil samples collected from eleven modern varieties grown across northern, central, and southern Italy were analysed using a multi-omics approach, combining metagenomics, metabolic pathways, and detailed agronomic data on fertilization and pesticide use. Microbial functional diversity was evaluated using Biolog EcoPlates™, with AWCD as an indicator of metabolic activity, the microbial communities were characterized by means of targeted 16S rRNA gene sequencing (using Oxford Nanopore) and the potential functions of the microbial communities were predicted using PICRUSt2. Soil microbial communities associated to T. aestivum showed significantly higher metabolic activity than those of T. durum ($p < 0.01$). Multivariate analyses revealed that wheat variety and agronomic practices jointly influenced microbial diversity, metabolic capacity, and predicted functions, with T. durum favouring Bacilli-dominated communities and T. aestivum supporting a more diverse microbiota. Moreover, gene analysis findings showed that genotype and agronomic management act synergistically in shaping distinct microbial communities with specific metabolic and functional profiles, including carbon sequestration activity, organic matter degradation and phosphate solubilization. This study provides new insights and perspectives for the validation of sustainable and personalized agronomic strategies, integrating variety selection with microbiome management to enhance crop resilience and productivity. These findings underscore the importance of microbiome-aware crop management not only for improving plant performance, but also for preserving soil ecological integrity, thereby contributing to broader One Health objectives that connect environmental sustainability, agricultural practices, and human nutrition and well-being.

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Sensory properties and nutritional composition of cookies with added insect meal

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Cookies enriched with insect meal have the potential to serve as innovative products with higher protein content and improved nutritional value. This study investigated the sensory and nutritional quality of butter cookies in which 0%, 5%, 10%, 15%, and 20% of wheat flour was replaced with insect meals from Acheta domesticus, Blaberus dis-coidalis, Tenebrio molitor, and Locusta migratoria. The sensory properties of the cookies were evaluated by a panel of 20 trained asses-sors using sensory profiling method, check-all-that-apply (CATA), and ranking test. Nu-tritional analyses included determination of dry matter, ash, fat, protein, and amino acid profile. Acceptability varied depending on the type and addition of insect meal. Cookies with 5% and 10% insect meal content showed sensory properties comparable to the control sample. In contrast, samples with 15% and 20% insect meal were less acceptable, ex-hibiting stronger off-flavours and lower overall taste scores. Findings from the CATA and ranking tests aligned with the sensory profile results. Among the nutritional pa-rameters, total protein content and amino acid composition were the most affected by insect meal addition. The results of this study may support the optimization of both sensory and nutritional quality in cereal-based products enriched with insect meal.

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Bifidogenic effect of prebiotics: a nutritional strategy for gut microbiome modulation

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Bifidobacteria are an important group of commensal bacteria within the human gut microbiota and are considered among the dominant microbial taxa in infants. Although their abundance tends to decline with the ageing of the host organism, their presence in the intestine remains associated with a range of beneficial effects that support human health. As saccharolytic anaerobes, bifidobacteria primarily colonise the distal parts of the gastrointestinal tract, where they produce short-chain fatty acids, antimicrobial compounds, and vitamins. Their metabolic activity involves cross-feeding interactions with other microbes, inhibition of pathogens, and modulation of the host immune system. To support bifidobacterial persistence, various strategies are being explored. One promising approach is the use of prebiotic substances, which may be incorporated into the diet either naturally or through dietary supplementation, in both endogenous and dietary forms. These substances (typically carbohydrate-based) are selectively utilised by host microorganisms and confer health benefits at various sites of action. To be classified as prebiotics, they must meet several essential criteria as defined by the International Scientific Association for Probiotics and Prebiotics (ISAPP). Common examples include human milk oligosaccharides (HMOs), galacto-, fructo-, xylo-, soybean-, pectic-, and mannan-oligosaccharides. In recent years, additional candidates such as novel plant-derived oligosaccharides, polyphenols, and β-glucans have also gained attention. Bifidogenic prebiotics positively modulate bifidobacterial abundance and play an increasing role in the modern nutrition of the human population. Their inclusion in the daily diet may contribute to disease prevention, enhancement of immune function, improved digestion, and overall health maintenance. Nevertheless, the bifidogenic response to prebiotics may vary depending on the host's age and microbial background, both of which must be considered. Thus, the ongoing search for novel prebiotic compounds with selectivity for typical bifidobacterial species is desirable and holds great promise for targeted modulation and long-term maintenance of gut microbiota homeostasis.

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Use of by-products in sourdough bread: Integrating analytical and technological services for sustainable food innovation

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Feeding the exponentially growing human population requires sustainable solutions that address current global challenges, such as farmland and water pollution, resource scarcity, and climate change. The valorisation of agrifood by-products plays a crucial role in minimising food waste and advancing a more resource-efficient circular economy. Globally, over 190 million tonnes of by-products are generated annually, many of which still contain significant valuable compounds including proteins, lipids, bioactive compounds and dietary fibres. In particular, by-products of plant origin, such as peels and seeds, are particularly noteworthy for their high nutritional value and potential use in food formulations. This study falls within the activities carried out in the METROFOOD-EPI project (GA. 101130162), which provided analytical services combined with food technology services to support food technology innovations. The focus was on incorporating cereal by-products into bakery products, with the dual aim of improving ingredient design and optimising processing techniques to enhance the nutritional quality and shelf life of final products. Preliminary tests were carried out to assess the valorisation of rice bran and almond okara by-products from rice and almond milk processing, respectively, both rich in bioactive compounds and nutrients. The service was provided through a close collaboration among several METROFOOD-RI facilities, including: IBA processing plants and sensory laboratories, TUM, ENEA, JSI and AUTH and analytical laboratories. At the ENEA facility, the content of toxic and/or potentially toxic elements was determined, and the macronutrient profile was evaluated (ICP-AES analysis). Samples of white bread enriched with different ratios of rice bran and almond okara were analysed. The results confirmed the absence of elemental contaminants and revealed an improved macro- and micronutrient profile in bread enriched with bran and okara compared to the control samples. The integration of approaches and expertise within a pipeline of services and facilities demonstrated the feasibility and benefits of developing innovative, safe and sustainable food products. It revealed the opportunities provided by Research Infrastructures to support industrial innovation in the agrifood sector.

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Application of ICP-MS for the determination of trace elements in side-streams in view of production of new food concepts

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In the framework of the "Up4Food" project (Upcycling side-streams for sustainable and healthy ingredients and new food concepts), researchers from five countries collaborate to improve food resource use by applying a systems approach to recycle processing side-streams from three key industries in Europe, such as potatoes, oil-seeds, and pelagic fish. The ingredients extracted from these side-streams are rich in minerals and antioxidants, proteins, essential amino acids, fibres, omega-3 and other bioactive fatty acids; hence they have a high value potential for the development of new food products or be used as supplement. To enable the development of healthy and sustainable new food products based on these side-streams, it is essential to assess both the nutritional quality and the safety of the side-streams, extracted ingredients and new food products. In this work, a multi-elemental method based on inductively coupled plasma-mass spectrometry (ICP-MS) was optimized for the determination of the (total) levels of 25 trace elements (TEs) in all the matrices addressed in the project, from the side streams (potatoes, pelagic fish and oilseeds by-products) to the ingredients (proteins, starch, oils, etc.). The method accuracy was assessed by the analysis of spiked side-streams at least at three different levels. The levels of TEs (25) were classified according to their contribution to hazard exposure (potentially toxic trace elements such as Pb, Cd, Hg and As) or their contribution to nutritional quality in the samples (essential TEs such as Na, Mg and Fe). Additionally, a selection of samples was also analysed for Hg speciation (mainly fishery by-products) and As speciation (all types of side-streams) based on high performance liquid chromatography coupled to ICP-MS (HPLC-ICP-MS). The results were compared to published data on similar sources and evaluated in relation to EUs toxic reference values in the food. The results on inorganic contaminants provide valuable insights into the risks associated with the novel food products proposed by the Up4Food project. Future research will apply similar approaches to investigate organic contaminants.

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Screening of pesticides in peaches using liquid chromatography high resolution mass spectrometry

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This study focuses on the determination of pesticide residues in fresh peach samples cultivated under Integrated Crop Management (ICM) systems in Imathia, a major peach-producing region in northern Greece. A sensitive and high-throughput multi-residue analytical method was developed and applied using liquid chromatography coupled with high-resolution Orbitrap mass spectrometry (LC-Orbitrap MS) for the screening and quantification of over 300 pesticides from different classes. Various high-resolution mass spectrometry (HRMS) acquisition modes—including full scan (FS), all-ions fragmentation (AIF), targeted MS2 (tMS2), and data-dependent MS2 (ddMS2)—were evaluated and compared. While all modes demonstrated strong performance in pesticide screening, full scan (FS) and data-dependent MS2 (ddMS2) were ultimately selected due to their suitability for non-targeted and retrospective analysis. Sample preparation involved a modified QuEChERS extraction with acetonitrile, followed by dispersive solid-phase cleanup, optimized for high recoveries and minimal matrix interferences. The optimised method was validated according to SANTE EU Guideline criteria. Method performance was evaluated through matrix-matched calibrations, recovery studies, and estimation of limits of quantification (LOQs), which ranged from 0.005 to 0.010 mg/kg, depending on the analyte. Recoveries exceeded 80% for most compounds, with relative standard deviations (RSDs) below 20%, indicating good method precision across different peach types. A total of 60 representative samples were collected during the first harvest season of 2025. The most frequently detected active substances were Acetamiprid, Boscalid, Pyraclostrobin, Fluopyram, Tebuconazole, Etofenprox, Fludioxonil, Cyprodinil, Mefentrifluconazole, and Chlorantraniliprole. Detected residue concentrations ranged from 0.010 to 0.150 mg/kg, with the majority of values below the corresponding European Union Maximum Residue Limits (MRLs). However, the co-occurrence of multiple pesticide residues per sample was commonly observed, reflecting the complexity of modern pest management in ICM systems. These findings emphasize the importance of high-resolution mass spectrometry as a tool for reliable food safety monitoring and regulatory compliance in fruit production chains, ensuring compliance with food safety standards and protecting consumer health.

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New trend in Multiresidue Methods: Achieving the maximum with the minimum

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The evolution of food analytical chemistry is continuous, delivering innovative solutions to classical challenges—low limits of quantification (LOQ), broad analyte scope, automation, and organic waste minimization. In routine laboratory management, accurately assessing your needs is essential for tailoring the adoption of these technologies, which may be constrained by time, accreditation requirements, and available resources. The primary objective remains meeting stringent food safety and trade standards, while also embracing ever more demanding measures that safeguard both human health and the environment. In recent years, key advances include: - Quantification of pesticides and related food contaminants down to low ppb levels - Screening hundreds of compounds with just a few multi residue and single residue methods - Turnaround times of 24 hours or less However, concerns over food security and the demands of expanding international trade are driving the need for even stricter contaminant controls measures that not only uphold the highest standards for human health but also address environmental impacts. During this talk, we'll showcase several recent technological developments in chromatography and mass spectrometry, alongside emerging requirements such as reducing organic waste and the increasing importance of monitoring PFAS contaminants.

Stable isotope dilution assays for mycotoxins help assess the risk of plant-based meat alternatives

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Worldwide dietary changes are partly due to consumers questioning the traditional production and consumption of animal-based food for its impact on animal welfare, energy waste, loss of biodiversity, and last but not least being detrimental to human health. Therefore, alternatives to traditional animal-based foods are increasingly developed, marketed and consumed. The range of products covers plant-based meat and milk alternatives along with products elaborated from cellular agriculture or tissues produced by protein-based additional manufacturing. We have been investigating plant-based meat alternatives for their mycotoxin content using table isotope dilution assays and have performed a risk evaluation. The outcome is giving a different perspective on the narrative that all of these alternatives are beneficial for ˝one health˝.

Building trust in the whitefish value chain: Organisational and technical dimensions of a traceability pilot

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The whitefish value chain faces persistent challenges related to fragmented data flows, limited transparency, and vulnerability to food fraud. These issues undermine regulatory oversight, hinder sustainable management of fish stock, and erode consumer trust. While emerging technologies like AI, DLT, and IoT can improve traceability, their impact and effectiveness depend not only on technical performance, but also coordination of actors, shared standards, and data governance. The pilot "Combating white fish counterfeiting in Norway", part of the Horizon Europe project WATSON (grant id: 10071171), currently under implementation in Norway, Denmark, and Poland, explores how a digitally enhanced traceability system can foster both consumer and regulatory trust in the seafood sector. The system integrates sensor data, a DLT-based platform, and Digital Food Product Passports (DFPP) based on GS1/EPCIS standards, enabling end-to-end data visibility, from catch to consumer. In parallel, an Early Warning System (EWS) is being developed in cooperation with control authorities to detect anomalies and potential fraud risks. Beyond its technical demonstrators alone, the pilot highlights the importance for joint governance in data-sharing infrastructures, including clearly defined roles, accountability of data input and quality, and mutually trusted rules for access and use. A key use case involves the development of a premium, single-supplier product line between the fishing vessel Hermes, and the processor Espersen. This coordinated supply chain enables full-cycle traceability testing, controlled and iterative feedback loops, and enhanced legitimacy among consumers and regulators. Consumers access product data through DFPPs, while regulatory bodies test the EWS for real-time oversight. Initial findings from stakeholder workshop and implementation planning suggest that trust is shaped by three interrelated factors: Data reliability (technical), process transparency (organisational), and role clarity (governance). Regulatory stakeholders value more continuous and granular access to supply chain data, while industry actors emphasise interoperability, proportionate data sharing, and protection of commercial confidentiality. Rather than treating technology as a standalone solution, the project underscores the significance of organisational and collaborative structures in making digital traceability credible and scalable. While core technologies are increasingly mature, major barriers lie in embedding them within real-world settings across diverse organisational contexts. Accordingly, digital traceability is framed not merely as technological innovation, but as a socio-technical transformation that requires institutional adaption, trust-building, and sustained coordination. Its success depends as much on governance and aligned incentives as on data standards and interoperability.

Consumer Purchase Intentions for Blockchain-Tracked Olive Oil and Feta Cheese

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Introduction: Blockchain technology appeared as a novel and promising way to address product quality, provenance, and food safety issues. Its main feature is the creation of a decentralized and immutable record that enables the secure and transparent exchange of data between the parties involved [1]. Previous studies have investigated the capabilities of blockchain technology (BCT) [1, 2]. However, research on consumer attitudes and purchase intentions for products tracked using blockchain technology has been limited. To better understand consumers' intentions to purchase products tracked through a blockchain system, this research assesses consumers' intentions to buy olive oil in Italy and feta cheese in Greece.

Data and Framework: Data collection was carried out via a consumer panel of a market research institute with a quota sampling method for age and gender groups. A total of 1000 responses were collected from Italian and Grecian adults. The questionnaire, grounded in TPB constructs, also incorporated items addressing consumer trust in quality certifications and their attitudes toward technology.

Results: Structural equation modeling (SEM) was employed to examine the factors influencing consumers' intentions. The PLS-SEM analysis showed that subjective norms, perceived behavioural control, attitudes toward the behaviour of buying blockchain-traced products and Attitude toward technology significantly impacted consumers' intentions to purchase blockchain traced olive oil and feta cheese. However, trust in quality certifications did not significantly influence purchase intentions.

Conclusion: The findings, based on two typical products in two different European countries, suggest that successful marketing strategies should focus on informing consumers about the benefits of blockchains, simplification of the user experience and use of social influences to promote the adoption of blockchain traceability.

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Blockchain based supply chain for PDO Feta Cheese: The ALLIANCE approach

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ALLIANCE is a European Horizon Europe initiative designed to enhance seven Food Supply Chains (FSCs), including one that facilitates the manufacturing and delivery of PDO Feta Cheese. ALLIANCE has developed an architecture that offers a thorough implementation plan, including the complete range from data acquisition to data utilization. IoT networks provide data collection via a modular architecture, permitting the dynamic integration of diverse sensor devices. The collected data are processed and stored before being utilized by the apps that support FSC administration. Blockchain is the essential technology utilized for safe and immutable data storage in a commercially viable manner. All stakeholders involved in the FSC contribute to the Blockchain network and are certain that no person can derive illicit advantages from data manipulation. The problem is that data storage in a Blockchain network presents performance issues. Efficient data storage requires the effective management of data, distinguishing the information intended for Blockchain from those stored in an auxiliary database referred to as off-chain. The simultaneous data storage in both Blockchain and off-chain systems is intricate, as maintaining consistency between the two repositories is crucial, requiring the deletion of data from one database if the other fails. In ALLIANCE, we engaged in iterative communication with stakeholders linked to each FSC to formulate its respective data model and ascertain the critical data to be preserved on the Blockchain, while the rest is retained off-chain. Additionally, we utilized the GS1 EPCIS protocol to standardize the storage and presentation of data of each FSC, hence enhancing interoperability among the FSCs. Finally, the UI of the ALLIANCE platform is a web-app that gives users the ability to interact with the data produced by the system. The administrators of the FSCs are provided with a dashboard that allows them to monitor their current state. This includes monitoring the materials that are present at each stage, the way they are processed, the outcomes of the relative quality controls, and the overall conditions of the FSCs. In addition, it serves as the point of input for the data that is generated by the users of the system, which includes farmers, drivers, people responsible for storage, and other individuals.

Securing Agri-Food Supply Chains with AI for Early Warning, Fraud Detection, and Decision Support

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The AI-enabled Early Warning and Decision Support System (EWDSS), developed within the ALLIANCE project, has proven to be a powerful system for detecting and managing food fraud across diverse agri-food supply chains. The system integrates predictive analytics, fuzzy logic, and multi-criteria decision analysis (MCDA) techniques to support proactive risk management and informed stakeholder decision-making. The early warning component leverages fuzzy logic to synthesize multiple risk indicators into a comprehensive fraud score. In the Organic Pasta supply chain, the system evaluates contamination levels across production stages (wheat, semolina, and pasta), field audit compliance rates, and certification validity, each mapped to fuzzy sets and aggregated into an overall fraud label. In the Feta Cheese supply chain, the system monitors key PDO-related parameters, specifically pH and temperature values, to identify potential adulteration or quality deviations early in the process. To support fraud prediction, a synthetic dataset simulating four years of Feta Cheese supply chain operations was developed. It captures complexities such as milk collection, transport, testing, supplier risk profiles, and realistic fraud injection mechanisms (e.g., cow milk adulteration, water dilution, and excessive goat milk in sheep milk). A key feature of the EWDSS is a multi-criteria evaluation framework for selecting optimal machine learning models using multiple performance metrics (e.g., accuracy, precision, recall, etc.). Based on the TOPSIS method, this framework objectively ranks supervised classifiers and unsupervised anomaly detection models applied in the Fava Beans and Organic Honey supply chains, using spectral, DNA, and sensor data. Complementing automated analytics, a human-in-the-loop decision support tool enables stakeholders to structure complex problems hierarchically, express preferences, assess consistency, and transparently rank alternatives. Use cases from the Fava Bean supply chain illustrate prioritization of fraud types by impact and detection difficulty, as well as evaluation of mitigation strategies based on practical and economic considerations. Implemented using modern technologies such as Python, FastAPI for RESTful services, Apache NiFi for data integration, and Apache Superset for dashboarding, the EWDSS delivers a robust AI-driven solution for early warning, predictive modeling, model evaluation, and participatory decision support in food fraud risk management.

Exploitation of seaweed for food and feed applications – the need for elemental analysis for assessment of safety

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Seaweed is the common term for marine macroalgae plants, which may be divided into green, red and brown algae types. There is a growing interest in increasing the exploitation of marine macroalgae for commercial purposes including their uses in relation to food and feed production and thereby contribute to the green transition by exploitation of this under-utilized bioresource. Many seaweeds have the potential to accumulate various trace elements and contain consequently relatively high levels of both essential and potentially toxic elements (PTEs). There is consequently a need to document the levels of potential toxic elements in seaweeds and to ensure that the use/consumption of the seaweeds is safe. In this context, a better understanding of how biological and environmental factors, like seaweed type, location, sampling season etc. affects the levels of trace elements is called upon, in order to be able to select seaweeds with optimum characteristics for commercial use. Additionally, further knowledge and understanding of the effect of post-harvest processing on the levels of elements in the biomass is called upon. Currently, the European Commission is considering setting future maximum levels for certain PTEs (incl. Cd, Pb, Ni, I, iAs) in seaweed and consequently there is a need to ensure the analytical capability of control laboratories for the future compliance testing. This will e.g. include harmonization of methods, development of reference materials, conduction of proficiency testing schemes (PTs). The lecture will present the outcome of recent research projects related to seaweed use in food and feed applications conducted at the National Food Institute at the Technical University of Denmark (DTU Food) with a focus on the analytical procedures used for the determination of trace element (including trace element species) and the subsequent evaluation of the obtained data in relation to the assessment of food and feed quality and safety. The lecture will further address the current status on element determination in seaweeds from the point of view of the EU reference laboratory for metals and nitrogenous compounds in feed and food (EURL-MN) hosted by DTU Food.

Development of an UHPLC-MS/MS method for determination of ultra-short PFAS in vegetable samples

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PFAS, a large group of widely used synthetic compounds, are known for high resistance to water, fat, and heat. Defined as environmentally stable "forever chemicals," their bioaccumulation and potential toxicity pose growing human health concerns. Tomatoes can accumulate high PFAS both from contaminated soil and irrigation water, becoming a primary food chain entry. In particular, matrix high-water content could facilitate the presence of highly polar ultra-short-chain (USC) PFAS. Monitoring health risks associated with PFAS exposure requires accurate and harmonized analytical methods. With common reverse-phase chromatography methods, poor or no retention of USC-PFAS causes poor reproducibility of retention time and, consequently, inaccurate quantification. This work aims to develop a Reversed-Phase Ultra-High-Performance Liquid Chromatography-Tandem Mass Spectrometry method capable of efficient retention and separation of USC-PFAS, as well as addressing the problems associated with these contaminants in laboratory environments. The investigation focused on DFA, TFA, PFPrA, PFBA, PFMeS, PFEtS, PFPrS, and PFBS. Analysis was performed with UHPLC- TRIPLE QUAD (SCIEX 6500+) on a variety of tomato products (concentrate, puree, and pulp) to quantify the possible presence of PFAS in the matrix. The optimization of the chromatographic conditions and the use of a delay column allowed efficient chromatographic separation. High sensitivity and good linearity were demonstrated in both solvent and matrix curves, with R2 ≥ 0.99 obtained for both considered concentration ranges (0.100 µg/L to 10 µg/L for DFA, TFA, and PFPrA; 0.010 µg/L to 1 µg/L for PFBA, PFMeS, PFEtS, PFPrS, and PFBS), corresponding to instrumental LOQs of 0.100 µg/L and 0.010 µg/L, respectively. The RSD% values, below 5% over 35 injections of both in solvent and in matrix standard mixtures, confirm the great repeatability and reproducibility of the developed method. The final evaluation confirmed extraction efficiency and quantification for USC-PFAS in tomato samples, showing recoveries and RSD% compliant with EU guidelines. Only PFBA was detected in screened samples—concentrate (0.265 ± 0.038 µg/kg), pulp (0.056 ± 0.005 µg/kg), and puree (0.063 ± 0.001 µg/kg)—suggesting its endogenous content increased during industrial processing.

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Chemopreventive Effects of Rosmarinic Acid against the Carcinogenic Food Contaminant Aflatoxin B1

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Rosemary (Rosmarinus officinalis L.) has long been valued for its therapeutic properties. This highly valued medicinal plant contains various natural bioactive compounds that exert diverse pharmacological effects. One of the key bioactive compounds is rosmarinic acid (RA). Available studies suggest that RA could be considered a potential anti-cancer agent in various cancer treatments, and its chemoprotective properties also highlight its potential in safeguarding against foodborne carcinogens. Therefore, in the present study, the chemopreventive effects of RA against the carcinogenic food contaminant aflatoxin B1 (AFB1) were investigated using both in silico and in vitro approaches. The in silico investigation of the chemical reactions between rosmarinic acid and the ultimate chemical carcinogen of AFB1, aflatoxin B1 exo-8,9-epoxide (AFBO), was conducted by calculating activation free energies with advanced DFT methods M11-L and MN12-L, in combination with the flexible 6-311++G(d,p) basis set and implicit Solvation Model Density (SMD), according to the newly developed QM-CSA protocol. Following computational analyses, the chemoprotective effects of RA were further studied in vitro in human hepatocellular carcinoma (HepG2) cells by analyzing its influence on AFB1-induced genotoxicity using the comet assay, γH2AX, and pH3, while its impact on cell proliferation and cell cycle modulation was assessed using flow cytometry. Our computational results revealed that the activation free energy required for the reaction of RA with AFBO is significantly lower than the activation free energy for the competing reaction of AFBO with guanine, which indicates that RA acts as an efficient scavenger of AFBO, potentially preventing AFB1-specific DNA adduct formation. The chemoprotective activity of RA was confirmed through in vitro experiments, which demonstrated a reduction in AFB1-induced DNA single- and double-strand breaks in HepG2 cells exposed to a mixture of AFB1 and RA at non-cytotoxic concentrations. In addition, RA reversed the AFB1-induced reduction in cell proliferation. Given the widespread occurrence of AFB1 in contaminated food, the chemoprotective effects of RA could have significant implications for mitigating the health risks associated with chronic AFB1 exposure and represent a potential dietary intervention strategy to reduce cancer risk. Further studies are needed to uncover the precise mechanisms underlying its effects, as well as in vivo studies to confirm its anti-cancer effects and to better validate its role in preventing AFB1-induced carcinogenesis.

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METROFOOD-BE service provision to support circular economy, food safety and sustainable solutions for food packaging

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Aim: This work presents two research use cases under METROFOOD-BE to showcase how Belgian infrastructure supports metrology-driven food safety research. The first use case focuses on compiling a comprehensive database of potentially migrating chemicals from paper-and-board food contact materials and evaluating their hazard and risk. The second use case characterises zinc oxide (ZnO) nanoparticles of a novel bio-based packaging system. By demonstrating database development, risk assessment and ongoing analytical workflows, we highlight how METROFOOD-BE enables reliable measurement science for food packaging safety.

Method: In use case 1, a substance database has been built to include 8 188 unique entries compiled from authoritative sources, such as the ESCO working group on paper and board, the Swiss ordinance on food contact materials, the council of Europe synoptic document (2005), the council of Europe resolution on paper and board (2024), EU regulation No 10/2011 on plastics, and relevant scientific literature. Each entry contains identifiers (CAS number, InChIKey), and when available, the reported use or occurrence, and available toxicological annotations. This list was filtered down through regulatory, exposure, and toxicological considerations to contain a more manageable database of 272 substances for detailed hazard classification via the SILIFOOD tool and further preliminary risk assessment. In use case 2, biodegradable films were formulated by embedding ZnO nanoparticles, olive leaf extract, and pine resin into a microfibrillated cellulose matrix. Physicochemical characterisation based on ultrathin sectioning of the films followed by scanning transmission electron microscopy (STEM) aims to visualise the distribution of nanoparticles within the film and to assess their size distribution. Parallel ICP-OES analyses are performed to quantify total ZnO vs nano partical ZnO in migration simulants under standard testing conditions.

Results: Both use cases were selected through an open call based on technical merit, innovation potential, and infrastructure availability. To date, the substance selection for use case 1 is fully compiled and underwent SILIFOOD-based hazard classification. The substance selection will now undergo risk assessment through exposure scenarios. For use case 2, sample preparation has been completed, STEM imaging is ongoing to assess ZnO nanoparticle size distribution, and migration experiments with the related ICP-OES measurements are in the final phase.

Conclusion: The creation of a large-scale, curated substance database and the initiation of physicochemical analyses for a biobased nanocomposite demonstrate how METROFOOD-BE's services underpin reproducible measurement workflows. These ongoing efforts will inform subsequent prioritisation and safety evaluation, ultimately guiding risk assessment protocols and fostering safer, more sustainable food packaging solutions. By providing open access to these metrological capabilities, Belgium reinforces its leadership in European food safety innovation.

Assessing the Uptake and Risk of Contaminants of Emerging Concern in Tomato Cultivation Using Treated Wastewater and Sludge

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Reusing treated municipal wastewater (TWW) and treated sludge (TS) for irrigation and fertilisation is a promising strategy to mitigate water scarcity and recycle nutrients in agriculture. However, TWW has been shown to contain contaminants of emerging concern (CECs), which may enter the food chain if TWW is used for crop irrigation, raising concerns about food safety and public health. This study investigates the uptake and translocation of 27 CECs in tomato plants cultivated under three experimental conditions: open-field, hydroponic systems, and sludge-amended pot experiments. In the field experiment, tomato plants were irrigated with (i) potable water (PW) as control, (ii) TWW, (iii) PW spiked with CECs at 1 mg/L and (iv) spiked TWW. In the hydroponic experiment, plants were cultivated using (i) control nutrient solution, (ii) TWW, (iii) nutrient solution spiked with CECs at 1 mg/L, and (iv) spiked TWW. For the pot experiment, treatments included (i) control peat substrate, (ii) TS amendment, and (iii) TS spiked with CECs at 12 mg/kg. Samples of irrigation water, sludge, soil and plant tissues were analysed by LC-MS/MS. In field experiments, only carbamazepine was >LOQ in tomatoes irrigated with TWW. Tomatoes irrigated with spiked media showed elevated CECs levels (up to 6 compounds). In a separate analysis of tomato plant parts, the trend in CEC levels was as follows: roots > leaves > stems > fruits. In hydroponic experiments, spiked growth media resulted in reduced plant growth. Three CECs were detected in tomatoes irrigated with TWW and up to 13 in those exposed to spiked TWW. Pot experiments revealed the uptake of up to 14 CECs among different treatments, and 6 CECs were quantified in the case of TS amendment. Human health risk assessment showed minimal risk from consuming tomatoes irrigated with TWW. In case of soil analysis (months 3 and 30), an environmental risk assessment revealed high ecological risks (RQ > 1) for azithromycin and triclocarban, in TWW-irrigated soils. The findings will be used to enhance our understanding of the risks and benefits of reusing treated urban wastewater in agriculture.

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Broadening Arsenic Speciation: Inclusion of Small Organoarsenic Species in Standard Food Testing Methods

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Arsenic (As) is a naturally occurring element frequently found in various foodstuffs including rice and cereals, marine organisms, algae, root vegetables, and infant formulas. [1] Chronic exposure to As has been associated with several adverse health outcomes such as cancer, skin lesions, cardiovascular disease, diabetes, and cognitive development problems in children. [2] Inorganic arsenic (comprising arsenite As(III) and arsenate As(V)) is considered as one of the most toxic arsenic species and is categorized as non-threshold Class I carcinogen (IARC, 2012). To mitigate exposure, maximum allowable levels for inorganic arsenic have been established in cereals, infant formulae and baby foods under Commission Regulation (EU) 2023/915. The recent EFSA risk assessment on small organoarsenic species (EFSA, 2024a [3]) highlighted no immediate health concerns for monomethylarsonic acid (MMA(V)), but raised potential concerns for dimethylarsinic acid (DMA(V)), recommending the development of robust and validated analytical methods to quantify specific organoarsenic species in food. The risk assessment for complex organoarsenic species (EFSA 2024b [4]) in food concluded that arsenobetaine and glycerol arsenosugar were not associated with health risks. However, insufficient data prevented conclusions on other arsenosugars and arsenolipids. The prevailing European standard method for determining inorganic arsenic in food (EN 16802) encompasses the quantification of other arsenic species. In response, the EN method has been adapted to enable the simultaneous detection and quantification of key small organoarsenic species across diverse food matrices. The following foodstuffs are tested for the presence of the species concerned: - edible insects, distinguished by their chitin content; - grain products other than rice, due to their significant contribution to dietary inorganic arsenic exposure; - novel plant-based protein sources such as lupins and beans; - seafood, in light of potential regulatory limits on inorganic arsenic in crustaceans, bivalves, and cephalopods. The analytical method comprises an extraction of the arsenic species contained in the matrix by heating in an acidic and oxidising medium. The species are separated using an anion-exchange column, followed by ICP-MS detection. The present work supports ongoing regulatory and risk assessment efforts by providing improved analytical capacity for arsenic speciation in a broad range of food products.

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Large-scale biomonitoring of bisphenols in the Swiss adult population

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In 2022 and 2023, the Swiss Federal Food Safety and Veterinary Office (FSVO) conducted a study about salt intake in Switzerland. The study included a representative sample of adults from different regions, age groups, and genders across Switzerland. Beside the determination of some cardiometabolic indicators, 863 Participants completed detailed questionnaires about their dietary habits, knowledge about salt consumption and other lifestyle factors. The participants were also asked to provide 24-hour urine samples. In this elaborate framework, the FSVO mandated METAS to determine in these urine samples the amount of some bisphenols, phthalate metabolites and iodine. Bisphenols (BPs) are used as monomer for the production of polycarbonates, epoxy resins and thermal paper. Due to their presence in common consumer products as well as their chemical structure, they can migrate into food, beverages, water, dust and soil, leading to human exposure by a variety of routes. Dietary ingestion is the most significant route of exposure. BPs can leach into food and drinks from containers, especially when they are scratched, heated or washed repeatedly. BPs are suspected to have disrupting effects on the endocrine system of humans and animals. Endocrine-disrupting chemicals may mimic, block or interfere with the body's hormones and are associated with health issues. Glucuronidation of BPs in the intestine and liver is considered the main metabolic pathway for most BPs while other metabolites only result when the glucuronidation pathway is saturated. These metabolites are mainly excreted through urine. Therefore, human biomonitoring in urine is a crucial method to assess the possible presence of these chemicals in various body fluids to determine the overall extent of exposure in both a qualitative and quantitative manner. During the sample preparation, enzymatic hydrolysis is performed to cleave the glucuronides in urine, followed by protein precipitation. Eleven bisphenols were selected and analysed with ultra-high pressure liquid chromatography–mass spectrometry in a 13-minute run. The mass spectrometer was operated in negative ionization mode, using a scheduled multiple reaction method with three transitions per substance (one quantifying and two qualifying transitions) to ensure selectivity. Corresponding isotopically-labelled standards were added in equal amounts to all samples to ensure robustness. The Method Accuracy Profile associated with the β-expectation tolerance intervals was selected to assess and validate the quantitative performance of the newly developed analytical method. Measurement uncertainties were estimated based on the validation measurements. We will present the results of this extensive biomonitoring study of bisphenols in Switzerland.

Lactose Tablets as suitable Microplastics Reference Material to support validation studies and food quality control

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A major hurdle in validating microplastics detection methods is the scarcity of appropriate reference materials. The EU-funded PlasticTrace project has overcome this by creating water-soluble tablets that precisely quantify polyethylene terephthalate (PET) particles. These tablets are designed with specific mass loadings (0.2, 18.5, or 400 µg) and particle counts (151 or 1764, verified by Raman spectroscopy). Their production utilizes a rigorous solid-phase dilution process, ensuring high reproducibility and stringent quality control. The PET particles possess an average size of approximately 40 µm (ranging from 10 to 200 µm) and an irregular, stone-like morphology. All metrological aspects adhere to ISO/TC 147/SC 2 standardization efforts, specifically ISO/DIS 16094-2 and ISO/DIS 16094-3. To confirm homogeneity, the most widely accepted microplastics detection techniques—µ-FTIR, µ-Raman, Py-GC/MS, and TED-GC/MS—were employed across different batches with varying particle numbers and masses, extending to the methods' detection limits. The results demonstrated exceptional consistency between tablets, confirming successful homogeneity. Moreover, no significant changes in composition or stability were observed after six months of storage. This innovative reference material represents a significant advancement in microplastics analysis, empowering laboratories to meet EU Commission requirements for monitoring microplastics in drinking water and wastewater with enhanced accuracy and reliability. The developed production process is transferable to other plastic particle types within this size range.

The ScreenFood project: Metrology for food safety in the circular economy

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Safeguarding consumers from potential harm caused by food contamination is of paramount importance to ensure food safety. The focus on safety is a central priority for European Commision lawmakers. Furthermore, as outlined in the EU circular economy action plan, the development of a sustainable food system is a critical objective. However, progress towards these goals can sometimes face obstacles, including the risk of eroding consumer confidence in food quality. Factors such as the increased use of recycled and sustainable packaging materials and the growing awareness of emerging contaminants necessitate immediate attention. To ensure a high level of food safety throughout production and distribution, it is crucial to improve and harmonise analytical techniques for contaminant quantification. This constitutes the basis for reliable data and compliance with regulations and for resolving disputes and minimising financial losses within the food industry. The ScreenFood project (June 2024 -May 2027) is funded by the European Metrology Partnership and aims to develop reference methods and reference materials for quantifying contaminants in both food and food packaging, with a specific emphasis on recycled materials. These metrological tools will aid industries and official food control in guaranteeing the delivery of safe food and sustainable packaging while adhering to regulatory requirements. Specific objectives of the project are i. To improve protocols for the quantification of the mineral oil aromatic hydrocarbons (MOAH) fraction and for the quantification of the fraction consisting of substances with three or more aromatic ring systems (3+MOAH); ii. To develop sensitive analytical procedures for detecting and quantifying per- and polyfluoroalkyl substances (PFAS) in selected matrices, in line with EU requirements; iii. To develop traceable and highly accurate reference materials for quality control and quality assurance purposes; iv. to develop screening methods addressing new/existing organic and inorganic contaminants, in virgin and recycled packaging, such as PET, and bio-based and reusable materials; v. To investigate the migration of contaminants from packaging into food simulants, as well as to foster the research in the discovery of Emerging and Novel PFAS through non-targeted screening. The consortium brings together 28 partners from EU metrological institutes, research centres, control laboratories, EU reference laboratories and industries. A large panel of collaborators and stakeholders is supporting the consortium in keeping the project aligned with EU and industrial priorities. This presentation will outline the project objectives and the planned advances beyond the state of the art and provide an overview of ongoing activities.

Antimicrobial Packaging Innovation for Fresh Strawberries

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The widespread presence of biofilm-forming microorganisms and the growing consumption of ready-to-eat fresh produce represent a critical dual challenge for the food industry. There is an urgent need for innovative and eco-friendly antibiofilm strategies and microbiological control systems to enhance food quality and safety. This study investigates the effectiveness of antimicrobial active packaging developed with a combination of natural compounds to preserve fresh Italian "Favette" strawberries. The most promising treatments were selected to develop five active packaging prototypes, consisting of absorbent PADs functionalised with different concentrations of chitosan, nisin, and carvacrol. Microbiological analyses were carried out to evaluate the extension of shelf-life up to twelve days by quantifying total bacterial and fungal loads. In addition, molecular techniques were employed to identify the ninety-five isolates and to evaluate the strawberry-associated microbiota under the different antimicrobial active packaging conditions. Moreover, migration tests were performed according to EU regulations, including specific analyses for metal migration, heavy metal content (Regulation (EU) 10/2011 and Directive 94/62/EC), and carvacrol-specific migration, using inductively coupled plasma mass spectrometry (ICP-MS) and Fourier-transform infrared spectroscopy (FTIR). The results revealed the enhanced antimicrobial efficacy of PADs functionalised with the combination of carvacrol, nisin, and chitosan compared to the single-agent applications. This innovative approach represents a sustainable solution to improve the microbial safety and shelf-life of fresh produce, while promoting the added value of Italian agrifood excellence.

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Assessment of the impact of cooking on the fate of potentially toxic elements and nutrients in foodstuff

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Current approaches typically used in chemical risk assessment related to food consumption rely almost exclusively on the information retrieved based on the composition of the raw food items. However, various cooking procedures may influence the chemistry of the contaminants, including potentially toxic trace elements (PTTEs), as well as the nutritional quality of food. Actually, the assessment of the impact of food cooking on the fate of both toxic and essential inorganic chemical species is scarcely carried out and knowledge in this field is lacking. The present study aims to contribute to a better understanding of the impact of the on the fate of potentially toxic trace elements such as Pb, Cd, Hg, As, Cr, Al, Sb, Mn, Co and Ni and the speciation analysis of As and Hg (in both cases, inorganic and organic species will be studied) in food. For this purpose, various food matrices of vegetable origin (lentils, rice) and animal origin (beef steak, beef liver, salmon and swordfish) were subjected to different domestic cooking methods depending on their type (these included e.g. boiling, steaming, deep-frying, and oven baking). Then, raw and cooked samples were analysed in parallel to evaluate the impact of the cooking procedure on the concentrations of different TE (potential losses, transformations, or enrichments). In order to accurately assess the impact of food cooking on the risk/benefit balance, the variation in levels of the most important nutriments, such as P, S, I, Na, K, Ca, Mg, Se, Fe, Mo, Cu and Zn were also investigated. The analytical approach was based on the quantification of total levels of 22 elements by ICP-MS and speciation analysis of As and Hg by HPLC-ICP-MS. Preliminary results in terms of lentils and rice cooking impact showed limited changes in total concentrations for most elements. A slight increase in chromium was observed in lentils, while the levels of other elements remained stable. In rice, reductions were noted for several elements, with inorganic arsenic decreasing, consistent with existing literature.

Oxidative Stress and Inflammation Dynamics in Type 2 Diabetes: Effects of the SGLT2 Inhibitor Empagliflozin

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This study examines oxidative stress and chronic inflammation, key factors in type 2 diabetes development. Oxidative and nitrative stress results from an imbalance between reactive oxygen species (ROS) and antioxidants, causing cellular damage. Chronic low-grade inflammation involves elevated pro-inflammatory cytokines that impair insulin signaling and metabolism. Hereditary Hypertriglyceridemic (HHTg) rats, a non-obese model prone to hypertriglyceridemia, insulin resistance, low HDL, fatty liver, and Wistar rats were fed a standard chow diet and treated with empagliflozin. Urine samples from four groups were analyzed: HHTg-Control, HHTg-EMPA, Wistar-Control, and Wistar-EMPA. Significance was tested within each strain (Control vs. EMPA) and between strains under EMPA treatment (Wistar vs. HHTg). Results showed significant differences in oxidative stress biomarkers between EMPA-treated and untreated groups. Lipid peroxidation markers changed notably: 8-isoprostane levels differed between Wistar-EMPA vs. HHTg-EMPA ($P < 0.0001$) and HHTg-Control vs. HHTg-EMPA ($P < 0.05$). MDA levels were also higher in treated rats ($P < 0.01$ and $P < 0.05$). Nucleic acid damage markers were elevated in HHTg-EMPA vs. Wistar-EMPA: 8-OHdG ($P < 0.01$), 8-OHG ($P < 0.0001$), and 5-HMU ($P < 0.01$). Peptide and nitrative damage biomarkers increased in HHTg-EMPA vs. HHTg-Control: o-tyrosine ($P < 0.01$), and between HHTg-EMPA vs. Wistar-EMPA for 3-nitrotyrosine ($P < 0.001$) and 3-chlorotyrosine ($P < 0.01$). Inflammatory biomarkers significantly decreased after empagliflozin treatment. In Wistar (Control vs. EMPA), leukotriene C4, IL-8, IL-6, and leukotriene B4 all declined ($P < 0.05$), leukotriene E4 and Leukotriene D4 ($P < 0.001$). In HHTg (Control vs. EMPA), leukotriene C4 and IL-8 decreased ($P < 0.05$), IL-6 declined ($P < 0.01$), while leukotriene D4 and E4 showed no change ($P = 0.94$ and $P = 0.357$). Empagliflozin reduces inflammatory biomarkers despite increased oxidative stress, which may limit pro-inflammatory cytokine activity by modifying their precursors and be influenced by deficiencies in daily dietary variability. Antioxidant-rich functional foods could manage oxidative stress and inflammation in type 2 diabetes, preventing further comorbidities. Supported by OMICs techniques like UHPLC-QqQ-MS and GC-MS and advanced statistical analyses, this approach proves valuable for early prognosis of complex pathologies. The strong association between metabolic syndrome (MetS) and chronic kidney disease (CKD) may be explained by shared mechanisms including chronic inflammation, oxidative stress, and insulin resistance.

Quality of tomatoes grown in sludge containing contaminants of emerging concern

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Aerobic biological wastewater treatment generates substantial quantities of sludge as a by-product, which poses challenges for its disposal and management due to its volume. Moreover, while sludge contains nutrients and organic matter, it frequently contains pathogens, toxic elements, hazardous chemicals, contaminants of emerging concern (CECs) and microplastics. If not properly treated or disposed of, these constituents pose serious environmental and public health risks, including the potential contamination of soil and water resources [1]. Anaerobic digestion is a common method for processing sludge. The technique employs anaerobic microbes under oxygen-free conditions to stabilize sludge, reduce its volume, and generate biogas (methane), which can serve as a source of energy [2]. However, the final digestate still requires dewatering and environmentally safe disposal. Identifying sustainable and safe methods for sludge disposal remains a challenge, as current practices, such as incineration, landfilling, and land application, are each associated with specific limitations, including environmental pollution, land use constraints, disposal costs and regulatory restrictions. [3]. In this study, the use of anaerobically digested sludge as fertiliser in tomato (Solanum lycopersicum L., cv. Rally) cultivation was investigated through pot experiments assessing metabolomic changes in tomato fruits due to exposure to sludge. Tomatoes were grown in various substrates: peat; peat spiked with CECs at two concentrations (27 CECs, 0.16 and 1.7 mg/kg); peat amended with dried sludge at two application rates based on N and K requirements; peat spiked with dried sludge (27 CECs, 11 mg/kg, sludge added according to N and K requirements) and peat mixed with non-dried sludge (1:1). Tomato fruits were analysed for quality parameters, including sugars (HPLC-RI), organic acids (HPLC-UV), polyphenols (HPLC-DAD), amino acids (GC-MS), fatty acids (GC-FID), volatile organic compounds (HS-SPME GC-MS) and elemental composition (ICP-MS). Preliminary results revealed significant differences in sugars, organic acids, carotenoids, polyphenols, and volatile organic compounds. Significant metabolic changes indicate that exposure to sludge and CECs triggers stress responses in tomato fruits.

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Natural actives for ecofriendly/sustainable alternative disinfection strategies for agricultural products

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The society and the habits of people are progressively changing as well as the request on global market. Indeed, the increasing frenzy of modern lifestyle prompted the consumers looking for fresh, healthy, and ready-to-eat foods. Nowadays a high attention is given to alternative strategies or technologies in the agriculture field to face the environmental and health needs. Synthetic pesticides have been intensively used in agriculture since the second half of 20th century; thus, given the general concern about the environmental and health risk, more sustainable and eco-compatible alternatives are arising. In the present work we focused on the use of natural actives which present antimicrobial activity on different stages of the production process. We developed alginate and carboxymethylcellulose hydrogel beads, which allow the direct and controlled release into the soil of isothiocyanates from Brassicaceae and then a formulation containing actives from Amaryllidaceae and biosurfactants to sanify the fourth range products during washing stage. The beads were characterized by means of ATR-FTIR and DSC measurements, while the loading efficiency and release profile by means of UV-Vis spectrophotometry. The obtained results show that these systems represent a versatile, ecofriendly and non-expensive alternative to biofumigation processes currently employed in agriculture. Liquid formulation based on ungeremine or diacetylicorine in presence of rhamnolipids are studied by means of surface tension measurements, UV-Vis and fluorescence spectroscopy. The results of ecotoxicological assays and microbiological analysis confirm the ecofriendly profile of the formulation which is able to significally reduce the bacterial load.

POSTERS

Antimicrobial profile of sourdough lactic acid bacteria against pathogen bacteria and molds

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This study aimed to characterize sourdoughs obtained by spontaneous fermentation from Einkorn wheat, corn and rye ecologic flour manufactured following traditional type I sourdough protocol, by their lactic acid bacteria population (LAB). The study also evaluated their antibacterial and antifungal proprieties against pathogen bacteria and spoilage fungi. For this purpose, 20 LAB strains were isolated from which 8 strains were identified to species level using a semi-automated Biolog® Microbial Identification System. The dominant LAB microflora was Lactobacillus bifermentas, Lactobacillus plantarum, Lactobacillus fermentum, Lactobacillus casei, Pediococcus acidilactici, Lactobacillus brevis, Lactobacillus coryniformis. The strains were evaluated for their antimicrobial proprieties using agar well diffusion method against pathogen bacteria Staphylococcus aureus, Echerichia coli, Enterococcus faecalis and Bacillus spizizenii and spoilage fungi Aspergillus brasiliensis, Penicillium crysogenum and Mucor racemosus. Most LAB strains showed antibacterial activity on the test microorganisms, especially on B. spizizenii ATCC 6633 but only four LAB strains showed inhibitory effect on the growth and development of fungi. P. chrysogenum was the most susceptible to the action of LAB strains, especially L. plantarum, P. acidilactici, L. coryniformis. Antimicrobial metabolites of these isolates inhibited B. spizizenii and S. aureus, P. crysigenum contaminants from flour, yeast and other sources. Gram-positive bacteria were more susceptible to the action of metabolites produced by lactic acid bacteria strains, E. coli being more resistant to the action lactic bacteria metabolites. According to the results of the study, generally, L. casei, L. brevis and P. acidilactici strains presented a high potential as sourdough starters, in single or mixted starter cultures, because of their antimicrobial activity against bacteria and fungi.

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The histaminergic system as a potential target in the treatment of binge eating behaviour in an animal model

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Background: Binge eating disorder (BED) is a psychiatric disorder characterized by regularly recurring episodes of binge eating, in which excessive amounts of food are consumed in a short period of time, with a feeling of loss of control over that behaviour. This health issue is often associated with obesity, but so far, anti-obesity medications are not recommended for BED. To date, only one drug (lisdexamfetamine)

is approved by FDA as a pharmacotherapy, so there is an urgent need to develop new therapeutic strategies. Much evidence indicates the role of neuronal histamine in the modulation of stress response and feeding behaviour. Therefore, we investigated the changes in the histaminergic (HA) system at the level of gene expression and the effect of HA system targeted compound in an animal model of binge eating behaviour.

Methods: Binge eating like behaviour in female Sprague–Dawley rats was induced using food restriction cycles and frustration stress with highly palatable food. After repeated binge eating episodes, rats were sacrificed and selected brain areas were dissected for the RT-PCR gene expression analysis. Furthermore, the effect of an acute and then chronic pharmacological treatment designed to enhance HA neurotransmission was evaluated in the same animal model.

Results: Significant alterations in the mRNA expression of HA receptors and enzymes responsible for histamine metabolism were detected in different brain areas of binge eating animals compared to control rats. Moreover, both acute and chronic pharmacological intervention completely blocked binge eating like behaviour and prevented some gene expression alterations.

Conclusions: The presented results indicate that the HA system could be involved in binge eating behaviour and might be a new target for pharmacological treatment of BED.

Recovery and Green Purification of Methylxanthines and Flavan-3-ols from Cocoa Husk Agro-Waste

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Cocoa husk accounts for ca. 12–20% of the total weight of cocoa beans and is one of the main by-products generated during the pre-roasting and roasting steps [1]. Global cocoa processing generates an estimated 700,000 tons of husk annually, most of which is discarded as waste despite being a rich source of bioactive compounds [2]. Among these, polyphenols such as catechins and procyanidins have been widely associated with antioxidant, anti-inflammatory, and neuroprotective properties, while methylxanthines, including theobromine and caffeine, are known for their stimulant and diuretic effects [3-6], making cocoa husk a promising raw material for sustainable valorization. In this study, a green purification strategy was applied to previously obtained aqueous-ethanol extracts of cocoa husk. A liquid–liquid extraction with food-grade ethyl acetate was initially performed to reduce polar impurities and enrich the target compounds. The resulting semi-purified extracts were subsequently processed using flash chromatography on a reverse-phase C18 column with an ethanol–water gradient, following green chemistry principles. The antioxidant activity of collected fractions was evaluated by ferric reducing antioxidant power (FRAP) assay. Fractions enriched in flavan-3-ols, particularly epicatechin and catechin, showed the highest antioxidant response, consistent with their known redox behavior [7]. The target compounds were identified and confirmed using high-performance liquid chromatography with diode-array detection (HPLC-DAD) and tandem mass spectrometry (HPLC-MS/MS) based on retention time, UV-Vis spectra, and MS fragmentation patterns in comparison to analytical standards. This study successfully demonstrates a viable and green methodology for the effective recovery of high-value bioactive compounds from cocoa husk, promoting circular economy principles and enhancing the sustainability of agro-industrial processes.

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Dietary Potassium Reduction in Fruits and Vegetables: A Study on the Efficacy of Ultrasonic Soaking and Thermal Processing

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Patients with chronic kidney disease (CKD) face an increased risk of hyperkalaemia, necessitating dietary potassium restriction. However, many potassium-rich foods, particularly fruits and vegetables, are vital components of a healthy diet. This creates a dilemma, as current guidelines often recommend limiting these nutritious options. Our research investigates how various food preparation methods, specifically ultrasonic soaking, can effectively reduce potassium content in fruits and vegetables, thereby expanding safe dietary choices for CKD patients. We analyzed six common fruits and vegetables, using gravimetric analysis and atomic absorption spectrometry (AOAC 999.11) to determine the impact of soaking type (water vs. ultrasound), heat treatment, soaking time, and food piece size on the levels of potassium, sodium, zinc, iron, dry matter, and ash. Our findings indicate that ultrasonic soaking significantly enhances potassium reduction. A 180-minute ultrasonic soak was more effective than water soaking in lowering potassium content to the target level (<200 mg/100 g). Both heat and mechanical treatment (i.e., smaller food pieces) notably influenced leaching efficiency. Heat-treated samples consistently showed lower final potassium levels. For broccoli and carrots, adequate potassium reduction was achieved only through combined soaking and heat treatment. Potatoes required longer soaking times (180 minutes) alongside heat treatment to fall below the threshold. Notably, peaches saw sufficient potassium reduction after just 30 minutes of ultrasonic soaking. Pears and blueberries, however, already had naturally low potassium levels in their raw state, making them suitable for CKD patients without special preparation. We also observed that smaller piece sizes in carrots and potatoes resulted in lower final potassium content. While this study reveals promising trends in potassium reduction through optimized food preparation, a limitation was the single subsample per influencing factor due to the broad scope of foods and variables. Future research should focus on a single food type with multiple subsamples to enable statistical analysis and further confirm these findings, including the influence of natural diversity on elemental content.

Evaluation of side-streams from sea buckthorn oil production

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Sea buckthorn berries (Hippophae rhamnoides L.) are widely known for their medicinal and nutritional benefits [1, 2]. Extracting oil from sea buckthorn berries produces a significant amount of side-streams, commonly referred to as cake, which is recognized for its high content of bioactive compounds. The objective of this work was to assess and compare the nutritional properties of sea buckthorn cakes generated after two different oil extraction techniques, namely: cold pressing (CP) and supercritical carbon dioxide extraction (SC). In terms of proximate composition, the most notable difference between

the two extraction methods was related to the fat content. The sea buckthorn cake obtained through SC extraction had significantly lower fat – about 10 times less – than the cake produced via CP. The CP cake exhibited a darker color, reflected by its lower L* value, and showed a more intense redness, indicated by a higher a* value, compared to the SC cake. The chromaticity towards yellow (b*) displayed comparable values for both cakes. The CP cake exhibited a higher concentration of total phenolics (15 mg gallic acid equivalent/g d.m.) and flavonoids (4.9 mg quercetin/g d.m.) compared to the SC cake. Additionally, antioxidant capacity, as assessed through four complementary methods, showed higher values for CP than SC. The comparative antioxidant capacity values (expressed as mg Trolox/g d.m.) for CP and SC cakes were as follows for each investigated assay: 9.6 vs. 6.3 (DPPH), 19.9 vs. 14.0 (FRAP), 45.0 vs. 31.9 (ABTS), and 36.8 vs. 24.8 (CUPRAC). The CP and SC sea buckthorn cakes are characterized by relatively high content of polyphenols, flavonoids and antioxidants, reinforcing their potential as valuable raw materials for enhancing the nutritional profile of food products. The findings highlight opportunities for using these side-streams from the sea buckthorn oil industry in food development. To improve their integration into food formulations, efforts should concentrate on optimizing sensory attributes, addressing atypical aromas and flavors, and evaluating consumer acceptance to ensure market viability.

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Exploring the amino acid profile of various legumes for optimal nutrition

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Legumes have an important role in promoting healthy and sustainable human diets due to their high content in protein, fiber, and bioactive compounds. The nutritional quality of food proteins is largely determined by their essential amino acids composition and digestibility. While the amino acid profile of legumes varies across different types, legume proteins are generally deficient in sulfur-containing amino acids. However, they are abundant in lysine, making them complementary to cereal proteins in a balanced diet. This study aimed to analyze the amino acid profile and assess the nutritional quality of protein in various legumes, including lentils (red, green, yellow, brown, black), beans (mung, pinto, black, kidney), chickpea, soy, and lupin. Amino acid analysis was conducted using a high-performance liquid chromatography system with an automatic pre-column derivatization method [1]. The results are expressed as g/100 g protein. Glutamic acid (15.2-27.6%) and aspartic acid (10.4-13.9%) were the most abundant amino acids, while methionine (0.8-1.6%) and cysteine (0.6-1.5%) had the lowest concentrations. In all the legume samples analyzed, the essential amino acids leucine, valine, isoleucine, threonine, histidine, lysine, and aromatic amino acids (phenylalanine + tyrosine) met the FAO recommended requirements. Chickpea and soy fulfilled the FAO requirements for sulfur-containing amino acids (>2.5%), whereas green and brown lentils had the lowest essential amino acids content. According to the amino acid scores (AAS), soy, black bean, kidney bean, and mung mean did not have any limiting amino acids. Protein digestibility corrected amino acid score (PDCAAS) values indicated that soy, chickpea, and mung bean generally exhibited high protein quality. Based on the essential amino acid index (EAAI), green and brown lentils had low protein quality (EAAI values below 75), while all the other legumes samples displayed moderate protein quality (EAAI between 75 and 86). Combining legumes or blending them with cereals are essential to develop innovative food products that meet the evolving preferences of modern consumer.

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Co-creation from University-based Living Labs: the case of the FUSTO Programme

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FUSTO (From Soilless to Table and Beyond) is an interdisciplinary innovation and learning program aimed at advancing sustainability and innovation in agri-food systems, operating within the framework of national programs such as AGRITECH (Spoke 9) and METROFOOD-IT, funded by the Italian NRRP. FUSTO connects the Santa Chiara Lab of the University of Siena, a certified Living Lab under the European Network of Living Labs (ENoLL), and Siena Food Lab Foundation, a Living Lab created by the University of Siena and the Monte dei Paschi Foundation, whose partners include seventy agricultural enterprises, a secondary school and all local farmers associations. In this way, a wide ecosystem connecting academia, industry, and local communities was developed, integrating in a perspective of co-creation scientific research, technological development, and stakeholder engagement. FUSTO addresses the entire value chain—from primary production to processing, packaging, consumption, and circular reuse-supporting a wide array of research and technology transfer activities, concerning: - Soilless cultivation research using advanced hydroponic and aeroponic systems to optimize plant growth in resource-efficient environments. - Sustainability assessment and ESG reporting through the ESG4Agri platform and LCA software (SimaPro), helping farmers and agrifood companies to evaluate and communicate their environmental and social performance. - AGRIHUB is an innovative platform that integrates a comprehensive database of sustainability indicators across the agri-food supply chain, collected from both primary and secondary sources. Through an interactive dashboard, users can easily and intuitively visualize the data using charts and tables. - Geographical and varietal traceability of agri-food products using isotopic, genetic, and chemometric analyses to ensure quality, safety, and authenticity. - Consumer behavior analysis using virtual reality, focus groups, and participatory methods to explore perceptions and choices related to food sustainability and innovation. - Food transformation and design in the Kitchen Lab, integrating 3D food printing, mold design, and dietary personalization aligned with Mediterranean diet principles. - Sustainable packaging innovation, developing biodegradable and functional materials from agri-food waste with antimicrobial and antioxidant properties. Through its Living Lab methodology, Fusto fosters co-creation among diverse stakeholders, ensuring that innovations are grounded in real-world needs and aligned with the Sustainable Development Goals (SDGs), particularly food security (SDG 2), sustainable consumption and production (SDG 12), and climate action (SDG 13). This dynamic ecosystem exemplifies how university-based Living Labs can cooperate among them and serve as effective platforms for systemic innovation, bridging research and practice to drive sustainable transformation in the agri-food sector.

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Multi-Analytical Assessment of Paprika and Cinnamon Authenticity and Quality in the Slovenian Market

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Spices such as paprika (Capsicum annuum) and cinnamon (Cinnamomum spp.) are highly susceptible to food fraud due to their economic value and complex global supply chains. This study presents an integrated analytical approach to assess the authenticity, declared origin, and production method of 45 paprika and 46 cinnamon samples available in the Slovenian market. Stable isotope ratio analysis (δ13C, δ15N, δ34S), multi-element profiling, Fourier-transform infrared (FTIR) spectroscopy, and antioxidant activity measurement were applied to provide a robust authenticity framework. Classification based on stable isotopes and elemental composition achieved 90?curacy for paprika (distinguishing products from Hungary, Serbia, and Spain) and 89% for cinnamon (differentiating Sri Lanka, Madagascar, and Indonesia). Organic paprika samples showed elevated δ15N, δ34S, and Zn, whereas conventional samples had higher levels of Na, Al, V, and Cr. In cinnamon, production systems were distinguished with 95?curacy using δ34S and Ba as primary indicators, supported by δ13C, Rb, Na, Fe, Cu, and others. FTIR analysis clearly separated Ceylon cinnamon from cassia and flagged several paprika samples showing spectral features indicative of undeclared additives such as azo dyes and the absence of key oleoresin bands. Antioxidant profiling provided further insight into spice quality, revealing the highest antioxidant levels in conventionally grown cassia cinnamon. The combination of isotopic, elemental, spectral, and functional profiling offers a powerful tool for verifying spice authenticity and production claims. This comprehensive strategy enhances transparency in the spice trade and provides a scientific basis for enforcing food labeling regulations and safeguarding public trust.

Analytical Characterisation of Emerging High-Value Seed Oils in Slovenia

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In recent years, the consumption of edible vegetable oils has significantly increased. While palm oil, soybean oil and rapeseed oil remain the most widely produced and consumed, there is a growing interest in high-value specialty oils. A similar trend has been observed on Slovenian market, where oils such as walnut oil, grape seed oil, oil of spotted thistle, apricot seed, hemp oil, hazelnut oil, castor oil, apricot seed oil, avocado oil and primrose oil are increasingly present on retail shelves, reflecting a shift in consumer preferences toward diverse and nutritionally rich oil sources. Due to their beneficial effects on human health and high market price, these oils are often susceptible to adulteration, highlighting the critical need for reliable authentication and traceability methods to ensure quality, safety, and consumer trust. This study explores the potential of stable isotope analysis as a powerful tool for verifying specialty oils. Stable isotope ratio analysis of key elements such as carbon, hydrogen, and oxygen provide valuable

insights into authenticity and traceability of oil. While stable isotope techniques offer high precision and accuracy, their integration with complementary methods such as volatile organic compound (VOC) profiling and fatty acid composition analysis further strengthens quality assurance and food fraud prevention. By combining advanced analytical techniques, this study underscores the importance of a multidimensional approach to ensuring the authenticity, safety, and sustainability of newly marketed high-value oils to protect them against adulteration. While this approach has been applied to selected oils such as olive oil [1], pumpkin oil [2] and Camelina sativa oil [3] their application to emerging high-value specialty oils remains limited. This research addresses that gap by applying advanced analytical techniques to characterize the composition and physical properties of newly marketed oils. The findings support the development of comprehensive control strategies aimed at protecting consumers and ensuring product integrity in the expanding market of high-value edible oils.

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Impact of Climate Change on Fatty Acid Composition and $\delta^{13}C$ Signatures in Slovenian Extra Virgin Olive Oil: A Long-Term Study

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Extra virgin olive oil (EVO oil), obtained from the fruits of olive tree, is a valuable vegetable oil that plays an important role in human diet due to its sensory qualities and health benefits. One of the purity criteria for EVO oil is fatty acid (FA) composition, which is regulated by the International Olive Council. However, climatic changes—such as variations in temperature, rainfall, and humidity—can influence the biosynthesis of FAs in olives, potentially leading to shifts in their concentration and affecting the oil's compliance with established quality standards. Nevertheless, there is a lack of long-term studies investigating how the quality parameters of EVO oils are affected by climatic factors. This study aimed to evaluate FA composition in authentic Slovenian EVO oils over a 27-year period (1993–2019), and to assess the stable carbon isotope ratios ($\delta^{13}C$) of bulk oil and individual FAs for selected harvest years (2006–2008 and 2019), in order to explore their relationship with changing climatic conditions. FA composition was determined using the in-situ-trans-esterification method and characterized by GC-FID, while isotopic characterization was performed using GC-C-IRMS. Compared to EVO oils from 2019, samples from 1993 showed a 26.3% and 20.5% increase in palmitoleic and linoleic acids, respectively, and a 15.9% increase in linolenic acid. Oleic acid content showed a moderate negative correlation with annual average, minimum, and maximum temperatures, suggesting that rising temperatures may reduce oleic acid levels. In contrast, palmitoleic and linoleic acids exhibited moderate positive correlations with annual temperatures. In 2019, the annual average and maximum temperatures were approximately 2 °C higher than in 1993, and the rainfall amount was also significantly greater. The $\delta^{13}C$ value of bulk oil from 2007 was significantly less negative (–29.1 ± 0.4‰) than those from 2006 and 2019 (–30.3 ± 0.4‰ and –29.7 ± 0.5‰, respectively). In 2007, the amount of rainfall was 52% and 18% lower than in

2019 and 2006, respectively, and the number of hot days was also the lowest among the years studied. Compound-specific $\delta^{13}C$ analysis revealed significantly lower values in 2019 across major FAs (palmitic, palmitoleic, stearic, oleic, linoleic), aligning with higher annual rainfall and average temperatures that year compared to 2006-2008. Our findings suggest that interannual climatic variability can affect both the FA composition and isotopic characteristics of EVO oils. This study offers insights into the impact of climate on EVO oil quality and supports authenticity and traceability efforts.

Quality Assessment and Adulteration Detection of Rosemary and Laurel Essential Oils Using GC-C-IRMS

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The antioxidant properties, chemical composition and authenticity of rosemary and laurel essential oils available on the Slovenian market were analysed. The quality assessment was based on the antioxidant properties measured using the DPPH and Folin-Ciocalteu tests, with laurel essential oils having a higher free radical scavenging capacity and a higher total phenolic content. Volatile organic compound (VOC) analysis showed that REO is rich in terpenoids, with 1,8-cineole and camphor being the predominant compounds. In LEO, 1,8-cineole was also the predominant compound and α-terpinyl acetate the second most abundant. The influence of individual VOCs on the antioxidant activity of rosemary and laurel essential oils was determined. It was found that the concentrations of VOCs in the essential oils had no significant effect on antioxidant activity. Fluctuations in the proportions of VOCs were observed, indicating the complexity of the chemical composition of VOCs in essential oils. The authenticity and possible adulterations were determined using the GC-C-IRMS method. The sensitivity of the GC-C-IRMS method was evaluated and showed that it can detect added synthetic compounds with a sensitivity threshold between 11% and 82%, depending on the volatile compound. This analysis is an important tool for manufacturers and regulators to verify product claims such as "100 % pure essential oil" and thus protect consumers from adulterated offers. The observed variability in carbon isotope profiles emphasises the complexity of determining authenticity characteristics and highlights the critical role of isotope analysis in ensuring the quality and integrity of essential oil products through stringent quality control measures.

Integrated Multi-Method Approaches to ensure Olive Oil Authenticity and Traceability

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Olive oil is a high-value product in the agrifood sector, widely recognised for its rich nutritional profile and health-promoting properties. Its supply chain plays a strategic role in agrifood systems, with significant implications for economic development and environmental sustainability. With over two-thirds of global production, the European Union leads the international olive oil market, not only in terms of volume, consumption, and exports, but also through its consolidated know-how rooted in agricultural tradition, high product quality, and extensive varietal diversity. In an increasingly complex and globalised agrifood landscape, ensuring authenticity and traceability of olive oil have become critical. The growing sophistication of food fraud, combined with the inherent geographical and varietal variability of olive oil, requires the development and implementation of advanced analytical methodologies that improve transparency and protect and enhance the value of high-quality products on global markets. In this context, the aim of the present study is to apply an integrated multi-method approach, based on the synergistic use of complementary chemical-analytical techniques to investigate the traceability and authenticity of olive oils. The proposed approach combine complementary methodologies including Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), UV-Vis spectrophotometry, and Isotope Ratio Mass Spectrometry (IRMS), to develop a robust model for the characterisation and discrimination of olive oils according to their varietal and geographical origin. This strategy underscores the importance of employing diverse and complementary analytical techniques to generate comprehensive data on both nutritional components and potential contaminants, as well as isotopic signatures. This is crucial to improve transparency, enhancing consumer safety, and promoting the recognition and competitive market positioning of authentic, high-quality olive products in global markets.

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Territorial origin determination of wheat flour by NMR profiling: A case study

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Determination of territorial origin by NMR is a well-established analytical approach. However, since the correlation between wheat origin and metabolite content is predominantly driven by pedoclimatic conditions, it is challenging to identify permanent metabolic markers and construct a robust statistical model applicable across different agronomic seasons. Consequently, developing a new model annually for wheat traceability assessment is both practical and useful. A reliable statistical model, however, requires a training dataset that accurately represents the regions to be discriminated and consists of samples with certified origin. Thus, increasing the number of regions under study necessitates a proportional enlargement of the dataset with verified samples. Given the considerable difficulty in obtaining wheat samples with certified origin, our study focused on discriminating between two broad macro-areas of the Italian peninsula—Northern vs Southern Italy. Twenty-five wheat samples from twenty different varieties were transformed into flour using a micro milling system and aqueous extracts of each flour were analysed by NMR spectroscopy. Spectra were annotated to identify principal metabolites, which were then quantified and multivariate statistical techniques were applied to classify samples based on geographic origin. Although the sample size was limited, the constructed Linear Discriminant Analysis (LDA) model achieved an accuracy of approximately 90%.

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Tracing the Sources of Adulteration along the Ghanaian Food Supply Chain using Isotopic and Chromatographic Techniques: Implications for Food Authenticity

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Food adulteration, often referred to as food fraud, is one of the most pressing challenges facing global food safety and quality assurance systems. In Ghana, food adulteration has become a growing concern due to the high demand for staple commodities and limited regulatory capacity for routine monitoring. Various foods including peanut butter, palm oil, honey, spices, and milk are especially prone to adulteration because of their high consumption rates, strong economic value, and the relative ease with which they can be tampered with. Ensuring the authenticity of these foods is therefore critical both for consumer protection and for maintaining the integrity of local and international food markets.

In this study, we focus on peanut butter, honey, and palm oil available on the Ghanaian market and investigate their authenticity. Stable isotope analysis and fatty acid profiling were applied to detect possible adulteration in these commodities. In honey, δ13C values were measured in both the bulk sample and the protein fraction. The results of EA-IRMS analysis revealed adulteration with C4 plant sugars (such as corn or sugarcane) in about 37% of the samples. Peanut butter, which is a C3 plant product, was also analyzed for δ13C, and the results similarly revealed the presence of fats derived from C4 plants. The analysis of free fatty acid profiles of both peanut butter and palm oil by GC-FID further indicated adulteration in some samples, suggesting the addition of cheaper oils or fats.

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FOOD DATA ANALYSIS

AI-Driven Review of Analytical Methods for Micro- and Nanoplastics Analysis

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The growing concern over micro- and nanoplastics (MNPs) contamination has significantly propelled scientific research focused on detection, characterization, and quantification methods. The rapid expansion and interdisciplinary nature of this field make extracting information about methodological developments and research priorities from such a vast body of literature a major challenge. In this context, AI-powered tools proved to be a powerful support to the processing, extraction, and analysis of information, enabling the efficient handling and categorization of large datasets. In this work, such AI-assisted approach was adopted by using SciSpace to significantly enhance both the accuracy and comprehensiveness of the analytical methods mapping process. Key data and references related to MNPs analytical techniques were identified, and multiple side-by-side queries were used to optimize information extraction and validate the results against a large database of over 800 scientific articles, developed under the FHERITALE project (www.fheritale.eu). In the following step, a manual assessment by experts allowed to optimize the initial inventory of technologies, and to obtain a more readable list of relevant technologies. This approach exemplifies the growing role of AI in enhancing scientific insight, accelerating innovation, and guiding future work in food safety and contaminant monitoring. By automating literature synthesis, AI tools not only save time but also provide a strategic overview of the MNPs research landscape.

Real-time AI-based monitoring system for microbiological safety of drinking water

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The WAFER (WAter SaFEty Plan Automatic MonitoRing System) project aims to transform microbiological water quality monitoring by developing an intelligent, fully automated platform for real-time pathogen detection. The project addresses the urgent requirement for decentralized, continuous control of drinking water safety and is aligned with evolving regulatory frameworks, such as EU Directive (EU) 2020/2184. WAFER integrates state-of-the-art biosensors, artificial intelligence and Internet of Things (IoT) technologies into a mobile, energy-autonomous unit designed for frequent, unattended operation. The system performs a fully automated workflow, including sampling, fluid treatment and biosensor-based analysis, capable of detecting contamination events earlier and more efficiently than conventional, laboratory-based methods such as PCR, which are slow, resource-intensive and restricted to centralised facilities. At the core of WAFER lies an AI-driven module that processes environmental and biological data in real time using adaptive machine learning models. This enables immediate alert generation, predictive diagnostics, and continuous model refinement. The biosensors exhibit high sensitivity and selectivity towards key microbial indicators, including Escherichia coli and intestinal enterococci, which are classified as fundamental parameters under EU and national regulations. Additionally, the system is designed to detect a broader range of pathogens, such as enteric viruses and AMR-related bacteria, enhancing its applicability across diverse health risk scenarios. The unit is designed for robust outdoor use and includes edge computing capabilities for low-latency data processing. Secure transmission protocols ensure integration with cloud platforms, enabling visualization, storage, and correlation with broader water safety and epidemiological data systems. WAFER supports remote diagnostics and over-the-air updates, making it suitable for large-scale network deployment with minimal operational burden. WAFER strengthens the resilience of water infrastructures by enabling real-time, autonomous monitoring, enhancing early warning capabilities, and supporting long-term environmental and public health strategies. Deploying WAFER contributes directly to Sustainable Development Goals (SDGs) related to clean water, health, and innovation, positioning it as a pioneering solution in the field of smart environmental monitoring. This work was supported by Italian Ministry for Industry and Made in Italy (MIMIT) program "SCOPERTA IMPRENDITORIALE" within the framework of the project WAFER, beneficiary company Opus Automazione S.p.A.

METROFOOD-RI integrated analytical services: Phenol determination in agro-industrial by-products and derived formulations

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METROFOOD-RI is a distributed European research infrastructure aimed at promoting scientific excellence in the field of metrology in food and nutrition (www.metrofood.eu). Considering its role as service-oriented entity, within the frame of METROFOOD-EPI project (HEu, GA 101130162), competitive open calls were launched to provide transnational access (TNA) with physical and remote contact to users, who were selected on the basis of excellence of their proposals. For the accomplishment of the call focused on food production and integrated analytical services, a pre-defined set of grouped combinatorial analytical services and food processing technologies involving multiple service providers was made available. The selected applicants provided the raw materials and asked for the development of specific formulations which would incorporate functional ingredients extracted from the former. Compositional analysis for both by-products and formulations was assigned to various laboratories upon pre-declared expertise. Aristotle University of Thessaloniki (AUTh) analytical facilities were involved in the analysis of polar and non-polar phenolic compounds using extraction and analytical protocols employing chromatographic techniques (NP-HPLC-DAD-FLD and RP-UHPLC-DAD-FLD). This work presents the "service section" provided by AUTh facilities with focus on metrological aspects for the selection of the fit for the purpose protocols.

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The Impact of Equipment Conformity Assessment in Ensuring the validity of Food Testing: A Comparison of Laboratory Practices

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Ensuring food safety is impossible without the reliability of measurement results and laboratory tests. Modern approaches to quality control in the food chain require strict adherence to the principles of metrological traceability, conformity assessment of measuring instruments and harmonization of laboratory procedures with international standards. The ISO/IEC 17025 standard sets out key requirements

for the competence of testing and calibration laboratories, covering both technical and management aspects. In addition, the ISO 10012 standard regulates the requirements for the measurement management system and the operation of measuring equipment, ensuring the integration of metrological functions into the overall quality management system. Certified reference materials (CRMs), the production of which is regulated by ISO 17034, play an important role in ensuring the reliability of measurements. They are used as a reference material for the verification of analytical methods, as well as within the framework of the participation of laboratories in proficiency testing (PT) programs according to ISO/IEC 17043. The combined use of these standards improves reproducibility indicators, as well as ensures metrological traceability and reliability of analytical results. In this study, a comparative analysis of metrological practices was conducted in 24 testing laboratories in various regions of Uzbekistan, including more than 10 accredited according to ISO/IEC 17025. The study examined methods for determining pH in food products using various types of samples: certified reference materials (CRMs) and artifact materials, the homogeneity and stability of which were assessed in accordance with the requirements of ISO/IEC 13528 in an accredited laboratory. The obtained data indicate that laboratories accredited in accordance with international standards achieve a higher degree of metrological traceability due to the systematic application of calibration procedures, intermediate checking and regular participation in interlaboratory comparison tests. At the same time, non-accredited laboratories of Uzbekistan continue to apply verification and metrological certification procedures inherited from the Soviet regulatory system, which is also aimed at ensuring reliability, but does not always meet the requirements of international practice. The results of the study confirm that the presence of an established metrological infrastructure and mechanisms for assessing the conformity of measuring instruments has a decisive impact on the reliability of control of food safety indicators.

Note: The analysis is in line with the direction of the 8th IMEKOFOODS Conference (TC23), which pays special attention to the international harmonization of measurement methods in the food industry, as well as traceability and confirmation of the reliability of analytical data.

Metal impurities in food additives: Do they contribute to dietary metal exposure?

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Toxic elements such as lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg) may enter the human food chain through the soil-plant-animal pathway, as well as through industrial processes, including their presence as impurities in food additives (FAs). Commission Regulation (EU) No 231/2012 outlines the specifications for FAs, including impurity limits. However, a preliminary intake assessment based on EFSA exposure estimates for the Belgian population indicated that, if these metals were present in FAs at concentrations approaching the regulatory limits, the resulting dietary intake could exceed general dietary exposure estimates by a factor of 2 to 12. This suggests that actual concentrations are substantially lower than specified limits and/or that current exposure models may underestimate intake from foods containing FAs. The present study aims to evaluate the exposure of the Belgian population to Pb, Cd, As, and Hg due to FA intake. The objectives are threefold: (i) to quantify the occurrence of metal impurities in selected FAs, (ii) to assess dietary exposure to these metals specifically from FA consumption, and (iii) to compare this exposure with current general dietary exposure estimates and conduct a risk assessment for the Belgian population. A prioritisation approach, considering both FA characteristics and Belgian consumption patterns, was used to select 17 food additives for analysis: E120, E170, E300, E301, E330, E401, E407, E410, E412, E415, E422, E440, E461, E500, E508, E509, and E516. Analytical methods to determine the concentration of metals in these different matrices were validated using inductively coupled plasma – mass spectrometry (ICP-MS) and Direct mercury analysis (DMA). This resulted in

expanded measurement uncertainties ranging from 9-33%. At least five samples of each selected additive were analysed, of which metal concentrations will be presented. The results of these analyses will be used to conduct a targeted sampling and analysis of FA-containing foods that may contribute to metal exposure. Based on these data, a re-evaluation of the exposure of the Belgian population to Pb, Cd, As and Hg will clarify whether FAs significantly contribute to metal exposure.

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Standardizing Plant Pathogen Detection using dPCR as a Reference Method for Xylella fastidiosa

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Reliable detection of plant pathogens is critical for ensuring biosecurity and food safety across the agricultural value chain. This study addresses two major aspects influencing diagnostic accuracy for Xylella fastidiosa, a quarantine pathogen of high regulatory concern in the EU: (i) the influence of DNA extraction methods, and (ii) the application of digital PCR (dPCR) for metrologically traceable measurements. Four different DNA extraction protocols, QuickPickTM SML Plant DNA Kit, Modified DNeasy Mericon Food Standard Protocol, Maxwell® RSC PureFood GMO and Authentication Kit, CTAB, were evaluated across diverse X. fastidiosa subspecies and plant matrices to determine their yield, repeatability, and matrix effects. Results showed significant variability among methods, particularly when processing complex plant samples such as olive tree (Olea europaea) leaves. This emphasizes the critical role of selecting the appropriate extraction protocol. In parallel, we developed and validated a dPCR method for X. fastidiosa quantification, following ISO 20395:2019 and EPPO PM 7/24 (3) standards. Three levels of complexity, synthetic targets, bacterial genomic DNA, and plant-spiked genomic DN, were analysed on four different dPCR platforms, QX200 (BioRad), Naica (Stilla Technologies), QIAcuity (Qiagen) and Absolute Q (ThermoFisher Scientific). The method demonstrated high sensitivity (LOD ~ 9 copies/ reaction), excellent intermediate precision (CV < 8 %), and robust inter-platform reproducibility (CV < 17 %). This work highlights the necessity of rigorous evaluation of extraction protocol performance in plant pathogen diagnostics and supports the role of dPCR as a potential reference measurement procedure for regulatory and research laboratories.

Development and validation of control materials for molecular detection of Listeria monocytogenes in milk

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Listeria monocytogenes is a foodborne pathogen that poses a severe threat to vulnerable populations. It can proliferate at refrigeration temperatures and persist in ready-to-eat foods such as dairy products. The most effective strategy to prevent serious outbreaks is the implementation of a well-designed,

standardized monitoring system. Currently, global standards for the detection and quantification of L. monocytogenes rely on microbiological culture methods that require several days to yield results. However, recent advancements in molecular biology, particularly the development of nucleic acid amplification-based methods such as polymerase chain reaction (PCR), have enabled rapid and accurate detection and quantification of microorganisms. Compared to traditional culture methods, PCR technology delivers results within a single day. Digital PCR (dPCR) enables absolute quantification traceable to the SI system of units, making it a promising tool for the future of standardized microbial monitoring. Besides precisely described and evaluated measurement procedures, metrological frameworks require fit-for-use reference materials to ensure traceability and harmonization of measurements across laboratories. In this study, we developed control materials for the detection and quantification of L. monocytogenes in milk and evaluated them using a dPCR assay targeting a species-specific, single-copy gene. We spiked milk samples with L. monocytogenes suspensions to create two materials, one with a high concentration estimated at 5E6 cells/mL and one with a lower concentration of approximately 5E4 cells/mL. A positive control sample consisted of genomic DNA that was extracted from a bacterial suspension estimated at 1E7 cells/mL and eluted in a stabilizing buffer. All of the prepared materials were assessed for homogeneity and stability. We evaluated the selected dPCR measurement procedure and calculated its measurement uncertainty associated with repeatability, intermediate precision and variation in the volume of partitions. The produced control materials were homogeneous and stable in the short term. However, after two months of storage, a substantial decrease in bacterial concentration could be noticed for milk materials with the lower bacterial concentration (5E4 cells/mL), while the positive control remained stable. Our findings underscore the importance of studies on control materials that closely mimic real-life samples, highlighting the challenges with developing stable materials in complex matrices such as milk. They represent a step towards the integration of standardized molecular methods into the legislative monitoring of foodborne pathogens that would benefit public health with fast, precise and accurate detection using the dPCR technology.

Grain moisture determination. Using of standard addition method

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Grain moisture content is a critical factor for storage optimizing and establishing a fair price for grain. However, according to the data of inter-laboratory comparisons, the moisture determination results obtained by main Loss-on-Drying (LoD) methods (ISO 712, ISO 6540) in different agricultural laboratories differ significantly. In particular, the range of variation reaches 1.5% in Ukrainian laboratories. At the same time, expanded uncertainty of a single result is estimated at only 0.3% (ISO 712). In our opinion, the reason for this variation in results may be the expressed influence of the equipment used for LoD methods execution. For example, the loss of moisture during grain grinding, insufficient efficiency of the drying oven, etc. can lead to an underestimation of moisture content. In our study, we tried to verify the correctness of the LoD method using the standard addition method. A precisely defined amount of water was added to wheat grain sample with a known moisture content. Grain samples were encapsulated in a sealed package. After stabilizing for approximately 1 month, the moisture content of the moistened sample was determined according to ISO 712. It was expected that if the measurement procedure was not implemented correctly, the result would differ significantly from the theoretically calculated value. According to obtained data, the use of a knife mill without cooling the working chamber leads to significant (up to 0.3 %) decrease in the moisture measurement result compared to the calculated one. At the same time, significant result underestimation wasn't observed for the 3310 Perten disc mill. Other equipment (oven, desiccator, balance) remained unchanged. Comparison of the results obtained

with different mills showed that the use of knife mills without cooling leads to a systematic significant results underestimation up to 0.7%. If knife mill is equipped by cooling system, as in the case of the KN 295 Knifetec, no underestimation was observed. For cases where the difference between theoretical and experimental moisture content values is insignificant, the SD of these differences was estimated as 0.04 %. The results of the study show the importance of assessing equipment influence on the LoD method results during moisture content determination. The standard addition method can be used to assess this influence. The results can be used to discuss possible changes to ISO 712 and ISO 6540. Also, the data obtained can be used to assess the characterization uncertainty of CRM of grain moisture content.

Metrology for the phosphorus content measurements in vegetable oils in support of European and international food safety

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Metrology for the phosphorus content measurements in vegetable oils in support of European and international food safety and trade Crude vegetable oils usually have impurities (phospholipids, as a specific class of phosphorus-containing compounds, FFAs, metals, etc.) which during the refining process may cause damage to the vegetable oil's stability, color, odor and taste, so that their removal is necessary. Having important physiological properties, phospholipids at the same time complicate the subsequent stages of vegetable oil processing and negatively affect the technical and economic indicators of refining and hydration in general. The presence of phospholipids in the subsequent stages of refining may damage the vegetable oil color, odor and taste. Phosphorus content in oil is a crucial quality parameter; thus, accurate and fast phosphorus content measurement supports fair trade in the vegetable oil market. To verify and calibrate phosphorus analyzers and ensure their traceability, it is necessary to use matrix phosphorus content CRM. We aim to create matrix reference materials for phosphorus content in vegetable oils in support of national and European and international food safety and trade. Many stakeholders are interested in this topic. The work can be performed by following steps: – preliminary investigation (literature overview, measurements); – creation of candidate RMs; – pilot comparison; – key comparison; – CMC claims; – creation of the CRMs. UMTS has two years experience in this field and permanently collaborate with oil manufacturers. Unrefined oils with different phosphorus content are provided by oil manufacturers on permanent basis. UMTS produce uniform batches of unrefined oils and study the homogeneity and stability for batches are studying. Currently, the preliminary studies for more than 15 oil batches are performed. As part of this effort, we have already obtained comparative measurement results using various analytical methods, including gravimetry, photometry, and X-ray fluorescence (XRF). Current data confirm the comparability of these methods with the expected target measurement uncertainty. Developing phosphorus content matrix reference materials will make possible to provide metrologically traceable measurements.

What is the future of FCM after the ban on single-use plastic articles? A deep dive into alternative materials in Belgium

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Since the ban on single-use plastic articles in Europe, the food contact material (FCM) industry has been forced to move to more sustainable alternatives. At the Belgian level, the Federation of Belgian Food Industry (FEVIA) states that all food packaging must be reusable, recyclable, or compostable by 2025. One way to tackle the waste problem is to introduce "environmentally friendly FCM", which must also be safe for consumers. Many options are currently available in the market. However, the market share, trends, and consumer preferences remain unclear. Therefore, this study aims to provide an overview of the Belgian FCM market, as well as the substitute materials available and their applications. The market analysis embraced an integrated web-based approach, diving into fifty-two diverse sources. These included e-shops dedicated to offering innovative alternatives to disposable plastics and showcasing environmentally friendly options, along with websites that inspire creativity through homemade food contact materials. The initial screening revealed a total of 10,523 articles. After a thorough data cleaning process, we achieved a consistent dataset consisting of 2,688 unique entries, divided into fifteen material categories and seven utilisation classes. Paper and board were the most commonly used material categories intended to replace single-use plastic articles, comprising 37% of the entries, followed by bagasse, which accounted for 9%. The most frequent usage categories were takeaway and food serving, representing 44.4% and 22.8% of the entries.

Enhanced untargeted method to detect organic and inorganic contaminants in biobased and recycled food contact materials

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Food packaging plays a vital role in maintaining food quality and safety1. Driven by the need to reduce waste and environmental impact, the development and use of bio-based, biodegradable, and recycled materials as sustainable alternatives to conventional plastics and paper2 are increasing. In parallel, the monitoring of novel contaminants potentially present in these emerging materials, including those originating from recycling processes, is needed to ensure their compliance with legislation and their safety. To address this critical need, a validated harmonized untargeted method for the comprehensive identification of both organic and inorganic contaminants is essential for characterizing the contaminant profile of these innovative food contact materials, particularly given the current lack of standardized

analytical approaches at the European level. This work has been developed in the framework of the 23IND13 ScreenFoodproject and aims to develop and harmonize untargeted methods using Liquid Chromatography-Mass Spectrometry (LC-MS) system for organic contaminants and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) for inorganic contaminants. Various types of packaging, both recycled and non-recycled, including cardboard, plastic, and biobased materials such as bagasse, he, were analyzed. The first part of the work was devoted to the optimization of the extraction methods both for organics and inorganics. Existing guidelines and protocols were optimized for the different types of packaging, each of which posed specific challenges based on its chemical nature, shape and final intended use and further analysis (organic and/or inorganics). Afterwards, non-targeted analysis, for identifying organic contaminants in food contact material samples, was performed using LC-MS system Thermo Fisher Q Exactive Hybrid Quadrupole-Orbitrap with ESI ionization source, in both positive and negative modes. The acquisition mode used was full scan-data dependent acquisition (DDA). The untargeted LC-MS method enabled the detection of different organic contaminant classes such as PFAS, phthalates, bisphenols, photo-initiators, primary aromatic amines and mineral oils. The ICP-MS system used for inorganic contaminants detection was Thermo Fisher XR element. ICP-MS analysis revealed the presence of heavy metals in food packaging samples, with Iron (Fe), Manganese (Mn), Copper (Cu), and Zinc (Zn) identified as the most abundant elements.The proposed strategy successfully characterized the contaminant profile of the food packaging materials sampled by Screen food partners. This approach has proved to be a reliable testing method for identifying the main contaminants in emerging recycled, sustainable, and biodegradable food contact materials.

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Microplastics on the Surface of Packaged Chicken Meat: Method Optimization for Detection, Isolation, and Characterization

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Microplastics are increasingly recognized as a food safety issue as they are widely distributed in the environment and can carry contaminants on their surface. In the context of food production, microplastics can come from various sources, such as processing equipment, packaging material or the air, and can end up on the surface of food during handling and processing. The aim of this study is to assess the presence of microplastics on chicken meat by optimizing meat surface sampling, chemical digestion of the meat, and the filtration process prior to isolating and characterizing microplastics from the filters. Chicken meat products of different producers and packaged in various packaging materials were sampled under sterile and dust-free conditions. A 50 g portion was taken from the outer 10 mm of the meat surface and then digested in 10% potassium hydroxide at 36 °C for 48 hours at 80 rpm. The resulting suspensions were filtered through 10 µm nylon filters. Suspected microplastics were isolated manually using pointed tweezers and visually examined under a stereomicroscope according to their morphological characteristics such as size, shape and color. The particles were then analyzed using Fourier transform infrared spectroscopy (FTIR) to identify the polymer type. Microplastics were successfully isolated from all meat samples with the number of particles per sample ranging from 1 to

6. Most of them were classified as fibers or films, ranging in size from 0.2 to 2.2 mm, and were mostly translucent or green, matching the color of some of the packaging materials. FTIR analysis confirmed that some of the isolated particles matched the polymer composition of packaging material, indicating it as one of possible routes of contamination. However, microplastics of other polymer types were also detected, indicating other routes of contamination, probably occurring during meat processing. We have optimized and applied a method for the detection and isolation of microplastics from chicken meat. The results indicate that microplastics from meat packaging and also other sources are present on the surface of chicken meat and thus present a direct (physical, chemical) and indirect (microbiological) food contamination threat. These results emphasize the need for further research into the role of microplastics in food contamination and for food safety assurance within the food supply chain.

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Poly (lactic acid)–Poly (L-lactide-co-ethylene adipate) Hybrid Films: A Promising Approach for Sustainable Food Packaging

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Poly(lactic acid) (PLA) is extensively employed across various industrial sectors due to its biodegradability; however, inherent limitations such as low crystallinity adversely impact its mechanical strength, thermal stability, and chemical resistance. Its susceptibility to hydrolysis and water absorption, are particularly problematic, reducing long-term durability. To mitigate these issues, this research investigates the formulation of hybrid films through blending PLA with poly (l-lactide-co-ethylene adipate) (pLEA) block copolymers. The study specifically aims to enhance crystallinity, mechanical performance, and chemical durability of PLA. Advanced analytical techniques, including Nuclear Magnetic Resonance (NMR), Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Polarized Light Microscopy (PLM), Differential Scanning Calorimetry (DSC), and Thermogravimetric Analysis (TGA), were utilized to comprehensively characterize the structure-property relationships within the blends. Through systematic optimization of blend ratios and processing conditions, notable enhancements were achieved compared to pure PLA. Remarkably, films containing 30 wt% pLEA (97.5/2.5) and 70 wt% PLA, fabricated via rapid cooling and a brief annealing period of just 5 minutes, transitioned from amorphous to highly crystalline structures. This resulted in approximately a 20 MPa increase in tensile strength, greater stiffness, reduced surface wettability, and improved resistance to chemical degradation. Significantly, these optimized films exhibited enhanced hydrophobicity, evidenced by a reduction of approximately 15° in contact angle and a roughly 7 mN/m decrease in the polar component of surface free energy. Such improvements suggest increased resistance to moisture and polar solvents, thus enabling superior barrier performance and chemical resilience. In conclusion, the developed strategy of copolymer blending effectively addresses inherent limitations of PLA, presenting a viable pathway for creating high-performance biodegradable materials suitable for demanding industrial applications[1].

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Food Processing Workshops in the RURBANIVE Project: Helping Local Producers Shorten the Supply Chain

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The RURBANIVE project (Rural-uRBAN synergies emerged in an immersIVE innovation ecosystem) aims to improve life in local rural communities through social and technological innovation. One of its key objectives is to enhance logistics and shorten the value chain. As part of this effort, a series of workshops and online courses were organized for a variety of stakeholders. These activities focused on modern food processing technologies that can help farmers and local producers shorten the journey of food products from production to direct sale on the farm or at local markets. In 2025, four workshops were held at the CZU Food Pavilion, covering meat, milk, bakery, and beer technologies. A total of 57 stakeholders participated, including representatives from public authorities, academia, research institutions, and agri-food producers. The workshops addressed practical topics such as Haloumi cheese production, enriched bread and bakery products, beef aging techniques, and beer brewing. According to post-workshop surveys, 88% (bakery), 100% (milk), 94% (meat), and 54% (beer) of participants stated they would definitely or probably apply the knowledge and skills gained in practice. Based on the workshops, a series of online courses is being developed to provide further guidance on food processing, labelling, certification, and inspection. These activities aim to foster co-creation among stakeholders, strengthen communication between academia and producers, and accelerate the implementation of scientific knowledge into practice.

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Antibacterial Potency of Slovenian Honeys against Foodborne Pathogens

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Honey has been used for nutritional and also therapeutic purposes since ancient times and has been found also to exhibit antimicrobial activity against broad spectrum of microorganisms. The antimicrobial properties of honey depend on several factors, including phenolic compounds, enzymatic production and degradartion of hydrogen peroxide, high osmolarity and low pH level. Beside this, the botanical origin, classified into the nectar/floral (light) and mannin/forest (dark) honey, and geographical origin of honey are also decisive. The antimicrobial activity also depends on the species of bees, environmental, seasonal, and climatic conditions that affect the composition of the honey, as well as the time of honey collection and subsequent handling. The spectrum of antimicrobial activity of 85 honey samples of defined botanical origin (multifloral, linden, acacia, fir, chestnut and forest) from all Slovenian regions

collected in seasons 2023 and 2024 was assessed against six pathogenic bacterial strains including Gram-positive (Staphylococcus aureus, Listeria monocytogenes, and Bacillus cereus) and Gram-negative (Campylobacter jejuni, Escherichia coli, and Pseudomonas aeruginosa) bacteria by determining the minimum inhibitory (MIC) and minimum bactericidal concentration (MBC) using the microdilution method. C. jejuni and L. monocytogenes proved to be the most sensitive bacterial targets, which is favourable result due to the fact that these are foodborne pathogens with the highest incidence and morbidity, respectively. When comparing dark and light honeys, the dark varieties proved to be more effective, especially against C. jejuni, E. coli, S. aureus, and L. monocytogenes. Chestnut honey exhibited the highest overall antimicrobial activity, while acacia honey the lowest. Fir honey demonstrated strong antimicrobial properties as well, especially against E. coli, against which chestnut and fir honey yielded similar results. The best antimicrobial effect was observed against C. jejuni while the weakest against sporogenic B. cereus. The results confirm some of our previous observations [1]. Due to high biodiversity, unique nature, and excellent beekeeping conditions, Slovenia is ideal for production of various types of high-quality honey, with bioactive properties, which should be respected in quality parameters, shelf-life and also pricing of the products with a wide range of applications.

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Rapid and non-destructive assessment of cultivars and geographical origin of durum wheat flour using Raman spectroscopy

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Spectroscopic methods have been suggested as a useful technology for the agri-food sector, as they can determine food quality and chemical composition. These non-destructive, real-time methods can also detect bioactive compounds and establish geographical origin [1]. They are particularly useful for detecting food fraud and adulteration also in wheat flour [2] [3] [4]. Identification of the origin and variety of raw materials is crucial to ensure traceability, quality assurance and product valuation across the agri-food supply chain. Raman spectroscopy emerges as a promising analytical technique due to its speed, sensitivity, and non-destructive nature. It provides molecular information that supports the characterisation of complex matrices such as durum wheat flour. In this study, Raman spectroscopy was used to analyse flour samples from three durum wheat varieties: Antalis, Iris and Platone. Samples were collected from different regions of Italy to assess varietal differences and identify geographical origin. Spectral data were collected using a Raman spectrometer (@785 nm excitation) equipped with a 40× microscope objective at 70% laser power. The spectra showed Raman shift at 480–580, 867, 940, 1052, 1130–1390 and 1302 cm^{-1}, corresponding to protein, lipid and carbohydrate structures [5], [6]. Amide bands, such as amide III (1200–1350 cm^{-1}) and amide I (1655 cm^{-1}), provide insight into protein conformation. Overall, the spectra displayed similar profiles, confirming a common molecular baseline across samples. However, variations in the relative intensity of specific bands suggest compositional or structural differences. Notably, the Antalis variety showed significant variability within regions,

particularly in samples from Lazio, suggesting higher sensitivity to environmental conditions than Iris and Platone. These results demonstrate the potential of Raman spectroscopy as a reliable method for classifying and tracing durum wheat flour based on variety and geographical origin.

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NANOPARTICLES IN FOODSTUFFS

Microplastics in food: literature review

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The presence of microplastics in food is an increasing concern for public health and the environment, as their widespread occurrence in water, air, and soil enables their transition into the food chain. This review presents data on microplastic content in various types of food, derived from published studies between 2014 and 2024. Publications search was conducted in the databases ScienceDirect, PubMed and Web of Science, where only freely available research articles with full text in English were included. Shellfish were found to be the most contaminated, with an average of 5.31 particles/g, 14.27 particles/individual, and 86.8 total counted particles. This is attributed to their filter-feeding behaviour, which leads to direct ingestion of suspended particles from seawater. Marine fish exhibited lower concentrations per gram (4,71 particles/g) but higher per individual values (26.84 particles/individual), likely due to their larger body size and dietary complexity. Shrimps showed elevated levels (11.22 particles/g), reflecting sediment-associated microplastic accumulation. In contrast, squid (0.18 particles/individual) and crabs (0.14 particles/individual) exhibited significantly lower concentrations. Canned fish contained an average of 1.28 particles/g and 3.125 particles/can, indicating the presence of microplastics even in processed and packaged seafood products. Dried fish showed particularly high concentrations (44.54 particles/g), possibly due to drying of the entire organism, including the gastrointestinal tract. Freshwater fish exhibited extremely high levels per individual (198.5 particles/individual), but low average values per gram (0.05 particles/g). This discrepancy may be explained by the accumulation of microplastics in the gills and digestive system, which are usually removed prior to consumption. Among plant-based foods, rice was the most contaminated (1.55 particles/g), followed by vegetables (0.58 particles/g), noodles and beans (0.36 particles/g). Sugar stood out with an extremely high concentration (291.1 particles/g), likely contaminated during processing and storage. Sea salt showed the lowest levels (0.21 particles/g), possibly due to effective purification processes, while seaweed showed higher concentrations (15.15 particles/g), possibly due to direct exposure to contaminated marine environments. Microplastics have been detected in infant formula, with an average of 0.42 particles per package, highlighting potential early-life exposure. Among animal-derived products, meat contained 0.49 particles/g, while eggs showed 11.67 particles/egg, suggesting contamination through feed and environmental exposure. There is a need for further research on sources of contamination and potential health effects; it is essential to standardise analytical methods and measurement units. The current lack of uniformity hinders the comparability of studies and prevents reliable risk assessment.

Identifying Technological Needs in Micro- and Nanoplastics Research: A FHERITALE Perspective

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Micro- and nanoplastics (MNPs) in the environment and food systems pose an emerging challenge for public health and food safety. Current analytical and regulatory frameworks remain insufficient to detect, quantify, and assess the risks of these particles in the food chain. The Horizon Europe project FHERITALE[1] seeks to improve coordination and service delivery across European research infrastructures. A dedicated work package examines the current technological landscape and identifies technological needs within this framework. The tasks include an extensive analysis involving more than 800 scientific publications from the FHERITALE literature database[2], complemented by documentation from several EU-funded MNPs-related projects and institutional sources such as the European Commission, ECHA, EEA, JRC, EFSA, and ISO standards. An AI-assisted methodology was employed, and a large set of technological needs was identified and then grouped into eight thematic categories. The analysis identified diverse technological needs; key gaps include more sensitive methods to detect MNPs, a lack of validated models for exposure and uptake studies, insufficient tools to trace environmental fate and particle transformation, an absence of scalable systems for biodegradation testing and safe polymer design, limited availability of reference materials and harmonised protocols, unestablished regulatory thresholds for MNPs, a lack of integrated digital infrastructures for data sharing and analysis, and a need for ecologically realistic, long-term ecotoxicological testing models. This effort outlines a concrete set of technological needs and underscores urgent gaps where targeted innovation and collaborative research, particularly through European research infrastructures, can significantly advance knowledge on risks, fate, exposure, health impact, monitoring, and mitigation strategies for MNPs in Europe.

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ANALYTICAL APPROACHES IN FOOD CONTAMINANTS

Multiresidual GC-MS/MS method for determination of pesticide residues in fruit

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Fruit is part of people`s daily diet because it contains vitamins and fiber that contribute to a healthy diet. But fruit is attacked by numerous diseases and insects as it grows. In order to produce fruit in sufficient quantities, farmers must protect it from mold, rot and insects. Plant protection products (PPPs) must

therefore be used. In the past, it has been observed that fruit generally has the highest content of various active substances (pesticides) compared to vegetables (Baša Česnik et al., 2009). In order to ensure safe products on the market, monitoring of PPP residues must be carried out. Therefore, reliable multiresidual methods are required that enable the determination of numerous active substances at the same time. In the past, three main solvents were used for the extraction of pesticide residues from fruit: Acetone, ethyl acetate and acetonitrile. Nowadays, the QuEChERS (Quick Easy Cheap Effective Rugged and Safe) method with acetonitrile is mainly used. This method reduces the amount of solvent used and provides buffering for pH-sensitive matrices. In the past, our laboratory used the acetone method, to which dichloromethane and petroleum ether were added, so that active substances with a wide range of polarity could be extracted (Baša Česnik et al., 2006). Now we have modernized this method by adding anhydrous Na2SO4 directly to the matrix mixture and using buffering similar to the QuEChERS method. The amount of solvent was reduced by a factor of 4. Buffering the matrix with anhydrous CH3COONa and acetic acid resulted in 10-20 % higher recoveries, especially in the apple and grape matrix. We validated the method for 29 active substances with a gas chromatograph coupled with a tandem mass spectrometer (GC-MS/MS) on three matrices: Apples, grapes and oranges. The LOQ for all active ingredients was 0.005 mg/kg. Linearity, recovery and measurement uncertainty were also checked.

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Multiresidual GC-MS/MS method for determination of pesticide residues in vegetables

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Vegetables are an important source of nutrients, vitamins and fiber and are consumed daily by the human population. In order to produce them in sufficient quantities for the entire population, farmers have to use plant protection products (PPPs) to protect them from numerous diseases and insects that attack the vegetables. However, discerning consumers demand not only healthy but also safe food. It is therefore important to monitor the residues of PPPs in the food on the market. The QuEChERS method (Quick Easy Cheap Effective Rugged and Safe) with acetonitrile as extraction solvent is nowadays most commonly used for the determination of pesticide residues with multiresidual methods. In the past, our laboratory used the acetone method, to which dichloromethane and petroleum ether were added, to extract numerous pesticides with a wide range of polarities (Baša Česnik et al., 2006). The disadvantage of this method was that it consumed large amounts of solvents. In addition, the separation of water and organic phase with separatory funnels was time-consuming and physically demanding. Now we have modernised the method by applying the same principle as the QuEChERs method: Eliminating water by adding anhydrous Na2SO4 directly to the mixture of matrix and solvents and reducing the solvent volume by a factor of 4. We validated the method for 35 active substances on three matrices using a gas chromatograph coupled to a tandem mass spectrometer (GC-MS/MS): Lettuce, which is high in chlorophyll, potato, which is high in starch, and tomato, which is an acidic matrix. The LOQ for all active ingredients was 0.005 mg/kg. Linearity, recovery and measurement uncertainty were also checked.

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GC-MS/MS method for acrylamide determination in various food matrices from Romania

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IARC classified acrylamide (AA) as "probably carcinogenic to humans", so the presence of this chemical contaminant in food represents a human health risk. Maximum limits for AA content in food products have not yet been established at the national or European level. However, since 2018, Regulation (EU) 2017/2158 established the benchmark level for several products and requires the AA levels to be below these levels. A GC-MS/MS method was proposed for AA determination in different food products by applying the solid phase extraction and purification (SPE) technique. Processed cereal, potato-based products, and coffee products were used for method validation. AA quantification was performed using the internal standard method, the positive electron impact ionization mode, and the selected reaction monitoring acquisition mode. The following analytical performances of the developed method were obtained: good linearities for all matrices (R^2 ≥0.99), recoveries from 82.29-109.90%, and precision (RSD) from 0.77-7.75%. The LOD and LOQ were: 2.06 and 6.20 µg/kg for bread and similar products, 2.67 and 8 µg/kg for biscuits and other similar products, 6.94 and 20.83 µg/kg for crisps, 10.29 and 30.87 µg/kg for French fries, 2.53 and 6.16 µg/kg for roasted and ground coffee, and 7 and 20 µg/kg for instant coffee and substitutes. The accuracy of the method was demonstrated by the z-scores obtained in the PT tests: z= 0 (chips), z= -0.8 (fries), z= -0.3 (biscuits), z= 0.1 (ground coffee). To verify the applicability of the developed method, 57 commercial samples from the Romanian market were analyzed: bread (3), biscuits and other similar products (3), French fries (8), chips (6), roasted and ground coffee (31), instant coffee (2), cereal-based coffee substitutes (2), and chicory-based coffee substitutes (2). The AA content varied between 11-30 µg/kg for bread, 50-157 µg/kg for biscuits and similar products, 31-371 µg/kg for French fries, undetectable-1504.93 µg/kg for chips, 67-262 µg/kg for roasted and ground coffee, 259-452 µg/kg for instant coffee, 307-478 µg/kg for coffee substitutes exclusively from cereals, and 996-1281 µg/kg for coffee substitute exclusively from chicory. The validated method meets the criteria imposed by Regulation 2158/2017, and the AA content was below the benchmark levels for the analysed samples, except for two chips samples, which exceeded the benchmark value of 750 µg/kg.

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A quechers-based protocol for analysis of polycyclic aromatic hydrocarbons (PAHs) in vegetable oils and their derivatives

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PAHs are organic pollutants with potential risks to human health. These compounds have genotoxic, mutagenic, and carcinogenic properties. The study aimed to develop and validate a modified d-SPE QuEChERS-GC-MS/MS method for determining 4 EU PAHs (benzo(a)anthracene, chrysene, benzo(b) fluoranthene, benzo(a)pyrene (BaP)) from vegetable oils and their derivatives. The main steps in sample preparation for PAHs determination were: PAHs extraction in hexane with QuEChERS citrate salts, concentration of the extract, reconstitution of the residue in acetonitrile, followed by freezing and d-SPE QuEChERS purification with Z-Sep$^+$ sorbent. The optimal conditions for extraction and purification by QuEChERS were established using a statistical design of experiments by varying the amount of sample, extraction solvent, volume of extract used for purification, etc. The purpose was to increase the extraction efficiency, eliminate matrix-induced chromatographic effects, and obtain clean extracts and good recoveries/RSDs for the 4 PAHs. Sunflower oil (SO), margarine (MG), and vegetable mayonnaise (MZ) were used for validation. PAHs quantification was performed by GC-MS/MS, applying the internal standard method. The developed method was evaluated for linearity (R^2), LODs and LOQs, recovery, and matrix effect (ME). Good linearities ($R^2 \geq 0.99$), for both standard solutions and real samples of MG, MZ, and SO, were obtained for the 4 PAHs. The levels of LODs and LOQs obtained were slightly higher than those established by European Commission Regulation No. 836/2011. For MG, MZ, and SO, LODs varied from 0.11-0.84 µg/kg, 0.40-1.47 µg/kg, and 0.49-0.86 µg/kg, while LOQs were 0.37-2.79 µg/kg, 1.32-4.86 µg/kg, and 1.63-2.83 µg/kg. Recoveries calculated at three concentration levels ranged between 92-116% for MG (3.5, 6.25, 12.50 µg/kg), 92-119% for MZ (9, 25, 50 µg/kg), and 100-116% for SO (5.5, 12.5, 25 µg/kg). The ME was ≤ ± 20% for all matrices and all analytes. The content of BaA and the sum of 4 PAHs were determined in cold-pressed vegetable oils (13) marketed in Romania. BaP was not found in 7.69% of the samples, it was <LOQ in 76.92%, and in 15.38% it was quantifiable with a maximum content of 4.30 µg/kg. Three samples exceeded the maximum level allowed by Regulation (EU) No. 835/2011 for the sum of the 4 PAHs of 10 µg/kg. Acknowledgment This research work was supported by the National Research Authority, Core Programme PN 23 01, contract 39N/16.01.2023, project PN 23010301.

Validation study according to commission regulation (EU) 2021/808 for determining PAHs in cereal derivatives by GC-MS/MS

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Polycyclic aromatic hydrocarbons (PAHs) are one of the most dangerous chemical contaminants in the environment and food, and some of them show carcinogenic effects and genotoxic properties. The European Union has set upper limits for benzo(a)pyrene (BaP) and the sum of BaP, benzo(a)anthracene, chrysene, benzo(b)fluoranthene (4 PAHs) in various foods as indicators of chemical contamination. A

sensitive and rapid GC-MS/MS method combined with the QuEChERS technique with modifications was developed for the simultaneous determination of 4 PAHs in cereal-based products (semolina, biscuits, pasta, breakfast cereals). QuEChERS extraction was performed with citrate salts and acetonitrile, and purification was realized by freezing and solid-phase extraction (d-SPE) with Z-Sep$^+$ sorbent in different amounts and combinations with magnesium sulfate. Analysis of 4 PAHs was performed using the internal standard method by selected reaction monitoring mode using a GC-MS/MS. The method was validated following the requirements established by the European Commission Regulation 2021/808. Mean recoveries for the 4 PAHs were determined for intra-day, inter-day, and intermediate precision conditions, by fortifying a blank sample at 1, 2, and 3 µg/kg concentrations and ranged between 74-115%, 86-108%, and 92-113%. Intra-day precision (RSD) ranged between 1.1-11.7%, 1.5-8.7%, and 1.5-6.3%, while inter-day precision values were 2.1-20.2%, 1.7-10.9%, and 1.1-11.4% for the three spiking levels. Linearities were checked on calibration curves plotted on standard solutions (0.5-3.5 µg/L) and on matrices (1-7 µg/kg). The method showed good linearities ($R^2 \geq 0.99$ for all analytes). LODs ranged from 0.01 to 0.21 µg/kg, and LOQs from 0.05 to 0.69 µg/kg. Trueness was verified for the 4 PAHs, separately and as the sum of 4 PAHs, by participating in a PT test of a corn semolina matrix, on three concentrations: < LOQ, 2.49 – 2.79 (∑4PAH=10.24) µg/kg, 6.93 – 7.75 (∑4PAH=29.84) µg/kg), obtaining average z-scores of: BaA, z= 0.42; Chr, z= 0.80; BbF, z= 0.64; BaP, z= 1.24; ∑4HAP, z= 0.66. The developed and validated method was applied to matrices like cereal flours (4), breakfast cereals (1), fresh bread (2), toast/crumbs (2), semolina (2), and biscuits for young children (7). None of the 4 PAHs were quantified in any sample. The proposed method met the criteria of Regulation 2021/808 and can be used to quantify the 4 PAHs in processed cereal products.

Fungal and Yeast Contaminants in Dried Fruits: Implications for Food Quality and Safety

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High content, low release: Exploring TiO2 nanoparticle migration from food packaging using APEX™-single particle ICP-MS/MS

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Titanium dioxide (TiO2) is the most commonly used white pigment in plastics and food packaging industry. TiO2 may be released from food packaging during storage, potentially entering the food chain and being ingested by consumers. Recent studies suggest possible toxic effects, including carcinogenicity

and reprotoxicity, however, a regulatory consensus is still lacking due to conflicting evidence. Since under current European Union (EU) legislation there is no specific migration limit (SML) for nanoparticles in food contact materials, assessing TiO2 migration from packaging into food is important for evaluating consumer safety. For this purpose, plastic containers from commercially-available dairy products and custom-made TiO2-spiked polypropylene materials were put in contact with 50% (v/v) ethanol and 3% (w/v) acetic acid, which were used here as food simulants. The migration assays were carried out under standard contact conditions of packaging use (as recommended by Commission Regulation N° 10/2011 for food contact migration testing), and under conditions of extreme mechanical degradation of the packaging. The TiO2 (nano)particles released in the food simulants were analysed by single particle inductively coupled plasma-tandem mass spectrometry (spICP-MS/MS) in mass-shift mode and using a high efficiency sample introduction system (APEX™ Ω) to avoid matrix effects from food simulants. For the dairy product containers and for the spiked polypropylene, results showed release of TiO2 particles of rather large sizes (average size: 164 and 175 nm, respectively) under mechanical degradation conditions, i.e when the polymeric structure is damaged. The highest amounts of TiO2 were observed in 50% ethanol after 10 days of storage at 50 °C (0.62 ng cm-2) for the dairy product containers and after 1 day of storage at 50 °C (0.68 ng cm-2) for the spiked polypropylene. However, the level of Ti released in particle form was very small compared to the total Ti content in the packaging and far below the acceptable migration limits set by European legislation. Release under standard contact conditions of use of the container was not measurable, thus the migration of TiO2 particles from this packaging to dairy products among storage is expected to be negligible.

Trace-level determination of PFAS in water samples using LC-HRMS and a novel MOF sorbent in miniaturized SPE

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A novel composite material comprising a modified iron-based metal–organic framework (MOF) dispersed in a polymeric monolith was developed and evaluated as a sorbent for miniaturized solid-phase extraction (SPE).The material exhibits a highly porous architecture, enhanced specific surface area, and excellent chemical stability, offering improved selectivity and sorption capacity for per- and polyfluoroalkyl substances (PFAS). Its tailored physicochemical properties make it a promising platform for sample preparation in complex environmental matrices. This innovation was integrated into a green analytical workflow aligned with the principles of Green Analytical Chemistry. The miniaturized SPE method was optimized using a Central Composite Design methodology by adjusting parameters such as sorbent amount, sample volume, microcolumn dimensions, and elution solvent, aiming for high recovery efficiency. Greenness was evaluated using the ComplexMoGAPI tool, confirming the method's eco-friendly profile. The developed approach was applied to the determination of PFAS including PFPeA, L-PFBS, PFHxA, L-PFPeS, PFHpA, PFHxSK, L-PFHpS, PFOA, PFOSK, PFNA, L-PFNS, PFDA, L-PFDS, PFUdA, L-PFUdS, PFDoA, L-PFDoS, PFTrDA, and L-PFTrDS in various environmental water samples, including river water, marine water, urban runoff, and treated wastewater. Analytical determination was performed using liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS). The method was validated for accuracy, linearity, sensitivity, repeatability, and reproducibility. Recoveries exceeded 70%, with relative standard deviations below 15%. This work demonstrates the potential of MOF-based sorbents for sustainable, efficient, and reliable environmental monitoring of persistent contaminants.

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CLUSTERING

Consumer Perspectives on Food Fraud Vulnerability and Traceability: Insights from a Cross-Country Survey

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Food fraud challenges consumer trust, public health and supply chain integrity, especially in globalized food systems. Addressing it increasingly relies on traceability and authentication tools, whose success depends on consumer acceptance. This study assessed consumer perceptions of food fraud and traceability across four EU countries, focusing on how supply chain, product, and institutional factors shape trust and willingness to pay—particularly for honey, a commonly fraud-affected product. A structured online survey was conducted in Italy, Germany, Portugal, and Slovenia (N≈550 per country), using nationally representative samples. It covered socio-demographics; purchasing behaviour, food fraud awareness and experience; trust in relevant actors, and a choice experiment (CE) on honey. The CE compared preferences for honey products varying in origin, authenticity testing tools, supply chain transparency, production method and price. Most respondents expressed concern for food fraud and a quarter had personally experienced it. While support for fraud prevention was strong, most saw it as the responsibility of authorities and industry, not consumers. Traceability ranked lowest among food purchasing criteria, yet origin and local production remained key trust signals. Trust was highest in short supply chains and certified labels, while digital authenticity verification tools (e.g., sensors or QR codes) raised skepticism. Over two-thirds found label information insufficient to assess authenticity and viewed packaged foods as more prone to fraud than fresh items. In the honey CE, consumers preferred products from their own country or the EU and favoured organic options. Tools verifying geographical origin were more accepted than those testing for adulteration. Willingness to pay for fraud prevention was low, but higher when technologies were part of familiar labels or schemes and did not increase price. Consumers expect industry and authorities to ensure authenticity. They trust origin labels and short supply chains but new traceability tools raise scepticism, especially if costly. Low willingness to pay for fraud prevention highlights a gap between consumer expectations and current approaches. Effective strategies should build on trusted cues and clearly show added value.

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Galician mussel species identification via HRM analysis and ML for automated DNA Classification

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Mussel aquaculture is a significant economic activity in many coastal areas and especially for the region of Galicia in Spain. European legislation mandates the declaration of scientific and commercial identification on product labels. Seafood mislabeling is a widespread issue impacting authenticity, consumer choice, and potentially food safety due to undeclared allergens or species substitution. DNA-based authentication techniques are crucial for improving traceability, compliance, and transparency in the mussel supply chain by identifying mislabeling and substitution cases. The DNA-based authenticity kit within the THEROS toolbox offers a portable and rapid method for DNA extraction and automated analysis to verify species origin and product provenance, protecting consumers from adulteration. This kit provides full supply chain transparency and digital records for authenticity verification through standardized protocols, user-friendly software, and portable equipment. The methodology involves DNA extraction from product samples using robust, low-cost methods. Subsequent PCR and HRM analyses are performed on a portable device. PCR amplifies the COI gene region for species identification based on nucleotide differences. HRM analysis of amplified DNA sequences generates profiles and melting temperatures specific to each species and origin. For AI/ML DNA analysis, a dataset of 70 samples with DNA sequences from the COI gene and geographical origin (Chalastra, Greece; Galicia, Spain; Nea Michaniona, Greece) was used. Pre-processing included encoding target columns and shuffling data. K-mers representation (k=6) was applied to convert DNA sequences into numerical vectors using CountVectorizer, resulting in 2200 features for machine learning models. The dataset was split 75%-25% into training (52 samples) and testing (18 samples) sets, ensuring representative class distribution. Multinomial Naive Bayes (MNB) and Multiclass Logistic Regression algorithms were used for DNA classification. MNB predicts class based on k-mer frequencies, while Multiclass Logistic Regression extends binary logistic regression for multiple classes. Evaluation metrics included Weighted Accuracy, Weighted Precision, Weighted Recall, and Weighted F1 Score to account for class imbalance. MNB results showed an overall accuracy of 94.4%, precision of 95.8%, recall of 94.4%, and F1 score of 94.7%, with only one misclassification for 'Galicia, Spain' samples. Multiclass Logistic Regression achieved 100?curacy, precision, recall, and F1 score, with no misclassifications across all three geographical classes, demonstrating its strong performance. The output is fed into a verification engine to ensure product authenticity and origin based on genetic signatures. THEROS project has received funding by the European Union under grant agreement No 101083579.

User-centred pilot testing of tools for organic and geographical indication of food products

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The EU-funded THEROS project aims to modernize the process of verifying organic and geographical indications of food products through the use of various technologies and innovations such as Earth Observation (EO) services, MEMS-based photonics systems, DNA authenticity kits, IoT sensors, blockchain-based traceability systems, and dynamic digital product passports. The project also aims to improve traceability, security, and transparency in the supply chain. To align these tools with the diverse needs of stakeholders—ranging from farmers and certification bodies to consumers—a user-centred design methodology was employed. This contribution presents a user-centred design of respective tools, starting with an analysis of the stakeholder landscape through co-design activities conducted in four THEROS pilots, resulting in various user scenarios. End-user needs were then consolidated into specific requirements and specifications for THEROS toolbox components. Personas representing key user groups were developed to guide the design and deployment of the THEROS tools in each pilot. The usability and perceived utility of each tool were assessed through structured user experience (UX) surveys targeting the primary stakeholders involved in the food value chain. These surveys evaluated factors such as ease of use, usefulness, efficiency, effort reduction, and visualization quality. Initial findings from the pilot sites indicate high user acceptance across multiple tools. In Serbia and Greece, EO tools and MEMS-based spectrometers can enable certification bodies and producers to monitor organic farming practices and detect adulteration in real-time. In Spain, DNA authenticity kits combined with blockchain traceability can improve the verification of mussel species and origin, building trust among retailers and consumers. In the Czech Republic, the digital marketplace and IoT network can enhance traceability and transparency in the delivery of regional products. Overall, the THEROS tools have been tested showing their potential to increase efficiency and trust in certification processes, improve decision-making through data visualization, and strengthen confidence in food authenticity. User feedback highlights the value of integrating these tools into a unified platform and emphasizes the importance of ongoing support and training to ensure continued engagement. To this end, this research underscores the value of participatory design and iterative evaluation in developing authenticity and traceability tools tailored to stakeholder needs.

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Biosafety assessment of raw materials and soil improvers for a safeuse in agriculture

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Recycling food processing residues streams using environmentally friendly technologies capable of inactivating harmful microbes represents a practical approach towards circular economy. These treated residues can serve as soil improvers for sustainable agriculture. The main aim of this study was to evaluate the biosafety of raw materials and soil improvers derived from sustainable, high-quality, and standardized valorisation processes designed to inactivate relevant biological hazards. Both culture-based and molecular analyses were employed to assess microbial pathogens and the presence of potential antibiotic resistance genes (ARGs) in raw materials and end products. Different DNA extraction methods, ranging from classical chemical methods to commercial kits, were used on different soil improver matrices (e.g. compost, biochar, digestate, biostimulant, and meat and bone meal) to standardize the experimental procedure. Preliminary screening of these DNA extraction methods enabled the identification of the most effective method for each type of sample, ensuring the retrieval of high-quality DNA suitable for subsequent metagenomic analyses. DNA extraction results were evaluated using Nanodrop, Qubit, and gel electrophoresis, leading to the development of a dedicated protocol for DNA extraction tailored to the different raw materials and soil improver matrices. Microbiological parameters were analysed in accordance with Standard Operating Procedures (SOPs) previously developed for the biosafety assessment of residues and soil improvers. Each sample was analyzed in quintuplicate, using 25 g for each replicate. Both compost and digestate met the established safety criteria, ensuring their suitability for sustainable agriculture. In conclusion, continuous monitoring of antibiotic-resistant bacteria (ARBs) and antibiotic resistance genes (ARGs) is essential to mitigate the spread of antimicrobial resistance. The integration of culture-based and molecular analysis will permit to evaluate the biosafety assessment of residues and soil improvers.