



BOOK OF ABSTRACTS

22nd IGWT Symposium
**"From Commodity to Quality:
Shaping a Sustainable Future"**
with associated
**3rd International Conference
on Quality and Management Sciences**

Organizers

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International Society of Commodity Science and Technology

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WELCOME TO THE CONFERENCE

Dear Colleagues,

It is our great pleasure to present the Book of Abstracts of the 22nd IGWT Symposium, “From Commodity to Quality: Shaping a Sustainable Future,” held jointly with the 3rd International Conference on Quality and Management Sciences (ICQMSc) in Poznań, Poland, on 9–11 September 2026.

This event is a special occasion for our scientific community, coinciding with two important milestones: the 100th anniversary of Poznań University of Economics and Business and the 50th anniversary of the International Society of Commodity Science and Technology (IGWT).

The symposium motto, “From Commodity to Quality: Shaping a Sustainable Future,” invites reflection on the evolution of our discipline and its role in addressing contemporary global challenges. In an era shaped by digital transformation, artificial intelligence, and the pursuit of sustainable development, commodity and quality sciences play an increasingly important role in developing innovative and responsible solutions. The contributions presented in this volume reflect the diversity of current research and highlight the value of interdisciplinary collaboration.

We would like to express our sincere gratitude to the International Society of Commodity Science and Technology (IGWT) for entrusting us with the organisation of this important edition of the Symposium. We are equally grateful to all authors, members of the International Advisory Board, International Scientific Committee, Organizing Committee, Honorary Patrons, and Supporting Organizations for their valuable contributions, commitment, and support, which have made this event possible.

We hope that the Symposium will provide not only an inspiring scientific forum but also an opportunity to establish new collaborations, exchange ideas, and build lasting professional friendships. We encourage all participants to enjoy both the scientific and social programmes and to experience the unique atmosphere of Poznań.

We warmly welcome you and wish you a successful, productive, and memorable conference.

With our warmest regards,

Ewa Sikorska, Director of the Institute of Quality Science
Daniela Gwiazdowska, Head of the Organizing Committee

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OPENING AND KEYNOTE LECTURES



FROM LAB TO MARKET: THE SILICON VALLEY WAY

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Silicon Valley has built a world-renowned way of turning scientific breakthroughs into scalable global products. Its momentum comes not from isolated institutions or public subsidies, but from a tightly connected ecosystem in which universities, entrepreneurs, venture capital, and industry work side by side. Its defining trait is the short distance between the laboratory bench and the people who build, sell, and service the product: scientist, business executor, and end user stay in one conversation from the first experiment to the shelf. The presentation examines the mechanisms that carry deep technology from bench to market and the principles other ecosystems can adopt.

Drawing on long experience at the interface of academia, technology entrepreneurship, and global business, the talk looks at what makes commercialization work in practice. The emphasis falls on the working partnership between the laboratory and the business executor. In Silicon Valley these roles are not sequential: founders, operators, and investors engage with a technology while it is still on the bench, and what the customer says travels back to the lab in weeks rather than years. Universities must therefore act less as producers of publications and more as platforms that build venture capability, manage intellectual property with commercial intent, and put researchers in direct contact with users and buyers.

That unbroken line from lab to executor to consumer is what carries a technology across the “valley of death” between technical excellence and commercial viability. Translation calls for disciplined team building, early testing of assumptions, firm industry alliances, and iterative execution in which science, business strategy, and funding move together. The talk closes with practical steps for Poland and Central Europe: durable university-industry bridges, faster technology transfer, and talent equipped to compete globally.

Keywords: commercialization, innovation, market validation, Silicon Valley, technology transfer, university-industry cooperation

HOW FAR HAVE WE COME: IS QUALITY POSSIBLE WITHOUT THE COMMODITY

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The transition from commodity to quality reshapes not only markets but the conceptual foundations of commodity science itself. A foundational question arises: Is quality possible without the commodity. Historically, commodity science emerged as a core component of economic reflection, grounded in the study of material goods whose properties, durability, and safety underpinned trade, money, and institutional trust. Today, however, the discipline in many countries finds itself in a twilight phase. Generational shifts, the weakening of academic centres, and the dominance of marketing, quality science, and management have displaced the material foundations of economics. Mainstream economics, embracing assumptions of unlimited growth and the planet's inexhaustible carrying capacity, gradually severed conceptual links between commodities, value, and money, paradoxically at a moment when the diversity and technological complexity of commodities reached unprecedented levels.

Against this backdrop, the lecture proposes a renewed ontology of commodity science: the commodity understood not merely as a physical object but as a carrier and manifestation of value, including in immaterial domains such as data, services, and affective experiences. Within this framework, three stages in the evolution of the discipline are distinguished:

- (1) the commodity as object,
- (2) the commodity as experience, and
- (3) the commodity as relation.

In this model, quality becomes a relational, context-dependent, and co-constructed category, more philosophical than purely technical, and essential for understanding contemporary forms of value. By integrating historical reflection, philosophical analysis (the ontology of quality), and futurological perspectives on the post-material economy, the lecture argues that the evolution from commodity to quality is not merely a shift in research focus but a paradigmatic transformation enabling the discipline to contribute meaningfully to future challenges. In doing so, it aligns with the theme of the symposium, demonstrating that a deeper, interdisciplinary understanding of quality may become a cornerstone of sustainable development.

Keywords: commodity science, futurological perspectives on the post-material economy, ontology of commodity science, ontology of quality, quality

ON COMMODITY SCIENCE: AN ATTEMPT AT A SUSTAINABLE RESUMPTION OF THE ACADEMIC ECONOMIC DISCOURSE

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The core natural science subject within the canon of economics is commodity theory in German semantics. Commodity Science is the third pillar in the discussion of what economics as a whole actually is.

Economists deal with aspects of the economy and assume a basic understanding of fundamental concepts. Commodity science is a foundational subject that examines the economy in interaction with nature. From a socio-ecological perspective, it is a field that extends beyond the structural commodity as an orientation subject. Business and economics focus on society – and nature as an extra-social sphere. Accordingly, two systems theories exist side by side: Their fathers are the biologist Ludwig von Bertalanffy and the social scientist Niklas Luhmann.

General systems theory is based on biophysical principles and views the economy as dependent on natural laws to which the entire biosphere is subject. Society is a part of this, and the environment is the totality of factors determining existence. Ecology is the science of natural balance, which emerged from biology. In this respect the study falls within the bio-cultural bridging discipline. Commodity is not only matter of commerce.

Physiological biology was born from the spirit of medicine. The medical study of economics is the origin of the subject of commodity science. With the end of physiocracy, the encyclopaedic study of commodities has fallen out of context. Following its displacement and a growing ecological crisis, the political economy's neglect of nature is evident.

Commodity science is the entire study of the functions of commodities. The concept of function distinguishes biology from chemistry and physics. Physiology thus constitutes the bioeconomic foundation of commodity science, which is why bioeconomics may become its paradigm.

Evolutionary theory is the foundation of biology; Ludwig von Bertalanffy and Nicholas Georgescu-Roegen are the fathers of Bioeconomics. Drawing on the physical economy of Leibniz and Beckmann, this represents biophysics in its current state of science. Biocracy is oriented towards the logic of life, a concept coined by Walter B. Cannon and later adopted by Lynton K. Caldwell in the context of environmental policy. With Arturo Rosenblueth and Norbert Wiener as the fathers of cybernetics, qualitative biocommunication became essential for sustainable development.

Economics is a field of practical ethics that cannot be permanently detached from biological constraints. For this reason, the study of commodities is also a study of sustainability. Therefore, commodity ethics is a principle of real-world economic responsibility. In their value systems, the commodity is ideology reified. We can choose a biocentric or anthropocentric perspective, and we ourselves are responsible for the consequences. Aristotle is considered the father of scientific biology and political economy in ethics.

Commodity is the opposite of money, payment is made for function. The functionality of the commodity corresponds to the morphology of the economic whole.

The holistic nature of Beckmann's theoretical framework is essential to the epistemological foundations of his commodity theory. Medicine was the mother of all science. In medical thought, the commodity became "materia medica," and technology its mother. With "Natural History, Technology, and Commodity Studies," Beckmann followed in "theoria cum praxi" Leibniz's guiding principle of "Medicine, Manufactures, and Commerce," thus establishing physical economics as a precursor to political economy. Unlike the economic theories begun with the moral philosopher Adam Smith,

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Beckmann's work is based on nature. He sought in Linnaeus the immaterial “principium vitalis”, now biophysics.

"Rem tene, verba sequentur": Hold fast to the matter, let the words follow. Otto Gekeler's intentions, building on the work of Johann Beckmann, were to bring the field up to the current state of science, which he considered necessary. Together with Josef Hölzl, he was the founder of FORUM WARE.

STUDY OF THE QUALITY LOSS IN VIRGIN OLIVE AND AVOCADO OILS: NEW ASSESSMENT METHODS

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Although virgin olive oil (VOO) and avocado oil (AO) share several compositional characteristics, they differ in botanical origin, processing conditions, antioxidant profile and degree of standardization. These differences strongly affect their oxidative stability during storage and the evolution of their chemical composition, highlighting the need for rapid and reliable methods for quality assessment. This work explores the potential of complementary spectroscopic techniques to evaluate the early stages of quality deterioration in both oils. Fourier-transform infrared (FTIR) and fluorescence spectroscopy were employed to obtain comprehensive information on major and minor oil constituents. FTIR spectroscopy was used to monitor oxidation-related changes in the lipid matrix, including variations in unsaturation, hydroperoxide formation and accumulation of carbonyl compounds. Fluorescence spectroscopy provided sensitive information on naturally occurring fluorophores and oxidation products.

The spectroscopic data revealed distinct degradation patterns for both matrices, even under mild storage conditions and at early oxidation stages. Avocado oil showed greater variability and more pronounced spectral changes, indicating a higher susceptibility to quality loss. This behaviour may be related to its broader compositional variability and the lower degree of regulatory harmonization compared with VOO. In contrast, virgin olive oil displayed a more consistent spectroscopic profile, suggesting greater stability and a better-preserved antioxidant system.

The results demonstrate that the combined use of FTIR and fluorescence spectroscopy is an effective strategy for the rapid evaluation of oxidative alterations in edible oils. This approach provides valuable information for quality control and the assessment of emerging products such as avocado oil, where additional analytical support is required. Furthermore, volatile compound analysis offers complementary information on the sensory impact of oxidation by determining how oxidative degradation modifies the volatile profile of these oils to understand how the earliest chemical modifications can lead to final sensory consequences.

Keywords: avocado oil, food quality control, fluorescence spectroscopy, FTIR, rancidity, virgin olive oil

PROBIOTICS: FROM IDENTIFICATION TO COMMERCIALISATION, FOCUS ON QUALITY

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Probiotics are live microbes that, when administered in adequate amounts, confer a health benefit on the host. This definition does also imply that the product is safe and of appropriate quality. Probiotic quality starts with identification; knowing what you have and what the microbe, genetically, can be expected to do or not do. For this, whole genome sequencing is essential. The microbe needs to be evaluated for its ability to grow on industrial scale, what growth requirements does it have? What quality requirements do we set for the product? This depends on the intended use. In parallel, (pre-) clinical studies need to be performed to document the microbe has a health benefit and qualifies as a probiotic. Here too, the question needs to be asked for what purpose and target population do we perform the study? What quality requirements do we have for the study? Upon commercialisation, quality control of culture ingredients is essential as well as quality assurance and quality control of the product. This must happen at each step along the production process to capture deviations from specifications as soon as possible. Product quality control depends on the intended use. For pharma and paediatric nutrition applications stricter controls are required as compared to products intended for use by the general public in dietary supplements or food and beverages. The controls concern probiotic viability but also the absence of microbiological and chemical contaminants. Quality control does not stop here also the final commercial product is subject to stringent quality assurance and quality control requirements. Finally, quality control and quality assurance procedures are continuously updated, either as required by law and/or as enabled by technological developments. This requires continuous education of operators, operational procedures, and lab personnel.

Keywords: probiotics, quality, identification, manufacturing, commercialisation

ONE QUALITY ECOSYSTEM: CONNECTING CULTURE, SUSTAINABILITY AND THE FUTURE OF ORGANIZATIONAL EXCELLENCE

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This paper presents the findings of an international study conducted by the Associação Portuguesa para a Qualidade (APQ) (Portuguese Association for Quality) to assess organizational maturity across three interrelated dimensions: Quality Culture, the integration of Quality and Sustainability, and preparedness for the Future of Quality. The objective was to identify current practices, perceptions, and challenges associated with quality management in contemporary organizations. Data were collected during the second half of 2025 through a structured questionnaire distributed across international quality networks. A total of 396 responses were obtained, of which 338 valid questionnaires from organizations representing 40 countries were analyzed. Statistical analysis was performed in R using descriptive statistics, non-parametric tests, and reliability analysis based on Cronbach's alpha, which exceeded 0.98 for all scales, confirming excellent internal consistency. The results indicate that organizations exhibit high levels of maturity in customer orientation, leadership commitment, and operational quality practices. However, structured continuous improvement methodologies and employee recognition remain less consistently implemented. Sustainability is well integrated into resource efficiency and environmental management but is less mature in sustainable supply chains and life-cycle product design. Regarding the Future of Quality, respondents strongly recognize quality as a strategic competitive advantage, yet significant gaps remain in the adoption of digital technologies, particularly Artificial Intelligence, predictive analytics, and IoT-based quality systems. Strong positive correlations among the three dimensions suggest that organizations with mature quality cultures also demonstrate greater sustainability integration and readiness for future quality challenges. Overall, the findings support a holistic view of quality management, highlighting that long-term organizational excellence depends on simultaneously strengthening culture, sustainability, and digital transformation.

Keywords: Quality Culture, Sustainability, Future of Quality

STANDARDIZATION ON CLIMATE CHANGE

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Climate change has become an increasingly important subject of international standardization. This presentation provides an overview of the development of climate-related standardization within the International Organization for Standardization (ISO), with particular attention to ISO/TC 207 and its Subcommittee 7 (SC 7), Greenhouse Gas and Climate Change Management and Related Activities.

The presentation distinguishes the development of ISO standardization from the parallel evolution of international climate governance under the UNFCCC, including the Kyoto Protocol and the Paris Agreement. ISO is an independent, non-governmental international organization, and its International Standards are voluntary. Consequently, ISO standards are neither direct implementations of intergovernmental agreements nor the result of a direct mandate from the UNFCCC, the Paris Agreement or national governments.

The presentation follows the development of ISO/TC 207 and the subsequent establishment of SC 7, explaining how SC 7 develops its work programme within the ISO system, including proposals originating through National Standards Bodies. Particular attention is given to the distinction between standards already published and standards currently under development.

A further development is the ISO London Declaration on Climate Action of 2021. The Declaration did not establish or newly mandate SC 7, but represented an explicit ISO-wide climate commitment and called upon relevant ISO committees to consider climate change in their own standards work.

The presentation focuses on the current and emerging work of SC 7, including published standards, standards under development, and the evolving collaboration between ISO and the GHG Protocol in the revision of key GHG standards. The presentation also points to current developments and forthcoming work within SC 7.

Keywords: climate change, GHG management standardization, ISO, ISO/TC 207, London Declaration, Paris Agreement, SC 7

ORAL COMMUNICATIONS



COMMODITY SCIENCE: SYSTEMIC CHALLENGES OF THE XXI CENTURY

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Commodity science as a science of goods originated almost 500 years ago has traversed a significant path of formation, addressing numerous problems and challenges through its development. Traditionally, commodity science systematically examines the quality, safety, assortment, competitiveness, and other aspects of goods across all stages of their formation and commodity circulation.

In the 21st century, commodity science is confronted with new systemic challenges, the main of which indicated and shortly described below.

Ecological transformation in production and product disposal to ensure sustainable development. This area encompasses issues of packaging safety, the proliferation of eco-labeling alongside the risks of greenwashing, and the efficient organization of disposal and recycling processes to minimize environmental impact. Climate risks and the carbon footprint of goods in the 21st century have evolved into a distinct research direction for commodity science.

Digital transformation of markets and trade digitalization. The rapid development of the digital environment requires ensuring impeccable supply chain traceability, developing expertise in ecommerce, as well as the effective control and analysis of large datasets (Big Data). Artificial intelligence (AI) constitutes a novel technological and methodological challenge for commodity science. Modern machine learning and computer vision algorithms are already being applied to product identification, counterfeit detection, quality forecasting, and the analysis of extensive datasets regarding consumer properties.

Faking spread combating. The modern market faces the emergence of new, more complex types of counterfeits, the need to improve identification methods for complex products, and counteraction to various informational manipulations regarding the consumer properties of goods, which is becoming one of the contemporary tasks of commodity science.

The need to adapt national standards to international and European standards. This process is critically important for the integration of the economy of Ukraine and other developing countries, the harmonization of technical regulations, and the ensuring of free and safe movement of goods flows.

Thus, modern commodity science is transforming into a proactive science capable of effectively responding to current global challenges, guaranteeing consumer rights protection, and supporting the concept of sustainable development.

Keywords: commodity science, quality and safety of goods, systemic challenges, ecological transformation, sustainable development, carbon footprint, digital transformation, supply chains, artificial intelligence, faking, harmonization of standards

FROM PENCIL TO BLOCKCHAIN: PRODUCT-CENTRED LEARNING AS A NEW PARADIGM FOR COMMODITY SCIENCE IN THE NEW AUSTRIAN CURRICULUM FOR COMMERCIAL EDUCATION

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This paper analyses the recent Austrian curriculum reform for commercial education and demonstrates how Commodity Science has been repositioned as an integrative discipline linking natural sciences, technology, sustainability, and business education. Building upon the historical development of Commodity Science, it introduces the concept of Product-Centred Learning as a theoretical framework for interpreting the curriculum. Within this model, authentic products become the common object of investigation across disciplines, while Commodity Science functions simultaneously as a foundation discipline, providing the scientific basis for understanding products and technologies, and as an enabling discipline, connecting scientific knowledge with commercial reasoning.

The transformation of economies through digitalisation, sustainability, artificial intelligence, and global value chains has fundamentally changed the competencies required in commercial education. Contemporary products are no longer understood as isolated physical goods but as complex systems integrating natural resources, manufacturing technologies, environmental impacts, digital information, and economic value creation. Consequently, commercial education requires educational approaches that connect scientific understanding with economic decision-making and enable learners to analyse products from scientific, technological, ecological, and commercial perspectives.

The Austrian curriculum represents one of the first systematic implementations of this educational approach. The paper argues that Product-Centred Learning provides a coherent framework for interdisciplinary commercial education by positioning authentic products as the common focus of learning across disciplines. Beyond its relevance for Austria, the proposed model offers an internationally transferable framework for curriculum development in vocational and commercial education, preparing learners to make informed, responsible, and sustainable economic decisions.

Keywords: commodity science; curriculum reform; business education; sustainability education; interdisciplinary learning

THE TRANSFORMATION OF THE FUTURE – FROM INDUSTRY 4.0 TO INDUSTRY 6.0

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The rapid evolution of industrial paradigms has fundamentally reshaped manufacturing systems, organisational structures, and global value chains. The transition from Industry 4.0 to Industry 6.0 marks a shift from digitally enabled efficiency toward industrial systems that are intelligent, human-centred, resilient and environmentally responsible. Industry 4.0 established the technological foundation for smart manufacturing by integrating cyber-physical systems, IoT, cloud computing, BD analytics, and AI into highly connected production environments. However, the pressure to address climate change, resource scarcity and workforce transformation has revealed the limitations of a purely technology-driven approach. Industry 5.0 therefore extends digital transformation by placing people, resilience, and sustainability at the centre of industrial development while promoting collaboration between humans and intelligent machines. The emerging concept of Industry 6.0 is the next stage of this evolution combining autonomous AI, advanced digital twins, quantum computing, decentralised decision-making, regenerative manufacturing, and circular economy principles within intelligent industrial ecosystems.

The paper aims to analyse the transition from Industry 4.0 to Industry 6.0, identify the drivers shaping future industry, and discuss their implications for manufacturing competitiveness and sustainable development. The paper proposes a conceptual framework illustrating the evolution of industrial paradigms. It highlights the growing importance of trustworthy AI, human-centric innovation, resource efficiency, and ecosystem resilience as complementary dimensions of future industrial transformation.

The proposed framework provides a basis for a structured interpretation of Industry 6.0 as a future-oriented paradigm linking competitiveness with environmental performance and social value creation.

Keywords: artificial intelligence, digital transformation, Industry 4.0, Industry 5.0, Industry 6.0, smart manufacturing, sustainable development

UNDERSTANDING OF SUSTAINABLE NUTRITION - ARE CONSUMERS READY FOR NATURALLY COLOURED PLANT-BASED PROTEIN PRODUCTS?

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Sustainable nutrition is an approach to eating that supports both human health and the long-term health of the planet. It focuses on diets that are nutritionally adequate, environmentally responsible, economically fair, and culturally acceptable. The growing global interest in sustainable nutrition has accelerated the development of plant-based food products, with innovations focusing additionally on applying natural colouring agents as an alternative to synthetic additives. However, consumer acceptance of such products depends not only on nutritional and environmental awareness but also on sensory expectations, purchasing habits, and trust in food innovation.

The aim of the presented study was to determine consumer knowledge and attitudes towards sustainable nutrition and assess the consumer acceptance of naturally coloured plant-based protein confectionery. For this purpose, firstly indirect interviews were conducted using a survey questionnaire (n=372). Secondly, consumer testing of five plant-based protein, low sugar meringues in different colours took place (n=90).

Sustainable nutrition was understood by more than a half of respondents through the lens of health and well-being benefits. The second distinct group of associations referred to a balanced diet, with adequate macro- and micronutrient intake. Only one-fourth of respondents interpreted sustainable nutrition in line with a broader understanding of sustainable development, linking individual dietary choices with environmental and social consequences. Beliefs about sustainable nutrition varied, depending on the individual environmental approach to food product selection. The coloured plant-based protein meringues were accepted by the majority of consumers, with the pink meringue enriched in raspberries receiving the highest liking.

Keywords: sustainable nutrition, natural colouring, plant-based protein, confectionery, consumer acceptance

This research was funded by the Polish Ministry of Science and Higher Education (MNiSW) "Student Scientific Association Create Innovations" program - project SKN/SP/601859/2024 "Development of an innovative high-protein confectionery product based on plant protein".

CONSUMER MOTIVATORS AND BARRIERS TO PURCHASE OF FOODS FORTIFIED WITH NUTRIENTS RECOVERED FROM FOOD SIDE-STREAMS: A COMPARATIVE STUDY ACROSS FIVE EUROPEAN COUNTRIES

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The valorisation of food side-streams (processing residues) is part of efforts to create sustainable food systems, but its market potential depends on consumer acceptance of foods fortified with nutrients recovered from side-streams.

This study examined attitudes in five European countries – France, Poland, Romania, Norway and Ireland – using a CAWI survey of 5,077 adults. The analysis focuses on Top2Box results on acceptance of the idea of food fortification with nutrients recovered from food side-streams, as well as on purchase motivators and barriers for food with such nutrients.

Acceptance levels were similar across the three value chains, with 43% of respondents agreeing that using nutrients recovered from potato processing residues in fortified foods is a good idea, compared with 42% for fish processing residues and 39% for oil production residues. Irish consumers had the highest acceptance across all three sources (47-50%), while the French and Polish were more cautious, especially for fish residues (34-37% respectively).

Purchase motivation was driven mainly by product-related and economic benefits. Better taste was the strongest motivator (66%), followed by better smell (61%), more appetising appearance (61%), lower price (61%), improved texture (57%) and higher nutrient content (57%). Sustainability-related arguments were weaker: supporting local producers and processors reached 51%, zero-waste 46% and lower carbon footprint 46%.

Key barriers were sensory and risk-related: worse taste (65%), worse smell (64%), worse texture (61%), high degree of processing (60%), less appetising appearance (60%) and concerns about unsafe technologies (58%). Information that nutrients were recovered from residues was a weaker but still relevant barrier (47%). Market acceptance, therefore requires more than sustainability communication: foods fortified with nutrients recovered from food residues must be safe, sensory-attractive, nutritionally valuable and competitively priced.

Keywords: consumer barriers, consumer motivators, food fortification, food processing residues, food side-streams

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"NATURAL" DOES NOT ALWAYS MEAN SAFE: CONSUMER MISUNDERSTANDINGS AND THEIR IMPACT ON COSMETIC PREFERENCES

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The growing popularity of natural cosmetics is accompanied by increasing consumer interest in ingredient transparency, product safety and “clean beauty” marketing claims. However, consumers frequently associate the term “natural” with safety and lower health risk despite the lack of a universal legal definition of natural cosmetics and despite evidence that natural substances may also exhibit allergenic, irritating or toxic properties.

The aim of this pilot study was to evaluate consumer knowledge regarding natural cosmetics and to analyze the relationship between declared knowledge, actual knowledge and behaviors related to reading cosmetic certificates and labels. The study was conducted using an online questionnaire among 88 respondents, with particular focus on natural shampoos intended for sensitive scalp care. Statistical analyses included descriptive statistics, Pearson correlations, ANOVA, Cronbach’s alpha and linear regression analysis.

The results demonstrated a discrepancy between self-assessed and actual knowledge. Self-assessed knowledge was significantly associated with declared reading of cosmetic certificates, whereas actual knowledge was not. Respondents showing higher levels of overconfidence were also more likely to declare engagement in label-analysis behaviors. No significant relationship was observed between actual knowledge and reading cosmetic certificates.

The findings suggest that consumer behaviors related to natural cosmetics may be influenced more strongly by subjective beliefs and perceived competence than by evidence-based understanding of cosmetic formulation and safety. The study also highlights the potential role of marketing narratives and “naturalness bias” in shaping consumer perceptions of cosmetic products.

Keywords: natural cosmetics, consumer behavior, cosmetic safety, natural shampoo, overconfidence, cosmetic claims, marketing, consumer awareness

ENHANCING SAFETY, SENSORY AND TECHNOLOGICAL ATTRIBUTES OF GOAT'S PASTEURIZED MILK CHEESE USING SELECTED LACTIC ACID BACTERIA AND KEFIR FERMENT

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In this study, previously-selected lactic acid bacteria (LAB) strains - *Leuconostoc mesenteroides*, *Lactocaseibacillus paracasei*, and *Loigolactobacillus coryniformis* - as well as kefir ferment were evaluated as bioprotective and technological cultures in goat's pasteurized milk cheese. Six experimental cheese treatments were produced: one control made of raw milk (benchmark) and another control made of pasteurized milk both produced at pilot scale, and a control and *L. mesenteroides*-, LAB cocktail-, and kefir-added treatments made of pasteurized milk produced at laboratory scale. Cheeses were characterised in terms of microbiological and physicochemical attributes during the 60-day maturation period, whereas proximate composition, instrumental texture and sensory analysis were carried out in the final product. Mesophilic bacteria and LAB were the predominant microbiota in all treatments, remaining high ($> 8 \log \text{CFU/g}$) throughout maturation, whereas the control exhibited significantly lower counts, averaging $\sim 7 \log \text{CFU/g}$ ($p < 0.001$). For *Staphylococcus aureus*, the most pronounced reductions occurred in kefir $> L. mesenteroides >$ LAB cocktail, with final counts of 3.67 ± 0.241 , 4.26 ± 0.241 and $4.36 \pm 0.241 \log \text{CFU/g}$, respectively. Physicochemical parameters changed significantly during maturation ($p < 0.001$), and cheeses containing adjunct cultures exhibited higher proteolytic activity (up to 0.361 ± 0.0131), titrable acidity (up to 0.1971 ± 0.0180) and lower pH (5.41 ± 0.0526), indicating more advanced maturation process than the three control treatments. Principal Component Analysis (PCA) clearly distinguished the quality of kefir and LAB cocktail cheeses from the pilot pasteurized milk and control cheeses, revealing strong positive correlations between microbial activity, acidification, and proteolysis. Furthermore, PCA revealed linkages between physicochemical and textural properties, namely: higher proteolysis, acidity and fat content were associated with higher cheese brittleness; whereas higher pH with higher cheese hardness. Sensory evaluation showed that kefir $> L. mesenteroides >$ LAB cocktail cheeses achieved the highest overall acceptance scores (9.15 ± 0.285 , 8.44 ± 0.285 , and 8.39 ± 0.285 , respectively, on a 10-point scale), being characterized by perceivable less holes, pleasant aroma, balanced acidity, and smooth, non-rubbery texture. Based on the results obtained in this study, incorporation of kefir ferment or selected LAB strains enhanced microbial safety, accelerated biochemical maturation, and improved compositional and sensory attributes, thereby highlighting their potential as effective bioprotective and functional adjunct cultures for artisanal goat cheese production.

Keywords: biopreservation, food safety, principal component analysis, artisanal cheese

PHENOTYPIC ANTIMICROBIAL RESISTANCE AND MULTIDRUG-RESISTANCE PROFILES IN FOOD-ASSOCIATED *STAPHYLOCOCCUS* AND *SALMONELLA* ISOLATES

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Antimicrobial resistance (AMR) in food-associated bacteria is a major concern for food safety and public health. This study characterised phenotypic antimicrobial resistance and multidrug resistance (MDR) among food-associated *Staphylococcus* and *Salmonella* isolates using an isolate-level analytical workflow.

A total of 87 unique bacterial isolates were analysed, comprising 67 *Staphylococcus* isolates and 20 *Salmonella* isolates. Each isolate was tested in triplicate, resulting in 261 laboratory records. Replicate-level antimicrobial susceptibility interpretations were assessed for concordance and consolidated into a single isolate-level result for each antimicrobial test. Resistance prevalence was estimated using exact binomial 95% confidence intervals. MDR was defined as resistance to at least one agent in three or more antimicrobial categories. A conservative MDR analysis excluded results subject to interpretive caution.

Complete concordance of susceptibility interpretations was observed among the three replicate measurements. Resistance in at least one antimicrobial or resistance-screening test was detected in 47/67 *Staphylococcus* isolates (70.1%) and 19/20 *Salmonella* isolates (95.0%). Among *Staphylococcus*, the highest resistance frequencies were observed for benzylpenicillin (32/67; 47.8%, 95% CI: 35.4–60.3%) and erythromycin (19/67; 28.4%, 95% CI: 18.0–40.7%). Resistance to gentamicin and tetracycline, and a positive norfloxacin fluoroquinolone-resistance screen, were each recorded in 4/67 isolates (6.0%, 95% CI: 1.7–14.6%). One isolate was positive in the cefoxitin methicillin-resistance screen (1/67; 1.5%). Seven *Staphylococcus* isolates were classified as MDR (10.4%). Among *Salmonella*, an azithromycin resistance phenotype under the applied conditional interpretation was observed in 11/20 isolates (55.0%, 95% CI: 31.5–76.9%). Resistance to gentamicin and trimethoprim was detected in 7/20 isolates each (35.0%), while 3/20 isolates were resistant to tobramycin (15.0%). One *Salmonella* isolate met the primary MDR definition (5.0%); however, no isolates remained classified as MDR after excluding results requiring interpretive caution.

Phenotypic resistance was frequent among the food-associated isolates examined, particularly to benzylpenicillin and erythromycin in *Staphylococcus* and to azithromycin, gentamicin, and trimethoprim in *Salmonella*. The isolate-level consensus approach ensured that replicate measurements were not treated as independent observations, while category-based MDR classification prevented multiple agents belonging to the same antimicrobial category from being counted as separate resistance events. These findings support continued surveillance of antimicrobial resistance in food-associated bacteria.

Keywords: antimicrobial resistance, multidrug resistance, *Staphylococcus*, *Salmonella*, food safety, antimicrobial susceptibility

BASIC FOUR-BOX SCHEME OF PROBLEM SOLVING FOR INFORMATION QUALITY IMPROVEMENT – THE CONCEPTUAL STUDIES WITH AN APPLICATION OF AI-BASED SOFTWARE AND PATENT DATABASE

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The research problem of this work refers to the search for methods and tools for improving the quality of information within the process of Product Development. At this work, the quality of information is understood in terms of the infological view, in which it is assumed that the data alone cannot "carry" information. The information that may be conveyed by a set of data depends on the person receiving structure. In the conducted research, a person receiving structure refers to the so-called pre-knowledge of engineers and their ability to solve assumed technical problems and contribute to the process of product development. The aim of the research is to develop a concept that will enable the effectiveness of information quality management. The first part of the work presents the importance of the solved problem in the context of the analogy-based reasoning adopted in the work, the concept of information quality in the context of data quality management, shaping knowledge, wisdom, and the infrological information model adopted in the research. The second part of the paper presents the basic assumptions of solving the assumed technical problems in terms of Theory of Inventive Problem Solving. The basic premises and the concept of analogy-based reasoning, according to the Basic Four-Box Scheme of Problem Solving, are presented. In the study of information quality, a four-step methodology utilizing Omnia, an AI-based platform built on a rag architecture integrated with a global patent database, was used. The results obtained at stage (1) Analysis of the initial situation were summarized, recognizing a set of current solutions presented in patent documents and related to the subject of research; (2) Abstraction, using Multi-Screen (System Operator) and considering the quality of information in a holistic perspective; (3) Conceptual Solution, using a contradiction model, from the TRIZ point of view and reference to 40 Inventive Principles. The concretization and determination of how we can transfer the generalized solution suggested by the model to a specific solution to our problem, how to integrate the identified, already existing solutions related to the research and the implementation of individual elements included in the adopted model in an overall perspective – is indicated as the direction of further research work. An important direction of further research activities is the development of a procedure related to the procedure for referring to patent applications in the process of innovative task solving utilizing analogy-based reasoning.

Keywords: information quality, product development, analogical reasoning, TRIZ, patent analysis

FROM VARIABILITY TO STANDARDISATION: EVALUATING AVOCADO OIL QUALITY UNDER EMERGING CODEX REGULATIONS

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Avocado oil (AO) has gained increasing commercial relevance due to its nutritional and sensory properties. In contrast to virgin olive oil (VOO), which is regulated under a long-established framework, avocado oil is subject to a more recent and still developing standard. This fact has led to the commercialization of products with variable quality under similar and often non-specific labels, highlighting the need for harmonised standards, recently addressed by the inclusion of avocado oil in the Codex Alimentarius. This study aimed to evaluate the purity and quality of commercial avocado oils using the recently amended Codex Alimentarius standard, and to compare their characteristics with those of VOOs. Commercial avocado oils were characterised by fatty acids, sterols, and tocopherols, according to the Codex Alimentarius criteria. Due to the absence of defined quality parameters for avocado oil, quality and oxidation state were further assessed through free fatty acids, peroxide value, and UV extinction coefficients (K_{232} , K_{270}), interpreted using International Olive Council (IOC) standards. Complementary analyses, including oxidative stability, fluorescence spectroscopy, and sensory evaluation, were performed to provide a comprehensive assessment of oil quality. The results obtained showed that most avocado oils complied with Codex standards limits, although some samples deviated in specific fatty acids or sterol criteria. Compared to VOOs, AOs exhibited significantly higher variability in composition, particularly in tocopherols (88–414 mg/kg). Quality parameters revealed that AOs had higher free fatty acids (up to 1.74 %) and peroxide values (up to 29.5 meq O₂/kg), indicating a more advanced hydrolytic and oxidative degradation. Accordingly, AOs showed lower oxidative stability (mean OSI 10.7 h) than VOOs (25.6 h), supported by fluorescence and sensory analyses that identified rancid and oxidized notes in several samples. These findings highlight the importance of the recent inclusion of avocado oil in the Codex Alimentarius, as well as the need to follow developing regulations, including improved labelling and the incorporation of quality parameters that guarantee acceptable sensory properties, thereby supporting product consistency, regulatory enforcement, and consumer confidence.

Keywords: avocado oil, authenticity and quality parameters, labelling, oxidation, sensory properties, virgin olive oil

THE ROLE OF WASTE QUALITY IN DESIGN ACCORDING TO THE 5R PRINCIPLE: A CASE STUDY OF POST-PRODUCTION DENIM WASTE

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The growing environmental impact of the textile industry has intensified interest in circular economy strategies and sustainable design approaches. The 5R principle (Reduce, Reuse, Recycle, Recover, and Redesign/Repurpose) provides a valuable framework for reducing waste generation and extending material life cycles. This study examines the role of waste quality in design processes, focusing on post-production denim waste as a potentially valuable secondary raw material.

The quality of textile waste is a key factor determining the range of feasible recycling and upcycling pathways. In the case of post-production denim waste, characterized by relatively high material purity and controlled composition, several recovery scenarios can be considered. While the production of recycled yarns from such waste remains debatable due to technological limitations, quality requirements, and economic considerations, alternative applications offer significant potential. These include the production of nonwoven materials for thermal and acoustic insulation, as well as the use of cotton-rich waste as a source of cellulose for innovative material and chemical recycling processes.

The presentation will showcase potential applications of post-production denim waste, emphasizing the importance of waste quality in selecting appropriate recovery and recycling routes. Particular attention will be given to the relationship between waste characteristics and their suitability for specific circular economy solutions. The findings highlight that the assessment of waste quality should be treated as a fundamental stage of sustainable product design and resource management, enabling more efficient valorisation of textile waste streams and supporting the transition toward a circular textile industry.

Keywords: 5R principle, textile waste, denim waste, waste quality, circular economy, nonwoven materials, cellulose recovery, sustainable design.

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DIGITAL ECOHYDROLOGY AS A BASIS FOR ADAPTIVE MANAGEMENT OF AQUATIC ECOSYSTEMS

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The current stage of development of ecological science and water management practice necessitates a transition from descriptive, discrete monitoring, which creates a “stroboscopic effect”, to continuous, predictive, and adaptive management of aquatic ecosystems. This study aims to provide a theoretical foundation for digital ecohydrology, develop a data-fusion-based methodology for integrated continuous monitoring, model a dynamic digital passport of a water body, and integrate nature-based biomeliorative technologies into a unified management system. The methods included systems analysis, Earth observation, instrumental IoT monitoring, multilevel ecological verification, and qualitative assessment of ecological processes without cumbersome mathematical models.

The study proposes a transition to a continuous data-driven management paradigm. Digital ecohydrology is defined as an interdisciplinary field of ecological science that investigates the functioning, evolution, self-purification, and resilience of aquatic ecosystems by creating dynamic information models based on integrated streams of continuous heterogeneous data. Its methodological framework comprises continuity, integration, adaptability, predictability, and the ecosystem-based approach. The developed integrated monitoring architecture combines satellite observation of higher aquatic vegetation and phytoplankton using the NDVI and NDCI spectral indices, instrumental measurements from autonomous IoT stations, and field bioindication studies. The platform centres on a dynamic digital passport of a water body that accumulates morphometric, hydrological, hydrochemical, and biological indicators and provides a basis for assessing integrated ecological characteristics and automatically linking nature-based technologies from the author’s patent portfolio. The proposed concept provides a theoretical and methodological basis for regional platforms for adaptive water resources management, eutrophication forecasting, and the prevention of ecological crises in Ukraine’s inland-water basins.

Keywords: adaptive management, biomelioration, data fusion, digital ecohydrology, dynamic digital passport of a water body, integrated monitoring, remote sensing.

This work was supported by a Grant of Swedish Institute 00237/2025 “Development of sustainable technologies for water and wastewater treatment using biosorbents” (Sweden).

INVENTORY MANAGEMENT CHALLENGES IN AQUACULTURE: A LIFE CYCLE ASSESSMENT PERSPECTIVE

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Inventory management in aquaculture involves live biomass continuously consuming feed, energy, oxygen, and water, presenting unique operational and sustainability challenges compared to traditional manufacturing. Inefficiencies like overstocking, harvest delays, mortality, and incorrect demand forecasting lead to higher production costs, resource waste, and environmental impacts.

This conceptual and literature-based study explores how inventory inefficiencies affect performance and sustainability at different life cycle stages, identifying key bottlenecks in feed utilization, biomass handling, storage, and supply chain coordination. Results show that inventory inefficiencies create an invisible environmental and economic burden overlooked in traditional assessments.

Overstocking, feed spoiling, and late harvesting result in excessive resource use, nutrient emissions, and operational losses. The study emphasizes incorporating inventory management into life cycle approaches to improve operational efficiency, minimize waste, and reinforce sustainable and quality-oriented aquaculture management.

Keywords: aquaculture, inventory management, life cycle perspective, quality management, sustainability, supply chain management

THE RELATIONSHIP BETWEEN SUSTAINABILITY PERFORMANCE DISCLOSED IN ESG REPORTS AND THE ECONOMIC PERFORMANCE OF FOOD AND BEVERAGE COMPANIES

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The food and beverage industry faces increasing pressure to improve sustainability while maintaining competitiveness. Consumers, investors, and regulators increasingly assess companies based on environmental, social, and governance (ESG) performance, creating a need to understand whether sustainability is associated with economic success. This study investigates the relationship between ESG performance and the financial performance of food and beverage companies.

Data are collected from publicly available ESG and sustainability reports of selected companies. Sustainability indicators, including renewable energy use, water conservation, waste management, recycling, sustainable sourcing, and carbon emission reduction, are identified and classified into a standardized evaluation framework. A multi-criteria decision-making (MCDM) approach is applied to evaluate sustainability performance and establish ESG-based company rankings.

The resulting ESG scores are compared with financial indicators such as revenue, revenue growth, and profitability. Correlation analysis is conducted to examine the association between sustainability performance and economic outcomes. The proposed framework enables a systematic assessment of ESG practices and their potential contribution to corporate performance.

The study contributes to understanding sustainability-driven competitiveness in the food and beverage sector by integrating ESG evaluation and financial analysis within a unified decision-support framework.

Keywords: ESG, food and beverage industry, MCDM, corporate performance, revenue growth, sustainability performance, sustainable business

QUALITY IN MUSIC: BETWEEN SOUND, ART AND MAN

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In the era of globalization and relentless technological development, modern society and the cultural market are undergoing profound structural transformations that significantly alter the ways in which works of art are perceived, experienced, and evaluated. The musical sphere is by no means an exception to these dynamics. The status and enduring presence of a musical work within the contemporary cultural landscape are no longer determined solely by its autonomous artistic value or aesthetic merit. Instead, the emergence, recognition, and persistence of a musical piece in collective consciousness are increasingly shaped by multifaceted economic, technological, and socio-cultural mechanisms. In the reality of the global village, the traditional boundaries separating pure aesthetic creation from commercial market circulation have become increasingly permeable, requiring novel, interdisciplinary analytical tools to comprehend the complex interplay between artistic autonomy and commercial imperatives.

To systematically address how musical works function within this interconnected global landscape - and to elucidate the precise role that intrinsic artistic value plays relative to distribution channels, market positioning, and promotional strategies in achieving sustainable success - this study reinterprets the musical work through the conceptual lens of an artistic product and its holistic quality. The presentation introduces an innovative theoretical framework: the artistic product quality model, constructed by integrating the commodity science simplex quality concept with the network perspective of cultural goods. By synthesizing multidimensional quality evaluation with socio-economic network relations, this approach bridges the gap between musicological aesthetics and economic analysis. It offers a structured methodology for assessing how acoustic material, artistic intentionality, human perception, and market realities converge, thereby shedding new light on the multidimensional nature of quality in contemporary music.

Keywords: artistic product, cultural economics, music theory, network approach, simplex quality model

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POSTER PRESENTATIONS



**SESSION 1. CIRCULAR ECONOMY AND WASTE
MANAGEMENT**

SESSION 2. CONSUMER BEHAVIOR AND PREFERENCES

**SESSION 3. DESIGN, QUALITY AND SAFETY OF FOOD
AND NON-FOOD PRODUCTS**

**SESSION 4. INNOVATIVE PRODUCTS, MATERIALS
AND TECHNOLOGIES**

SESSION 5. PRODUCT AND PROCESS MANAGEMENT

**SESSION 6. SUSTAINABLE PRODUCTION AND
CONSUMPTION**

DEVELOPMENT, OPTIMIZATION AND BIOACTIVE CHARACTERIZATION OF CHOKEBERRY POMACE BIOFERMENTS FOR SUSTAINABLE FRUIT WASTE PROCESSING

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The increasing generation of agro-food processing by-products highlights the need for sustainable strategies enabling their effective management and valorization. Fruit pomaces are particularly promising substrates due to their high content of phenolic compounds and other biologically active constituents, which may be recovered or transformed into value-added products through biotechnological processes. In this context, biofermentation represents a promising approach for the bioconversion of fruit processing residues and the development of bioactive materials with commercial potential.

The aim of this study was to develop and characterize bioferments obtained from chokeberry pomace. The fermentation process was performed using *Levilactobacillus brevis* Inv 021 strain under four different conditions: without enzymatic pretreatment, with pectinase, with hemicellulase, and with a combination enzymes. The obtained bioferments were subjected to microbial quality and bioactive characterization based on total phenolic content (TPC), antioxidant activity (TEAC), and antimicrobial activity against selected indicator microorganisms.

All tested bioferments demonstrated a high content of phenolic compounds and pronounced antioxidant activity, confirming the preservation and/or bioconversion of bioactive constituents during the fermentation process. Moreover, the bioferments exhibited inhibitory activity against selected microorganisms associated with the human skin, indicating their potential protective and functional properties. Differences observed between the technological variants suggest that enzymatic pretreatment may influence the efficiency of bioactive compound release and consequently modulate the bioactive profile of the resulting bioferments.

The obtained results demonstrate that chokeberry pomace can be effectively transformed through lactic fermentation into bioactive bioferments with enhanced functional value. The study highlights biofermentation as a promising biotechnological strategy for the valorization of fruit processing by-products and provides a basis for the further development of chokeberry pomace-derived bioferments as sustainable, value-added ingredients for potential application in accordance with the principles of circular economy and sustainable waste management.

Keywords: waste management, lactic acid fermentation, chokeberry pomace, biological activity

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ENVIRONMENTAL IMPLICATIONS OF NANOWASTE: SOURCES, REGULATORY ASPECTS AND MANAGEMENT STRATEGIES

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Nanomanufacturing is defined as an economically viable production of materials, structures, systems and devices with a size not exceeding 100 nm. Nowadays, nano-derived technological innovations are implemented in various industries, such as medicine, pharmaceuticals, cosmetics, the food industry, electronics, the automotive industry and many others. This has led to the creation of a new class of waste described as “nanowaste”. Regardless of its origin, it is assumed that the nanoparticles it contains, due to their small size, can easily enter the environment, thus impacting ecosystems. For this reason, special emphasis is placed on both environmental and human health risk assessment of nanomaterials. Currently, four methods are proposed for deactivating nanowaste streams: incineration, landfill disposal, recycling, and wastewater treatment. It should be noted, however, that literature indicates a lack of sufficient legal regulations regarding the management of nanowaste. Within the European Union, the most important documents applicable in this regard include the Basel Convention, the Waste Framework Directive (2008/98/EC), the REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) Regulation, and the CLP (Classification, Labeling, and Packaging) Regulation, but none of them directly address nanomaterials or do so only to a limited extent.

The aim of the study was to review the implications of nanowaste. The investigation addresses issues related to the legal regulations, sources of nanowaste, nanomaterials in the environment, risk assessment and nanowaste management. The research involved a comprehensive review of both domestic and foreign literature using academic databases such as Scopus and Google Scholar.

Keywords: nanowaste, nanotechnology, sustainability

EVALUATION OF SELECTED QUALITY PARAMETERS IN WINE FERMENTED FROM CHOKEBERRY BY-PRODUCT

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Nowadays, evolving consumer preferences for novel beverages and the urgent need to reduce food waste in agri-food industry including utilizing agricultural residues offers a promising avenue for creating innovative, value-added products. Among the countless wine products available on the market, consumers are still inclined to look for unconventional and surprising products. Therefore, study aimed to determine the possibility of using the by-product generated after sorting biodynamic chokeberries to ferment wine with various starter cultures of microorganisms. Fermentation was conducted using spontaneous microbiota alongside specific yeast strains, including *Kluyveromyces marxianus* KD2, *Metschnikowia pulcherrima* AP 008, and a commercial *Saccharomyces cerevisiae*. Microbiological safety and bioactivity — specifically polyphenol profile, total phenolic content and antioxidant activity — were evaluated on various stages of fermentation process. All wine variants met safety standards, exhibiting an absence of *Escherichia coli*, acetic acid bacteria, and filamentous fungi. The *K. marxianus* KD2 wine had the highest abundance of yeast count comparing to all the wine variants at the stage of proper fermentation as well as the greatest polyphenol concentration and antioxidant capacity in the final product. Nevertheless, the other wine variants, were also characterized by the high biological activity. The polyphenol content in tested samples varied depending on both starter microorganism used for the wine fermentation and the stage of the process.

Overall, the use of chokeberry sorting by-product, as a material for wine fermentation proved to be an excellent high bioactive and health-promoting raw material source for innovative beverage production which fits into the concept of a circular economy.

Keywords: biological activity, by-products, circular economy, chokeberry, microbiological quality, sorting waste, waste management, wine

LEGITIMATING UPCYCLED FOOD IN A HALAL MARKET: CERTIFICATION, TRACEABILITY AND CATEGORY EMERGENCE IN MALAYSIA

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Upcycled foods valorise food-grade side-streams and by-products by converting them into products intended for human consumption. Although prior research has extensively examined consumer acceptance, less is known about how institutional actors make this emerging category intelligible, certifiable and commercially accessible in Muslim-majority markets. Malaysia provides an analytically revealing setting because food constitutes a major share of its municipal waste stream, while halal certification, although legally voluntary in most domestic market contexts, remains commercially consequential for access to mainstream Muslim consumer segments.

Drawing on category legitimation theory and institutional logics, this study examines how producers, regulators, innovation intermediaries and trade actors classify upcycled food and negotiate the potentially competing and complementary demands of circularity, halal-tayyib, food safety and commercial viability. Halal status, provenance and environmental performance are treated as credence attributes requiring credible verification, while sensory quality remains primarily an experience attribute.

The exploratory qualitative study combines regulatory and documentary analysis, a structured market scan conducted at two international food fairs, and five semi-structured expert interviews with key informants representing regulatory, trade, innovation-ecosystem and entrepreneurial perspectives. The European Union is used as an institutional benchmark rather than as an equivalent comparative case.

Preliminary findings indicate that a central challenge is classification ambiguity. The terms “waste”, “by-product” and “side-stream” appear to activate different judgments concerning product quality, safety and religious permissibility. Actors address this ambiguity through linguistic reframing and supply-chain traceability. Halal certification appears to operate as a commercially consequential, de facto mechanism of legitimacy rather than as a universal legal prerequisite. The study proposes an initial framework of authority-mediated category legitimation and develops propositions for further investigation in halal-market and ASEAN contexts.

Keywords: food safety, category legitimation theory, upcycled foods

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LOW IMPACT DEVELOPMENT (LID) FOR RUNOFF WATER CONTROL IN AIRPORT AREAS

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Airport areas are highly impervious catchments where runways, taxiways, aprons, service roads, car parks, and maintenance zones generate substantial volumes of runoff. Its quantity and quality depend on airport layout, traffic intensity, pavement type, rainfall–snowmelt dynamics and seasonal maintenance. This runoff may contain a complex mixture of contaminants, including de-icing and anti-icing agents, metals, polycyclic aromatic hydrocarbons (PAHs), benzotriazoles (BT), per- and polyfluoroalkyl substances (PFAS) suspended solids, nutrients, and surfactants. It is therefore a complex matrix requiring chemical monitoring, ecotoxicological assessment and site-specific risk evaluation.

Conventional airport drainage is designed to remove water rapidly from operational surfaces to maintain pavement safety and air-sized functionality. However, rapid conveyance may increase peak flows, reduce infiltration, and transfer pollutant loads to receiving water. Low Impact Development (LID) offers a source-control framework for managing runoff close to where it is generated. Its objective is to maintain or restore, as far as technically feasible and compatible with airport safety requirements, the pre-development hydrological balance through decentralized stormwater control measures.

In airport environments, LID-based solutions may include bioretention systems, vegetated swales, infiltration trenches, permeable pavements in selected non-critical zones and hybrid treatment trains combining retention–detention, filtration, sorption-based polishing or carefully designed constructed wetlands. These systems can reduce runoff volume and peak discharge, enhance sedimentation and filtration, promote sorption and biodegradation, and support groundwater recharge where hydrogeological conditions are suitable and contaminant migration is controlled. Their use must be adapted to winter maintenance, groundwater vulnerability, soil permeability, wildlife-strike risk, emerging contaminants, and climate-change-driven rainfall extremes. Thus, LID should be treated not as a single technology, but as a flexible planning and design framework for sustainable airport drainage.

Keywords: airport runoff, Low Impact Development (LID), sustainable airport infrastructure, sustainable airport stormwater management, water quality management

EXPLORING THE POTENTIAL OF WATERMELON SEED BY-PRODUCTS: LIPID FRACTION AND ANTIOXIDANT PROPERTIES

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Global interest in the valorization of food processing by-products has increased in recent years due to the growing demand for sustainable and value-added raw materials. Watermelon seeds, often treated as waste, may constitute a promising source of bioactive and nutritionally valuable compounds. The aim of the study was to characterize the lipid fraction of watermelon seeds in terms of total lipid content and fatty acid profile, and to evaluate the antioxidant properties of watermelon seeds.

The study involved six samples of watermelon (*Citrullus lanatus*) seeds obtained from the *Crimson Sweet* cultivar. Total lipids were determined gravimetrically using petroleum ether in Randall extraction. Fatty acid methyl esters (FAME) were obtained by simultaneous lipid extraction with hexane and *in situ* derivatization using sodium methoxide. The FAME profile was determined by GC-FID, and the results were expressed as percentages of total fatty acids. Antioxidant properties of watermelon seeds was evaluated *in vitro* after extraction with 80% ethanol. Total phenolic content was determined using the Folin–Ciocalteu method. Antioxidant activity was assessed using the DPPH radical scavenging assay, while reducing power was determined spectrophotometrically at 700 nm.

Watermelon seeds contained from 21.3% to 26.4% crude fat on a dry weight basis. Four major fatty acids were identified, with unsaturated fatty acids predominating, particularly linoleic and oleic acids. Their combined content ranged from 81.4% to 83.6% across all samples. Saturated fatty acids were represented by palmitic and stearic acids. Total phenolic content ranged from 23.1 to 41.6 mg/g dry weight of ethanolic extract. Radical scavenging activity and reducing power increased with increasing extract concentration. Watermelon seeds demonstrate significant potential as a valuable by-product, and understanding their properties is essential for the design of sustainable products with high nutritional value and functional quality.

Keywords: antioxidant properties, by-products valorization, fatty acids, food quality, sustainable food systems, sustainable consumption, sustainable production, watermelon seeds

The research was financed by the Poznan University of Economics and Business as part of a subsidy received from the Ministry of Science and Higher Education.

ESSENTIAL OILS IN FOOT CARE PRODUCTS USED BY POLISH CONSUMERS AS AN INDICATOR OF PRODUCT QUALITY

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Body care products enriched with ingredients of plant origin, showing the desired effect due to the specific properties of the natural substances they contain, are currently enjoying increasing popularity. The study aimed to analyse foot care products available on the Polish market in terms of the content of natural essential oils and their effects as ingredients the presence of which may be an indicator of product quality. The survey research shows that foot care products enriched with oils are applied by consumers most commonly in the form of creams, lotions, and deodorants, mainly in connection with fungal infections, hyperhidrosis, and inflammations. In addition, they are thought to be more effective in comparison with their counterparts that do not contain oils. In the overall range of foot care products available on the Polish market, those with essential oils account for about 20% and come in various forms, with *Melaleuca alternifolia* oil being the one most commonly included in their composition. Due to the presence of the aforementioned plant-based ingredients, these preparations are characterised by antimicrobial, refreshing, nourishing, regenerating, irritation-soothing, smoothing, deodorising, stimulating, and relaxing properties. In the context of the concepts of quality attributed to the different phases of the product life cycle, in the case of foot care products enriched with essential oils it is possible to point to their high design, marketing, utilitarian and environmental quality. Therefore, the presence of natural plant-based essential oils in these types of care products can be considered an indicator of good product quality. The analysis presented serves as a valuable source of insights not only for consumers but also for beauty product manufacturers, especially by supporting the creation of more eco-friendly products and technologies, which aligns with the increasing emphasis on sustainable care.

Keywords: essential oils, foot care products, product quality, survey

DETERMINANTS OF CONSUMER ACCEPTANCE OF BIODEGRADABLE BEVERAGE PACKAGING

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Biodegradable beverage packaging may represent one possible approach to reducing the negative environmental impact of single-use packaging. Its wider adoption, however, depends not only on declared environmental benefits, but also on whether consumers perceive such solutions as functional, trustworthy and economically acceptable.

The aim of the study was to identify the factors shaping consumer acceptance of biodegradable beverage packaging. Particular attention was paid to price, functional packaging attributes, trust in manufacturers' claims, understanding of environmental labels, and requirements related to post-use packaging management. The study was conducted using an online survey among 119 respondents.

Based on the results, it was found that the acceptance of biodegradable packaging is conditional. Respondents positively assessed the potential environmental benefits of such solutions; however, price, ease of opening and closing, and packaging durability were more important in purchasing decisions. Informational factors also proved relevant, particularly the clarity of labels and trust in information provided by manufacturers. The main barriers to acceptance were associated with higher price, limited availability, established purchasing habits and the additional effort required to manage packaging waste after use.

The findings support the conclusion that the environmental character of packaging alone is not a sufficient condition for making a purchase decision. Biodegradable beverage packaging may gain broader consumer acceptance when environmental benefits are combined with convenience, durability, credible information and simple post-use handling instructions.

Keywords: biodegradable packaging, beverage packaging, consumer acceptance, purchasing decisions, consumer trust, environmental labelling

CONSUMER-DERIVED DESIGN REQUIREMENTS AND TRADE-OFFS IN SUSTAINABLE FERMENTED DAIRY PACKAGING

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This study examines consumer-derived requirements and design trade-offs associated with sustainable packaging for fermented dairy products. The empirical material comprised two focus group interviews involving sixteen participants, written elicitation tasks and evaluations of ten commercially available packaging solutions. The data were analysed qualitatively, with attention to the transition from general sustainability expectations to the assessment of actual packaging formats.

The findings show that consumers did not define sustainable packaging through a single material, environmental claim or certification. Instead, acceptance depended on a combination of information clarity, product quality, credible environmental attributes, functionality, affordability and limited consumer effort. Clear product identification, legible information, an accessible expiry date and understandable ingredients functioned as basic acceptance requirements. Environmental attributes such as recyclability, reduced plastic use, reuse potential, local production and certification became meaningful when these fundamental conditions were satisfied. The comparison of packaging solutions revealed recurring trade-offs between reuse and weight, convenience and environmental concern, minimalism and product recognition, technical recyclability and sorting effort, and local or organic production and affordability. The study proposes a consumer-derived framework in which acceptable sustainable packaging results from a credible and usable balance between environmental responsibility, product quality, functionality and market accessibility.

Keywords: sustainable packaging, fermented dairy products, consumer requirements, packaging design, recyclability, focus groups, design trade-offs

SUSTAINABLE COFFEE CONSUMPTION: CONSUMER BEHAVIOUR AND EMERGING TRENDS

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Coffee is an important part of everyday consumption and one of the most popular beverages worldwide. Changing lifestyles, growing consumer awareness and increasing interest in responsible purchasing are creating new challenges for the coffee market and encouraging a shift towards more sustainable consumption patterns. The aim of this study was to identify current coffee consumption and purchasing behaviours and to assess emerging trends that may contribute to the development of more sustainable consumer choices. Particular attention was paid to coffee preferences, frequency of consumption, purchasing practices, brewing methods and selected factors influencing consumer decisions. The empirical study was conducted in Poland in 2025 among 615 adult coffee consumers aged 18–65 using a computer-assisted web interview (CAWI). Quantitative data were analysed to identify the dominant patterns of coffee consumption and differences in consumer behaviour.

The findings indicate that whole bean coffee is the preferred type of coffee among respondents, while daily consumption is a well-established habit, with many consumers drinking coffee once or several times per day. Consumer choices are also shaped by purchasing and preparation practices, indicating the coexistence of traditional habits and emerging market trends. The results provide insight into contemporary coffee consumption patterns and highlight the importance of consumer behaviour in the transition towards more sustainable consumption. Understanding these patterns may support coffee producers, retailers and other market stakeholders in developing strategies that combine changing consumer expectations with sustainability objectives.

Keywords: consumer behaviour, consumer preferences, emerging trends, sustainable coffee consumption

DIFFERENCES IN SPICE USAGE AMONG CONSUMERS PREFERRING SELECTED WORLD CUISINES

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The traditional association of spices with specific cuisines does not always reflect the actual behaviour of modern consumers. The widespread availability of spices from various geographic origins, the globalization, and the growing interest in ethnic cuisines are contributing to changes in how spices are used. For this reason, it seems interesting to compare traditional associations of spices with specific cuisines with consumers' behaviours.

The purpose of the study was to identify the spices most frequently used by respondents and to assess the extent to which they are associated with their preferred types of cuisine.

Among the purposeful selected respondents, those who used a wide variety of spices were in the majority. The most frequently prepared dishes were those of Polish cuisine (81% of responses), Italian (68%); the respondents prepared Indian (11%), Japanese (11.3%) dishes the least often. The cluster analysis conducted using Ward's method identified four clusters characterizing the types of cuisine selected by the respondents. Cluster 1 combines Polish, traditional, and regional cuisines with Italian cuisine. Cluster 2 consists of distant, exotic, and distinctive cuisines, such as Indian and Japanese. Cluster 3 comprises cuisines from various parts of the world- Asian, Mexican, and Greek and 4 is a combination of French and vegetarian cuisines.

The Mann-Whitney U test was used to assess the frequency with which specific spices are associated with different types of cuisine. E.g. enthusiasts of Asian cuisine are more likely to use basil, curry, garlic, capers, soy sauce, and wasabi, while they are less likely to use allspice.

The tendency to experiment in the kitchen was also assessed based on preferred cuisine.

The results indicate that spices play a significant role in how consumers identify and distinguish between different cuisines. The sometimes surprising use of spices may result from individual sensory preferences, independent of their traditional uses; the blending of elements from different culinary traditions (fusion cuisine); and the adaptation of dishes to local conditions- such as substituting hard-to-find ingredients or selecting them according to personal preferences.

Keywords: consumer behaviour, cuisine, frequency of consumption, spices

SEGMENTATION OF FUNCTIONAL FOOD CONSUMERS BASED ON THEIR ATTITUDES TOWARDS FOOD

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Changing consumption patterns and growing health awareness are reshaping consumer behaviour in the food market and increasing interest in foods that combine nutritional value with additional health-promoting benefits. Functional foods respond to these expectations and are becoming increasingly relevant in the context of health prevention, sustainability and product innovation. Understanding consumer attitudes towards this food category is therefore important for market segmentation and the development of products and communication strategies tailored to specific consumer groups.

The aim of the study was to identify groups of consumers based on their attitudes towards food and to describe the demographic characteristics of each group. A diagnostic survey was conducted among 539 consumers who declared purchasing and consuming functional foods. Data were collected using a web-based questionnaire (CAWI).

Cluster analysis identified four consumer segments differing in their attitudes towards functional food: "health-conscious consumers", "novelty enthusiastic consumers", "green consumers", and "sport enthusiastic consumers". The findings may support product management activities, including the development of innovative functional foods, targeted marketing strategies and decision-making related to the further development of the functional food market.

Keywords: segmentation, consumer, functional food, consumer perception, personalisation

CONSUMER OPINIONS ON SORBETS WITH KUMQUAT

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The global market for functional and health-oriented foods has experienced significant growth over the past decade, driven by increased consumer awareness regarding the health benefits of natural ingredients and functional foods. Fruit sorbets have gained popularity due to their inherent nutritional value, refreshing qualities, sensory appeal, and perception as healthier alternatives to conventional dairy-based desserts. Kumquat, a small citrus fruit native to Asia, has garnered scientific and commercial interest due to its composition, including flavonoids, essential oils, and vitamin C. Taking into account the excellent sensory, health-promoting and physicochemical properties of kumquats and citrus fruits, a survey was conducted on attitudes towards sorbets containing these fruits. The study aimed to fill the knowledge gap regarding consumer attitudes towards fruit sorbets containing kumquats, provide valuable information on their market potential, and identify key characteristics influencing consumer decisions in this growing segment. The study aspiration was also to support the development of innovative, health-promoting fruit desserts that meet contemporary consumer demands, contributing to greater acceptance and market penetration of kumquat products. The survey was conducted among 995 people living in different regions of Poland. This is a representative sample of the country's inhabitants in terms of numbers. A random sample was selected, but the survey questionnaire was addressed only to people who declared eating ice cream.

Respondents were surveyed regarding their openness to new food products—based on the Food Neophobia Scale—and their potential willingness to buy and consume sorbets with kumquats. Respondents were asked about their opinions and behaviors regarding ice cream and sorbets, including new, unfamiliar flavors, liking of selected citrus fruits, including kumquat. All data was analyzed for demographic variables such as: gender, age, number of people in the household, income, education and place of residence.

The survey results, indicate that consumers are open to new food products, but their attitudes depend on selected sociodemographic data. 75% of respondents liked sorbets or liked them very much; differences in sorbets' taste preferences were found between men and women. The most popular fruits were oranges and tangerines, which were liked by 97% and 92% of respondents, respectively. Lemons and limes were also popular and liked by approximately 86% of respondents. These results indicate that Polish consumers enjoy citrus fruits, although there are statistically significant differences in their preference. The most popular sorbets are made from native fruits (strawberries, raspberries for Polish consumers), but also from exotic fruits and citrus fruits. Oranges and tangerines which are sweet and sour fruits with a pleasant aroma were the most preferred. This study provides a basis for designing and introducing new or innovative frozen desserts to the market. Therefore, we recommend developing citrus fruit sorbets with kumquats and subjecting them to quality assessment, including consumer and sensory evaluation

Keywords: citrus fruits, consumer behavior, sorbets; kumquat, functional properties, consumer opinion, survey, PAPI, FNS.

MODELING EDIBLE INSECT FOOD PURCHASES AMONG POLISH GEN Z: A MULTI-MODEL APPROACH

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Eating insects is often presented as a sustainable way to produce protein, but in many European countries, people are still hesitant to include them in their diets. In this study, we looked at how young Polish consumers, especially university students, view insect-based foods.

The aim of this study was to determine:

- (1) Whether health and environmental concerns, attitudes and intentions towards purchasing edible insects and foods containing edible insects are associated with willingness to consume edible insects and foods containing edible insects among young consumers (Generation Z) in Poland?
- (2) How young Polish consumers, especially university students, view insect-based foods?
- (3) Whether Polish students are willing to pay more for foods containing EI when production is environmentally friendly? The analysis focused on identifying socio-demographic and product-related factors influencing willingness to pay a higher price.

An empirical study was carried out in 2023, using a questionnaire with an indirect interview method via an online platform. Data from 947 respondents were analyzed using: chi-square test with Yates' correction, Spearman's rank correlation analysis, polynomial ordered logit model, logistic regression model and exploratory factor analysis (EFA) followed by k-means clustering.

On the basis of surveys conducted among Generation Z in Poland, it can be concluded that the more positive the respondents' attitudes towards health and environmental concerns are, the greater their willingness to consume foods containing edible insects is. Attitudes and intentions towards purchasing foods containing edible insects were positively correlated with willingness to purchase and consume this type of food. We found that young people are not all the same: some are enthusiastic about trying insect products, others are curious but cautious, while many remain skeptical or uninterested. What mattered most about these differences were personal attitudes and perceptions. Students who were less afraid of trying new foods and who cared about the environment were more open to eating insects. In contrast, fear of unfamiliar foods, doubts about safety, and feelings of disgust created strong barriers. Interestingly, factors such as gender, place of residence, or field of study did not make a clear difference. Results revealed that gender and place of residence significantly affected willingness to pay more for foods containing EI, with women and urban residents showing higher readiness. Attributes related to convenience, availability, sensory appeal, health and nutrition claims, and CO₂ reduction benefits were the strongest positive correlates.

The results of our study show that communication among young Polish consumers (students) should focus on building trust, highlighting taste and nutritional value, and providing clear information about safety in order to make insect-based foods more acceptable.

Keywords: entomophagy, novel food, willingness to consume, willingness to pay, sustainable consumption

CONSUMER EXPERIENCE AS AN OBJECT OF CONTEMPORARY COMMODITY SCIENCE RESEARCH

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The transformation of modern markets, increasing competition, and growing consumer demands regarding product quality and functional characteristics necessitate a reconsideration of traditional approaches to commodity science research. At the same time, contemporary commodity science is gradually shifting from classical approaches, which primarily focused on the assessment of consumer properties, safety, quality, and product assortment, toward a comprehensive analysis of consumer value, with Consumer Experience (CX) representing one of its key components.

Consumer Experience (CX) encompasses the cognitive, emotional, behavioral, and practical responses that arise throughout all stages of consumer interaction with a product – from information search and purchase decision-making to actual product use and the evaluation of the extent to which the product meets consumer needs and expectations.

Within contemporary commodity science, the study of consumer experience is of fundamental importance because it provides feedback between manufacturers, market operators, and end consumers. The findings of such research enable the identification of factors influencing product choice, the assessment of consumer satisfaction with product characteristics, the detection of unmet consumer needs, and the substantiation of directions for improving product assortments, enhancing product competitiveness, and increasing consumer value.

The integration of consumer experience research into the methodology of contemporary commodity science enhances the scientific validity of commodity research, promotes a stronger market orientation toward actual consumer needs among manufacturers and other market operators, provides a scientific foundation for the development and market introduction of safe, competitive, and functionally valuable products.

Keywords: assortment, consumer experience, needs and expectations, products, satisfaction

EVALUATION OF CONSUMER ACCEPTANCE OF ICE CREAM ENRICHED WITH INSECT-DERIVED POWDER

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Growing interest in alternative and sustainable protein sources has increased the potential application of edible insects in the production of innovative food products. The aim of this study was to evaluate consumer acceptance of ice cream enriched with 10% insect powder obtained from yellow mealworm (*Tenebrio molitor*) and house cricket (*Acheta domesticus*) in comparison with a control sample. The ice cream matrix consisted of strawberry-flavoured dairy ice cream.

Sensory evaluation was conducted using a consumer-based method with a 5-point hedonic scale. The assessed attributes included structure, texture, colour, taste, aroma, and overall acceptability of the product. Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test ($p < 0.05$). Additionally, the Acceptability Index (AI), Top Box, and Top-2 Box indicators were calculated to determine the practical level of consumer acceptance.

The results demonstrated that the type of insect-based additive significantly influenced the sensory evaluation of the analysed ice cream samples. Statistical analysis revealed significant differences between the examined groups ($F(4,538) = 186.20$; $p < 0.001$), indicating that the type of additive had a significant effect on the sensory quality of the ice cream. The highest level of consumer acceptance was obtained for samples enriched with yellow mealworm powder (4.62 ± 0.26), with ratings comparable to the control sample (4.65 ± 0.41). The lowest level of acceptance was recorded for ice cream containing house cricket powder (3.26 ± 0.33).

Acceptability Index values exceeding 90% were obtained for both the control sample without insect powder and the ice cream enriched with yellow mealworm powder. Furthermore, Top-2 Box values reached up to 100%, indicating a high level of consumer acceptance. The obtained results suggest that an appropriately selected flavour matrix may significantly enhance the sensory acceptance of products enriched with edible insects, while also confirming their promising potential in the development of innovative dairy desserts.

Keywords: edible insects, *Tenebrio molitor*, *Acheta domesticus*, insect powder, consumer acceptance, sensory evaluation, dairy ice cream, sustainable protein

CONSUMER ATTITUDES TOWARD NON-ALCOHOLIC ALTERNATIVES TO ALCOHOLIC BEVERAGES AS A KEY ELEMENT IN DEVELOPING A PRODUCT STRATEGY

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The modern beverage market is subject to constant change in direct response to consumers' evolving expectations, lifestyles and growing health awareness. One of the most striking manifestations of this transformation is the growth of the non-alcoholic beverage category. This consists of beverages that are direct equivalents of traditional alcoholic drinks and are referred to in the literature as 'NoLo' products (no- or low-alcohol beverages). This segment is gradually losing its niche status and becoming a significant and enduring part of the global and domestic retail sector.

The aim of this study was to examine consumer attitudes in Poland towards non-alcoholic alternatives to alcoholic drinks and to identify the factors influencing their consumption.

The study was conducted using a diagnostic survey method via a CAWI (Computer-Assisted Web Interviewing) online questionnaire. The study included 209 adult residents of Poland. The analysis examined the frequency with which NoLo-type and traditional alcoholic beverages were consumed, the level of awareness of specific product categories, and the motivations and barriers associated with consumption. It also examined the influence of selected sociodemographic characteristics on respondents' attitudes.

The survey results showed that non-alcoholic alternatives to alcohol are consumed less frequently than traditional alcoholic drinks, with non-alcoholic beer being the most recognisable and most frequently consumed category. The most frequently cited reason for choosing NoLo-type products was the ability to drive after consuming them, whilst the most commonly stated reason for not consuming these products was the lack of a need to replace traditional alcoholic drinks with their non-alcoholic equivalents. The research also showed that the age of the respondents influenced the frequency of NoLo product consumption; however, no statistically significant correlation was found between the frequency of alcohol consumption and the frequency of consumption of its non-alcoholic equivalents.

Keywords: consumer attitudes, consumer behavior, non-alcoholic alternatives to alcoholic beverages, NoLo beverages, product strategy

POLISH CONSUMERS' PURCHASE INTENTION AND DETERMINANTS FOR FORTIFIED FOODS

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Interest in healthier diets has increased the market relevance of functional (including fortified) foods, but consumer acceptance depends on perceived benefits, sensory quality, safety and purchasing convenience. This study examines purchase behaviour and choice determinants for fortified foods among Polish consumers. The analysis is based on a CAWI survey of 1,003 adults in Poland, with quotas reflecting gender, age and place of residence. The questionnaire covered current purchasing of fortified foods, declared the likelihood of purchasing selected product categories, and the importance of product attributes.

Results show that fortified foods are present in consumer repertoires mainly as occasional purchases: 6% of respondents reported buying them regularly, 46% occasionally, 31% did not buy them, and 17% were unsure. Women declared regular or occasional purchase more often than men.

Purchase likelihood varied by product type. The highest Top2Box scores were recorded for products with added vitamins (63%) and omega-3 fatty acids (62%), followed by products with added collagen (50%). Lower interest was noted for products with added antioxidants (37%) and added proteins other than collagen (43%).

Product choice was driven primarily by sensory, safety and practical attributes. Good taste (80% - Top2Box) and product safety (77%) were the leading determinants, followed by absence of artificial additives (74%), good smell (70%), availability in the usual place of purchase (69%) and price comparable to standard products (68%). Sustainability-related cues, including recyclable or reusable packaging (44%), and organic, ethical or sustainable production certificates (42%), were less influential.

The findings suggest that the market potential of fortified foods in Poland is high, but the acceptance of specific products will depend primarily on sensory appeal, product safety and price parity with non-fortified products.

Keywords: choice determinants, fortified foods, functional foods, Polish consumers, purchase behaviour

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QUALITY AND EFFICIENCY ASSESSMENT OF PALLADIUM(II), PLATINUM(IV) AND GOLD(III) ION RECOVERY FROM AQUEOUS SOLUTIONS USING PHOSPHONIUM DECANOATE

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In recent years, considerable attention has been focused on precious metals (PMs), including palladium, rhodium, gold and platinum, because of their wide range of industrial applications and high economic value. These metals are extensively used as catalysts in organic and chemical processes, as important components of metal alloys and automotive catalytic converters, as well as in jewellery manufacturing and in the chemical, pharmaceutical, petroleum and electronic industries. Due to the continuously increasing demand for precious metals and the limited availability of their natural resources, the recovery of these valuable elements from spent and secondary materials has become an important issue for both economic and environmental reasons.

Ionic liquid-assisted solvent extraction has demonstrated high efficiency and selectivity in the extraction and separation of precious metal ions from chloride solutions. Therefore, this technique can be considered a promising alternative to conventional separation and recovery methods.

The aim of this study was to investigate the ability of trihexyltetradecylphosphonium decanoate to recover and separate Pd(II), Pt(IV) and Au(III) from hydrochloric acid solutions. The obtained results confirmed that the investigated reagent can be successfully applied as an extractant for the removal of these metal ions from chloride media. However, the separation of Pd(II) from Pt(IV) and Au(III) was less effective and strongly depended on the acidity of the aqueous phase.

The extraction affinity of the studied reagent towards noble metal ions changed with hydrochloric acid concentration. At 0.1 M HCl, the extraction ability decreased in the order Au(III) > Pd(II) > Pt(IV), whereas at 3 M HCl the order was Au(III) > Pt(IV) > Pd(II). These results clearly indicate that the acidity of the aqueous phase has a significant influence on extraction selectivity and separation efficiency. Moreover, Pd(II), Pt(IV) and Au(III) can be effectively recovered and separated by stripping from the loaded organic phase. The obtained results confirm the potential of trihexyltetradecylphosphonium decanoate as an effective extractant for the recovery and separation of precious metals from chloride solutions.

Keywords: precious metals, ionic liquids, solvent extraction, separation quality

EFFECT OF ALGINATE MICROENCAPSULATION ON THE PROPERTIES OF COSMETIC FORMULATIONS CONTAINING BEETROOT-WASTE-DERIVED PIGMENTS

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Using plant-processing residues as cosmetic ingredients supports circular product development. Beetroot waste contains pigments that provide colour, but their use is limited by instability and uneven dispersion. This study evaluated the effect of alginate microencapsulation on cosmetic formulations containing beetroot-waste-derived pigments. Beetroot extracts were obtained by ultrasonic extraction using water or aqueous ethanol. They were incorporated into model creams in free form or in sodium-alginate microcapsules prepared by ionic gelation. The formulations were evaluated by UV–Vis spectrophotometry, instrumental colour measurement, rheological tests, transepidermal water loss measurement, corneometry and organoleptic assessment.

The extraction medium and pigment form affected the quality profile of the formulations. The hydroalcoholic extract showed stronger absorption than the aqueous extract in the spectral region associated with betacyanins. The addition of beetroot extracts modified colour and viscosity compared with the base formulation, while creams retained shear-thinning behaviour. Encapsulated pigments were distributed more uniformly than free extracts. Skin measurements and organoleptic assessment showed formulation-dependent differences. The formulation containing microencapsulated hydroalcoholic extract exhibited a favourable combination of colour uniformity and application characteristics. Under the investigated conditions, alginate microencapsulation facilitated the incorporation of beetroot-waste-derived pigments into cosmetic formulations. Extended storage studies are required to confirm long-term colour stability and optimise formulation composition.

Keywords: beetroot waste, colour stability, illuminating cosmetics, microencapsulation, plant pigments, zero waste

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A COMPARATIVE EVALUATION OF COMMERCIALY AVAILABLE GROUND GINGER BASED ON ANTIOXIDANT ACTIVITY, COLOUR AND FT-NIR SPECTRA

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Ginger is a source of many bioactive compounds, including (poly)phenols, which exhibit antioxidant, antimicrobial, anti-inflammatory, and anticancer properties. It is widely used in the food, pharmaceutical and cosmetics industries, as well as in households as a spice.

The aim of the study was to compare different brands of ground ginger available on the Polish market. The analyses were carried out on the four most popular brands, using products from two or three different production batches of each product. The study included the determination of total phenolic content (TPC) and total flavonoid content (TFC), antioxidant activity using the Ferric Reducing Ability of Plasma (FRAP) assay, colour evaluation using tristimulus colorimetry, and spectral analysis using near-infrared (NIR) spectroscopy. The obtained FT-NIR spectra were subjected to Principal Component Analysis (PCA) to identify any similarities and differences between the tested samples.

The results showed that the ginger from the four brands differed significantly in terms of colour and antioxidant activity, expressed as TPC, TFC and FRAP values. PCA of the FT-NIR spectra also revealed both similarities and differences between the samples, including those from different production batches.

Based on the present study and literature data, it can be concluded that ground ginger, available on the Polish market, is a good source of antioxidants, particularly plant phenolic compounds, including flavonoids, comparable to other herbs and spices such as marjoram or basil. The content of phenolic compounds in dried ginger is even higher than in various types of pepper, parsley, or dill.

The study showed that commercially available ground ginger can vary in certain quality parameters; however, it consistently exhibits high antioxidant activity and may offer potential health benefits when consumed regularly.

Keywords: antioxidant activity, colour, ginger, near infrared spectroscopy, spice, quality

ANTIFUNGAL ACTIVITY AND MYCOTOXIN DETOXIFICATION CAPACITY OF SOIL MICROORGANISMS

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Biological contaminants, especially microbiological hazards such as pathogenic bacteria and filamentous fungi, pose a serious food safety problem. The *Fusarium* genus is among the most common phytopathogens inhabiting crops, causing significant yield losses and raw material degradation. These microorganisms synthesise mycotoxins, including trichothecenes and fumonisins, which pose a threat to health and life at high concentrations. In pursuit of sustainable development goals, which include responsible production of consumer goods and food, producers are increasingly seeking more ecological alternatives to standard synthetic plant protection products. Due to reports of the negative impact of chemical pesticides not only on the natural environment and biodiversity but also on the health of humans and animals in direct contact with them, there is growing interest in the use of biological pesticides.

The study aimed to evaluate the fungistatic properties of environmental microorganisms against *Fusarium* sp. Additionally, their potential to degrade deoxynivalenol was examined. The fungistatic properties were tested against seven species of *Fusarium* genus using the poisoned medium technique. The detoxification quality of the examined soil microorganisms was evaluated using HPLC.

The isolated microbiota showed strong, species-dependent fungistatic activity against the tested fungi, with certain strains within the same species displaying notably different levels of growth suppression. Selected bacterial isolates and their consortia inhibited mycelial development by 70-100%. HPLC analysis indicated only limited DON degradation. Overall, the findings highlight the substantial potential of soil microbiota to restrict plant-pathogenic fungi and emphasise the need for continued research to identify effective, safe, and sustainable plant-protection solutions.

Keywords: food safety, mycotoxins, sustainable development, antifungal activity

ANTIFUNGAL PROPERTIES OF METSCHNIKOWIA STRAINS ISOLATED FROM APPLES

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The problem of microbiological hazards in the food chain requires a multifaceted approach, from plant cultivation to food production. In line with the concept of sustainable agricultural production, the use of chemical plant protection products is limited and environmentally friendly solutions are preferred. However, ensuring product safety is crucial. Therefore, there is currently a growing interest in biological methods. A number of studies are focusing on the identification, characterization, and application possibilities of biological plant protection agents. The aim of the presented study was to assess the biological potential of yeasts isolated from fruit surfaces.

Yeasts were isolated from apples obtained from an orchard where no plant protection products were used. Isolation was performed on PDA (Potato Dextrose Agar) and Sabourad Agar with chloramphenicol for 5 to 7 days at 30°C. Selected isolates were passaged onto PDA medium to obtain pure cultures and then propagated in liquid cultures for testing. The fungistatic activity of the isolates was assessed against the fungi *Alternaria alternata*, *A. brassicicola*, *Botrytis cinerea*, and *Sclerotinia sclerotiorum* using the well diffusion method.

A total of 50 yeast isolates were isolated, the morphology of which suggested potential belonging to the genus *Metschnikowia* (including production of a red pigment on solid media). The results of the fungistatic activity assessment indicated strong fungistatic activity of most yeast isolates. The isolates with the strongest activity against the tested fungi were identified using the MALDI-TOF method, confirming that they belong to the species *Metschnikowia pulcherrima*.

Keywords: sustainable agriculture, microbiological quality, biological plant protection, environmentally friendly methods

ANTIFUNGAL COMPOUNDS AS MODULATORS OF ALLERGENICITY IN *ALTERNARIA* SPP.

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Antifungal compounds are widely used in plant protection to limit pathogen development and crop losses. Their effectiveness is primarily assessed based on inhibition of fungal growth and reduction in spore production. Much less is known, however, about how antifungal stress affects spore characteristics, including the levels of proteins contributing to their allergenic potential. This is particularly relevant for fungi of the genus *Alternaria*, whose spores are commonly found in the air and may contribute to allergic symptoms such as rhinitis, conjunctivitis, and lower respiratory tract symptoms. One of the major allergens of *Alternaria* is the protein Alt a 1.

The aim of this study was to determine the effects of selected synthetic fungicides on the growth of *Alternaria alternata*, spore production, and Alt a 1 content. Six *A. alternata* isolates were used, with their identification confirmed by MALDI-TOF MS. The minimum inhibitory concentrations (MICs) of the tested compounds were determined using the broth microdilution method. The effects of sublethal concentrations on colony development on PDA medium and spore production were subsequently assessed. Alt a 1 content in spores was quantified using ELISA.

All tested compounds reduced fungal growth and decreased the number of spores produced. At the same time, some of the tested fungicides increased Alt a 1 content in spores. This indicates that a fungicide may effectively limit fungal development while simultaneously increasing the amount of the major allergen per spore. From a human health perspective, this is particularly relevant, as a reduction in airborne spore concentrations does not necessarily correspond to a proportional reduction in allergen exposure and, under certain conditions, may increase the allergenic potential of individual spores.

The results show that the effectiveness of antifungal compounds should not be assessed solely on the basis of spore numbers. Considering changes in the content of major allergens may be important for a more accurate assessment of actual exposure to airborne allergens and the associated risk of allergic symptoms. The findings also indicate that the consequences of using plant protection products may extend beyond their direct effects on pathogen development and may be relevant to both the environment and human health.

Keywords: airborne fungal allergens, allergic potential, Alt a 1, antifungal compounds, *Alternaria alternata*

ASSESSMENT OF THE EFFECTIVENESS OF REMOVING BIOFILM PRODUCED BY MICROORGANISMS ISOLATED FROM SURFACES IN PUBLIC BUILDINGS

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The formation of biofilm by microorganisms on surfaces is a phenomenon that requires appropriate management through the use of appropriate cleaning and disinfecting agents. While this problem is already well-known in hospitals and food processing industries, public buildings are places where this problem is not well understood. However, knowledge about the types of microorganisms found in such places, their ability to form biofilm, and methods for its removal can significantly improve safety and hygiene in public places. The aim of the study was to determine the potential for biofilm formation by microorganisms isolated from public surfaces and to assess the effectiveness of their removal with common cleaning agents.

In the first stage of the research, microorganisms were isolated from selected surfaces in the shopping mall and identified using the MALDI-TOF method. The biofilm test was conducted in a 48-well plate to which a suspension of standardized cultures of microorganisms was added. After incubation, the degree of biofilm formation was assessed spectrophotometrically using crystal violet staining. To test the effectiveness of detergents in combating the biofilms formed, the plates were flooded with specially prepared detergents before staining.

From the collected samples, microorganisms from the first and second microbiological threat categories (BSL) were isolated and identified. The results showed that the ability to form biofilm depended on the microorganism, and the detergents varied in their effectiveness in removing biofilm.

Keywords: microbiology, biofilm, hygiene, cleanliness, cleaning products

COMPARISON OF THE ANTIOXIDANT PROPERTIES OF FREEZE-DRIED BERRIES BY COUNTRY OF ORIGIN

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Freeze-dried berries are becoming increasingly popular in the consumer market. In recent years, there has been a significant increase in their consumption and an ever-wider range of food products containing them. For raw materials subjected to freeze-drying, quality is of paramount importance, particularly their health-promoting properties. In this study, freeze-dried berries, including raspberries (*Rubus idaeus* L.) and bilberries (*Vaccinium myrtillus* L.), were tested for antioxidant capacity (using the DPPH radical method). The fruits tested were sourced from various regions of Poland, Ukraine, Sweden, and Bulgaria. The study showed that the highest antioxidant capacity was found in raw materials originating from regions of Poland and Ukraine with similar climatic conditions. The results of the study indicate that the main determinant of the antioxidant content in the freeze-dried samples is the climatic conditions prevailing in individual regions of Europe. The most significant parameters determining these properties are optimal sunlight exposure and humidity (soil water saturation index).

Keywords: food quality, freeze-dried products, berries, antioxidant activity, DPPH, climatic conditions

WHEN ALCOHOL LEAVES, DOES FLAVOR FOLLOW? VOLATILE AROMA COMPOUNDS IN NON-ALCOHOLIC BEER

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Consumption of non-alcoholic beers (NABs) has experienced unprecedented growth over the last few years. Among the factors affecting flavor formation, the production method is one of the most critical determinants of NABs. Producers may choose between physical methods based on dealcoholization of a regular alcoholic beer, or biological methods, which modify the fermentation process. However, achieving a balance between low or no alcohol content and desirable flavor remains a major challenge, as the absence of ethanol in NAB reduces perceived sweetness and diminishes overall flavor. Therefore, the aim of a study was to identify the volatile aroma compounds in selected NABs available on a market.

Static headspace extraction together with gas chromatography coupled with flame ionization detector (SHS-GC-FID) was used as a screening method for volatile analysis in NABs. Volatile chemical compounds were tentatively identified using gas chromatography mass spectrometry detection (GC-MS).

Analysis of volatile aroma compounds in commercial samples of NABs identified 19 compounds including ethanol, Strecker aldehydes, esters, higher alcohols, and terpenes, all of which contribute to the overall flavor and aroma profile of the products. Strecker aldehydes, particularly 2-methylbutanal and 3-methylbutanal, play a key role in the characteristic sensory properties of NABs, imparting malty notes and being recognized as major contributors to wort-like off-flavors. The presence of esters, higher alcohols, and hop-derived compounds such as linalool, myrcene, and humulene enhances the beers with fruity, floral, and hoppy characteristics, while their concentration largely depends on the production technology employed.

Keywords: flavor, gas chromatography, NAB, volatile aroma compounds

ASSESSMENT OF SELECTED FUNCTIONAL PROPERTIES OF SKINCARE CREAMS CONTAINING LACTOFERRIN

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The aim of this research was to analyse the functional properties of creams intended for the care of problematic skin containing lactoferrin. Authors presents the characteristics of problematic skin, including the factors responsible for its development and skincare methods, with particular emphasis on cosmetic products in the form of emulsions. The biological properties of diet supplement – lactoferrin as a natural protein with antibacterial, anti-inflammatory, and immunomodulatory effects were thoroughly discussed, as well as its application in cosmetology.

In the practical part, the functional properties of the formulations were evaluated through detailed tests such as stability testing, pH measurement, dynamic viscosity and yield stress analysis, consumer sensory evaluation. The addition of lactoferrin resulted in stable cream prototypes that spread easily over the skin, smoothed it and improved its texture, compared to the sample without this ingredient. The addition of this ingredient to the emulsion reduces viscosity and the yield point, which in practice means a lighter texture for the formulation, in particular, it improves the cosmetic's application properties and allows it to spread more easily over the skin. In summary, based on the research carried out, it can be concluded that lactoferrin has potential as a valuable ingredient in the care of problematic skin.

Keywords: lactoferrin, diet supplements, cosmetics, skincare creams, functional properties, problematic skin

ANALYSIS OF THE BIODEGRADATION PROCESS OF SELECTED DRINKING STRAWS

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The study carried out a qualitative analysis of the biodegradation of straws made of various materials, approved for use in accordance with Directive (EU) 2019/904 of the European Parliament and of the Council (SUP). The research was carried out in an original device developed by the Department of Natural Science and Quality Assurance simulating the conditions in an industrial composting plant. The research material was commercially available straws made of biodegradable plastic (PLA), paper and straw. In biodegradation tests conducted over a period of eight weeks, on a weekly basis, the advancement of the decomposition process was subjected to an organoleptic assessment. A qualitative method was used, enabling the observation of morphological and structural changes in materials over time, commonly used in preliminary studies, where the course of degradation is assessed on the basis of visual changes, supported by photographic documentation and comparative analysis. The obtained results indicate a significant variation in the susceptibility of the studied materials to biodegradation. A much faster process of material destruction was observed in the case of polylactide straws compared to straws made of paper or straw. The analysis showed the dominance of changes in physicochemical parameters in the polymer at the first stage of the process, resulting in its brittleness and rapid fragmentation. In the case of samples made of natural materials and paper, the dominant process was typical biological decomposition with long-term preservation of the integrity of the samples.

Keywords: biodegradation, single-use plastics, compostable materials, industrial composting conditions

EFFECT OF SNAIL SECRETION FILTRATE ON THE PHYSICOCHEMICAL, RHEOLOGICAL AND FUNCTIONAL PROPERTIES OF COSMETIC EMULSIONS

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Natural-origin ingredients are increasingly incorporated into cosmetics and affect emulsion structure, stability and performance. Snail secretion filtrate (SSF) contains compounds associated with skin-conditioning activity and is used as a cosmetic raw material. This study evaluated the effect of SSF on the physicochemical, rheological and functional properties of cosmetic emulsions. Three products were compared: a model oil-in-water emulsion containing SSF, the matching base without SSF and a commercial cream used as a reference. The analyses included organoleptic characteristics, pH, Brookfield viscosity, rheological flow behaviour and mechanical, thermal and light stability. Functional assessment comprised short-term skin hydration measurements and consumer evaluation of application characteristics.

The formulations differed in pH, consistency, apparent viscosity and rheological parameters. The SSF-containing emulsion exhibited non-Newtonian, shear-thinning flow behaviour. Stability tests recorded formulation-dependent changes in appearance and consistency. Short-term skin hydration and consumer assessments also differed among the tested products, particularly in relation to spreadability, absorption and tackiness. Instrumental measurements and sensory ratings were not fully convergent, confirming the importance of complementary methods in cosmetic quality evaluation. Under the investigated conditions, SSF modified the physicochemical and application properties of the model emulsion, while the final quality profile remained dependent on the complete formulation. Extended stability tests and optimisation of SSF concentration are required before broader formulation applications.

Keywords: consumer assessment, cosmetic emulsions, physicochemical properties, rheology, snail secretion filtrate, stability

FOOD SAFETY HAZARD IN NUTS, FRUITS AND BERRIES IMPORTED INTO THE EU: A RASFF-BASED ANALYSIS OF CONTAMINANT PATTERNS (2020-2025) WITH A CASE STUDY OF UKRAINIAN EXPORT

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The growing complexity of international agri-food trade has increased the frequency of border rejections and regulatory non-compliance in plant-based products entering the European Union. Despite the extensive use of the Rapid Alert System for Food and Feed (RASFF), limited empirical evidence is available on how notification patterns reflect structural vulnerabilities in exporting countries and food safety compliance systems. This study systematically analyzed 3,464 RASFF notifications related to nuts, nut products and seeds and 5,023 notifications concerning fruits and berries recorded between 2020 and 2025, including a focused case study of Ukrainian exports. Notifications were classified according to product category, notification type, hazard category, and administrative non-compliance. Particular attention was given to border rejections, contaminant profiles, labeling deficiencies, and documentation inconsistencies.

The results demonstrated that border rejections were primarily associated with pesticide residues, mycotoxins, pathogenic microorganisms, and failures in official certification and accompanying documentation. Pesticide residues represented the dominant hazard category in fruit and berry products, whereas mycotoxins accounted for the majority of notifications concerning nuts. Labeling deficiencies, undeclared allergens, missing health certificates, and inconsistencies in official documents constituted a substantial proportion of administrative non-compliance, representing approximately 20–35% of notifications. The case study of Ukrainian exports identified recurring problems related to pesticide residues, mold contamination, heavy metals, foreign bodies, post-harvest handling, and discrepancies between accompanying documentation and product batches. Although contaminant-related hazards remain a major reason for border rejections, the findings indicate that administrative deficiencies are equally important barriers to market access. The findings support the implementation of strengthened pre-export controls, enhanced monitoring of contaminants, improved labeling and certification practices, exporter training, and digital traceability tools to increase compliance with EU food safety legislation.

Keywords: food safety, imports, labeling, notification, Rapid Alert System for Food and Feed (RASFF)

COLOUR OF RAW, GROUND RED MEAT CONTAINING *NIGELLA SATIVA* EXTRACT; THE RELATIONSHIP TO LIPID/PROTEIN OXIDATIVE CHANGES DURING STORAGE

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The colour of red meat is the most important sensory indicator that consumers use to assess the freshness of the product. The aim of the study was to investigate the effect of 0.5% m/m *Nigella sativa* (NS) extract added to minced beef on lipid, protein, myoglobin oxidation and colour changes during storage at 4°C.

The diene concentration (CD), thiobarbituric acid reagent substances (TBARS), hexanal, thiol content (SH), and the contribution of oxymyoglobin (OxyMb), deoxymyoglobin (DeoMb) and metmyoglobin (MetMb) forms were analyzed on the 0, 3, 5, 7, 10 and 12 day of storage and related to colour parameters, namely L*, a*, b*, C, h, redness index (RI) and Mb content. The pH values of meat were also monitored.

The significant effects of time and treatment were observed for all tested parameters excluding lightness with only time effect significant. Based on the Principle component analysis (PCA) using a scree plot and eigenvalue criterion the two PCs were extracted which explained 83.4% of total variance. Using loaded values, showing the correlations between components and variables, it could be stated that the PC1 was mostly related to colour parameters L*, a*, C, h, RI, myoglobin forms: DeoMb, OxyMb, MetMb, Mb denaturation and autooxidation as well as pH values. The PC1 was given the name meat colour and pigment oxidation. The PC2 was related with the lipid and protein oxidative stability and was described by CD, TBARS, hexanal, SH, Mb content and b* values. The plot for scores located onto the factor plane described by PC1 and PC2 separated the NS samples with high Mb content, SH, DeoMb, pH and h values from the control with high CD, TBARS, hexanal and redness.

Multivariate adaptive regression splines (MARS) were used to build regression models to describe oxidation of beef using CD, TBARS, hexanal, SH and MetMb as dependent variables and colour parameters as L*, a*, b*, C, h, RI and Mb content as independent variables. MARS models created for the data matrix included a maximum of 21 basis functions, the penalty was set to 2 and the threshold to 0.0005. The MARS models of first order were obtained having from 2 to 7 basis functions and 3 to 8 terms with adjusted R² from 0.26 for hexanal to 0.98 for TBARS values.

Concluding, based on simple colour measurements it is possible to model the values of lipid and protein oxidative stability of beef.

Keywords: beef, *Nigella sativa*, oxidative stability, colour, regression models

THE IMPACT OF INULIN ADDITION ON THE QUALITY PROPERTIES OF FRUIT SORBETS

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Inulin is a popular prebiotic that is often used in the production of ice cream, mainly to improve its consistency. It also reduces the hardness of ice cream, as well as improving the ice cream's organoleptic characteristics. Inulin can also improve the texture of sorbets, which are gaining popularity as an alternative to milk-based ice cream. Sorbets can be an excellent source of natural vitamins and antioxidants. The aim of this study was to evaluate the effect of the addition of inulin on the sensory characteristics and health-promoting value of avocado, kiwi, honey melon, yellow melon and mango sorbets. Three types of sorbets were made—two with inulin (2% and 5% wt.) and the other without—using fresh fruit with the addition of water, sucrose and lemon juice.

The odor of the avocado sorbets was not significantly different to the cantaloupe sorbets. The addition of inulin did not influence significantly on the taste of sorbets. The best rated was the mango sorbet with the addition of inulin, and the consistency of this sorbet was rated the highest. The amount of water that was added into the sorbet mixtures influenced the sensory evaluation, as well as the melting resistance of the sorbets. Inulin addition did not influence the color estimation. Regarding the overall preference, the sorbets of mango, kiwi, honeydew melon, and cantaloupe melon were statistically equal, although the mango and kiwifruit sorbets were evaluated with the highest points estimation. The addition of inulin generally improved all the features that were estimated in the organoleptic assessment but the amount of inulin (both 2 and 5% wt.) did not statistically affect the organoleptic features of the sorbets from the given fruit. The melting resistance of the tested sorbets ranged from 11.46 to 38.41%, and the addition of inulin influenced this parameter, depending on the type of fruit and the amount of the additive. The addition of 5% of inulin influenced the meltability of all the sorbets. The highest melting resistance values were obtained by the kiwifruit sorbets, as well as the melon sorbets. Inulin addition decreased the melting resistance of the sorbets. The overrun of sorbets was influenced by the composition of the mixture. In the tested sorbets, the overrun ranged from 12.33 to 19.67%, which was influenced by both the type of fruit and the inulin addition. The total polyphenols in the sorbets ranged from 4.83 to 10.97 (mg GAE/g product), depending on the type of sorbet. The highest number of total polyphenols was estimated in the avocado sorbets, and the lowest in the honeydew melon sorbets. The DPPH assay showed the highest antioxidative activity in the kiwifruit and mango sorbets, while the lowest antioxidative activity was assessed in the sorbet with the lowest content of total polyphenols (honeydew melon). The largest amount of vitamin C was determined in the kiwifruit and mango sorbets, and the lowest in the melon sorbets. The inulin sorbets contained lower amounts of vitamin C, total polyphenols and oxidative activity. The determination of titratable acidity showed that the acidity of all the sorbets was in the range of 2.2–4.5°SH; the kiwifruit sorbet showed the highest acidity, and the addition of inulin increased or decreased this parameter, depending on the fruit.

Keywords: antioxidative activity, inulin, polyphenols, sorbet, tropical fruit

BULGARIAN SEA SALT FLEUR DE SEL: ORIGIN, COMPOSITION, OPPORTUNITIES FOR PROMOTION AND APPLICATION IN CULINARY TOURISM

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This study explores the natural Bulgarian sea salt Fleur de Sell, or “Flower of Salt”, its origin, composition and cultural significance. The research analyses current perspectives and practical opportunities for promoting the natural sea salt in both local and global contexts. A mixed-method approach combining literature review, experimental results of research on sea salt were analysed and finally comparative case studies from selected countries was used. Successful practices for safeguarding and marketing are presented. The findings highlight the origin, composition, cultural significance, promotion and application of the sea salt Fleur de Sel. The study concludes with practical recommendations for supporting and promoting natural Bulgarian sea salt Fleur de Sell, or “Flower of Salt” through sustainable development programs and its application in culinary tourism.

Keywords: natural Bulgarian sea salt Fleur de Sell, culinary tourism, sustainable development, regional branding, tangible cultural heritage, regenerative tourism

SPECTROSCOPY-BASED MONITORING OF NATURAL COSMETIC PRODUCTS DURING STORAGE

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Cosmetic creams and oils are among the most widely used skincare products. Owing to their antioxidant, antibacterial, soothing, and occlusive properties, oils derived from exotic plants, such as almond, argan, tamanu, macadamia, and marula, have attracted considerable interest in the cosmetics industry. Historically, these oils have been used as natural ingredients in cleansing and beautifying rituals across the cultures of the Middle East and the Far East. With the growing popularity of natural cosmetics free from synthetic stabilizers and preservatives, ensuring product quality and monitoring changes that may occur during storage after opening have become increasingly important. Product quality may be affected by several factors, including exposure to light, elevated temperature, atmospheric oxygen, microbiological contamination during use, and the type of packaging material.

The aim of this study was to evaluate the quality of exotic plant oils and creams containing these oils during storage under typical consumer-use conditions using UV-VIS-NIR spectroscopic methods. Commercially available exotic plant oils and creams enriched with these oils were stored for three months under conditions simulating normal consumer use. The products were applied three times per week, kept at room temperature, and exposed to light, atmospheric oxygen, and potential microbiological contamination associated with routine handling. NIR spectra were recorded, and lipid oxidation was monitored by UV spectroscopy at 233 nm at four time points throughout the storage period. Principal component analysis (PCA) of the NIR spectral data revealed the effects of storage time, product formulation, and oil incorporation on the tested creams after 1, 2, and 3 months of storage. Partial least squares (PLS) regression was applied to model the relationship between the NIR spectra and the selected quality parameter, namely the level of lipid oxidation. A moderate to strong correlation was obtained ($R^2 = 0.86$). The results indicate that UV-VIS-NIR spectroscopy can serve as a simple, rapid, and non-destructive tool for monitoring the quality and stability of cosmetic products during storage.

Keywords: cosmetic product quality, consumer-use storage conditions, NIR spectroscopy, lipid oxidation, exotic plant oils

HAZARDS RELATED TO THE SAFETY OF RICE AVAILABLE ON THE COMMON MARKET OF THE EUROPEAN UNION

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Despite relatively low per capita rice consumption in the European Union (EU), averaging approximately 9 kg annually between 2010 and 2023, imports from Asian countries have shown a sustained upward trend since 2013. This study assessed hazards associated with rice available on the EU market. Data were obtained from Faostat, Eurostat, the Rapid Alert System for Food and Feed (RASFF), and the Web of Science. Pivot tables and a two-way joining cluster analysis were applied to examine temporal and geographical patterns in reported notifications. Notifications primarily concerned genetically modified rice (32%), pesticide residues (21%), and mycotoxins (17%). During 2006–2014, notifications mainly related to unauthorized genetic modifications in rice originating from China and the United States, whereas between 2017 and 2023, they predominantly involved excessive pesticide residues and mycotoxin contamination in rice from India and Pakistan. Most hazards were classified as border rejections (37%), reflecting the effectiveness and vigilance of EU food safety authorities. While rice is generally considered low risk for European consumers, rising cultural integration and the growing popularity of Asian cuisine may increase consumption in the future. Continuous monitoring, rigorous risk assessment, and collaboration with exporting countries are therefore essential to maintain high food safety standards and ensure consumer protection across the EU market.

Keywords: import, food safety, pesticides, mycotoxins, heavy metals, hazard analysis

FOOD FRAUD AS A FOOD SAFETY RISK FACTOR: CURRENT EUROPEAN UNION APPROACHES AND A CONCEPTUAL MODEL FOR UKRAINE

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Within modern food safety systems, economically motivated adulteration (food fraud) is no longer regarded solely as a form of economic deception but also as a significant risk factor that may affect consumer health, product traceability, and the effectiveness of official food control. This has led the European Union to shift from responding to individual fraud incidents toward the systematic assessment of vulnerabilities across food supply chains.

The aim of this study is to analyse current food fraud trends based on data from the Alert and Cooperation Network (ACN, 2025) and to develop a conceptual approach for assessing food safety risks associated with food fraud. Analysis of the ACN Annual Report 2025 revealed that the network recorded 10,490 notifications during the year, representing an 11% increase compared with the previous reporting period. This trend reflects not only a higher number of detected non-compliances but also improved efficiency of risk-based official controls and enhanced cross-border information exchange among competent authorities.

Based on a synthesis of European experience, a conceptual framework for food fraud risk assessment is proposed. The framework integrates four key dimensions: the economic attractiveness of a product for fraudulent practices, supply chain vulnerability, the complexity of laboratory verification of authenticity, and the potential impact on food safety. The proposed approach is adapted to the needs of risk-based official control and incorporates economic, technological, and food safety factors throughout the entire food supply chain. For Ukraine, the issue is particularly relevant due to the absence of an integrated food fraud monitoring system. Furthermore, the full-scale war has increased the vulnerability of food supply chains through disruptions in logistics, shortages of certain raw materials, and changes in supply patterns, thereby increasing potential food safety risks. The proposed approach can therefore serve as a practical basis for risk-based planning of official food control, laboratory monitoring, and evidence-based decision-making in the field of food safety.

Keywords: Alert and Cooperation Network (ACN); food fraud; food safety; risk assessment; supply chain vulnerability

QUALITY ASSESSMENT OF CORN EXTRUDATES ENRICHED WITH A PLANT PROTEIN BLEND

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The growing demand for high-protein and plant-based foods has increased interest in the use of alternative protein ingredients in cereal products. The aim of the study was to assess selected quality characteristics of corn extrudates enriched with a commercial plant protein blend and to determine the effect of increasing levels of the additive on the properties of the obtained products. Corn grits were used as the basic raw material, while the enriching ingredient was an organic plant protein blend composed of pumpkin protein (50%), brown rice protein (30%) and hemp protein (20%). Four product variants were prepared: a control without the protein additive and extrudates containing 5%, 10% and 15% of the plant protein blend.

The raw material mixtures were conditioned before extrusion and processed using a single-screw extruder under controlled technological conditions. The obtained extrudates were evaluated with respect to selected quality parameters relevant to expanded cereal snacks, including product appearance, expansion, texture and selected physicochemical properties. The assessment focused particularly on changes associated with the increasing proportion of plant proteins in the formulation. The results indicated that the level of the plant protein blend differentiated the quality characteristics of the extrudates and should therefore be considered an important formulation factor in the development of protein-enriched expanded products. The use of a multicomponent blend based on pumpkin, brown rice and hemp proteins may represent a promising approach to increasing the nutritional potential of cereal snacks while maintaining technological feasibility. The study provides a basis for further optimisation of product formulation and extrusion conditions in the development of innovative plant-based snack products.

Keywords: corn extrudates, extrusion, plant proteins, quality, snack products

SODIUM IN ELIMINATION BREADS: IMPLICATIONS FOR PUBLIC HEALTH NUTRITION

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Sodium (Na) is a critical nutrient in every day diet, particularly due to its widespread presence in staple foods such as bread. The excessive intake of Na is associated with increased risk of hypertension and cardiovascular diseases, making the reduction of sodium levels a major public health priority. The study evaluates sodium content in gluten-free, dairy-free, egg-free, and low-protein (PKU) breads in comparison with conventional breads. A total of 73 breads available on the Polish market were analyzed using microwave plasma-atomic emission spectrometry prior the microwave mineralization.

The results demonstrate that, although elimination breads generally contain lower levels of essential minerals such as calcium, iron, magnesium, and potassium, they also exhibit reduced sodium content compared to conventional breads. Sodium levels in elimination products ranged from 561 to 611 mg/100 g, whereas conventional breads reached approximately 716 mg/100 g. Despite this difference, sodium intake from elimination breads remains substantial, covering around 30% of the recommended maximum daily intake (2000 mg/day) from one (100 g) portion. Taking into account that bread consumption in Europe can reach 100–270 g/day, total sodium intake from such products alone may exceed 800–1900 mg/day. Therefore, even moderate differences in sodium concentration have meaningful public health implications.

Reformulation strategies should then prioritize sodium reduction to improve the overall nutritional quality of elimination diets, particularly for individuals adhering to them long-term. These results are particularly relevant for dietitians, clinicians, and food producers involved in managing elimination diets and developing nutritionally balanced “free-from” products.

Keywords: bread, food safety, food quality, gluten-free, mineral, sodium

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CHOCOLATE AS A MOOD MODULATOR: ROLE OF BIOACTIVE COMPOUNDS AND SENSORY PROPERTIES

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The evidence suggests that chocolate can have a positive effect on mood have been linked to its bioactive components, such as theobromine, caffeine, phenylethylamine, tryptophan, anandamide and its flavanol compounds. It's sensory analysis also indicates its overall palatability and consumer preference. The study aims to understand chocolate as a method to manipulate mood via its effect on neural pathways through bioactive components and neurotransmitters such as tryptophan. Relevant literature for this review was collected from PubMed, Scopus, and Web of Science, emphasizing original research and latest review articles.

The findings were synthesized qualitatively to identify principal themes and trends in the field. The correlation between chocolate and mood was analysed based on the presented results from data based on clinical trials.

Numerous research indicates that chocolate, especially dark chocolate, may improve mood. Although chocolate's mood-boosting benefits are fleeting, including it in a balanced diet may improve general wellbeing. Several limitations include studies that have small sample sizes and short durations, not reflecting the true long-term effects of chocolate consumption. The placebo effect and individual differences in taste preferences can also influence the outcomes of these studies. Also, the high sugar and fat content of many chocolate products may counteract potential mood benefits if consumed in excess. Elements like the sensory palatability of chocolate and attentive intake, as well as the presence of flavonoids and methylxanthines, are likely responsible for this impact. The studies show that chocolate holds the potential to be a carrier for functional ingredients and is also a functional food by itself. To completely understand the long-term impacts of chocolate on mood, more studies with bigger sample numbers and longer time frames are necessary.

Keywords: chocolate, functional food, mood, sensory analysis

FUNCTIONAL PROPERTIES OF AMAZAKE: A REVIEW OF ITS PREBIOTIC AND ANTIOXIDANT POTENTIAL

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Amazake is a fermented food product with significant amount of antioxidant and pre-biotic potential. Its composition also offers a quick and nutrient-rich energy source, enhanced by bioactive substances with antioxidant qualities. The research aimed to gain an understanding of technical and functional properties of Amazake through its relationship with pre-biotics and antioxidants which are released during the fermentation process. For the narrative literature review relevant studies were identified through searches of electronic databases including PubMed, Scopus, and Web of Science with particular emphasis on original research articles and recent review papers. Keywords used in the search included amazake, health benefits, and chemical composition. The selected literature was analyzed and synthesized qualitatively to identify key themes and research trends.

Several existing studies were examined for the valuable effects of Amazake and its functional benefits. Due to its fermentation process, Amazake has several functional benefits. In the enzymatic activities of *Aspergillus Oryzae*, complex macromolecules are hydrolysed. Starch is broken down into (primarily) glucose, a sustainable source of energy, and the proteins into amino acids and peptides. Amazake can also be attributed to improved gut health due to the presence of pre-biotics in the form of oligosaccharides. Results show there may be potential for antioxidant activity due to the formation of bioactive compounds during fermentation. These include Ferulic acid, Vitamin E, some forms of vitamin B and citric acid.

When taken as a whole, numerous qualities make Amazake an appealing functional ingredient for use in food systems that promote health. This effect can be used by researchers to incorporate Amazake into day-to-day food products as a functional food product.

Keywords: Amazake, functional food, prebiotic

QUALITY AND COUNTERFEITING OF PERFUMERY PRODUCTS

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The development of economic relations and the globalization of markets pose new challenges to trade in consumer goods. Protecting the market interests of consumers in a given market requires strict control and clarification of the quality criteria of the particular good. Perfumery goods have specific consumer properties. The formation of their basic consumer properties such as the nature and strength of the aroma, the durability of the aroma in hours is directly related to the type and quality of the raw materials used and the aging period. This creates prerequisites for offering a diverse assortment of perfumery goods with the absence of precise indicators for its identification and falsification possibilities.

The factors influencing the quality of perfumery products and the potential forms of their falsification—regarding assortment, quality, and value—are outlined. Issues leading to the misidentification and falsification of these products are examined. A methodology for investigating and detecting the various types of potential falsification of perfumery products is presented. Addressing the challenges associated with identifying and detecting potential counterfeits requires: developing standards or other regulatory documents specifying quality requirements for this product category; incorporating labeling information regarding composition, the type of fragrance formulation, and batch traceability; developing product certification systems for quality assurance.

Keywords: counterfeiting, identification, perfume products, quality

TOWARDS PREDICTIVE BIOFILM RISK ASSESSMENT: SCREENING ENVIRONMENTAL FACTORS AFFECTING *LISTERIA MONOCYTOGENES* BIOFILM

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Biofilm formation by *Listeria monocytogenes* poses one of the most significant challenges to food safety. This pathogen's ability to persistently colonize processing surfaces increases the risk of secondary contamination and limits the effectiveness of standard cleaning and disinfection procedures. Therefore, identifying the environmental factors that determine biofilm growth is a key element in improving preventive measures and developing tools to support microbial risk management in the food industry.

The aim of the study was to conduct a pilot identification of environmental factors influencing biofilm formation by *L. monocytogenes* using the Design of Experiments (DoE) methodology. The study constitutes the first stage of a project aimed at developing a predictive model to assess the risk of biofilm formation depending on environmental conditions.

The Plackett–Burman screening design was used to plan the experiments, allowing for the simultaneous evaluation of the effects of multiple variables with a limited number of experiments. Eight environmental factors were analyzed: incubation time, temperature, sodium chloride concentration, glucose content, protein presence, pH, initial inoculum density, and BHI medium dilution ratio. All variables were tested at two levels in accordance with the experimental design. Biofilm biomass was determined using the crystal violet staining method and then assessed spectrophotometrically based on absorbance measured at a wavelength of 550 nm. The obtained results were subjected to statistical analysis to identify variables that significantly influence biofilm formation intensity.

The use of the Plackett–Burman design enabled effective screening of the analyzed factors and the selection of variables for further stages of the study. The results obtained form the basis for developing a predictive model describing the relationship between environmental conditions and the risk of biofilm formation by *L. monocytogenes*. In the long term, this model may support decision-making regarding the design and optimization of production processes and measures to prevent biofilm formation, thereby contributing to increased food safety and more effective management of microbiological risk.

Keywords: biofilm, Design of Experiments, food safety, food safety management, *Listeria monocytogenes*, Plackett–Burman design, predictive modeling, risk management, screening design

THE UNIVERSAL INDICATORS OF BACTERIAL SURVIVABILITY FOR MONITORING MICROBIOLOGICAL CONTAMINATION OF TEXTILES

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Textiles are an important material used as personal protective equipment (PPE) and other garment, not only in the hospital environment but also in the industrial area, during the production of food or cosmetics. Fabrics have a close contact with human skin and therefore, they are the great source of pathogens, where bacteria may survive, causing cross-contamination of products and the production environment.

The main objective of this study was to determine the survivability of three bacteria strains on four different textiles (cotton, polyester and their blend) using microbiological culture method. The strain gram-negative bacteria *P. aeruginosa*, regardless of the kind of the fabric exhibited the greatest survivability, which was detected in large quantities until the end of the experiment, both in extracts taken from textiles and from textiles after extraction. Moreover, *Pseudomonas aeruginosa* turned out to be the best indicator for use in survival experiments, where too intensive growth or no growth was observed, hence not detectable on media. Survival microorganisms in viable state on textile are at least four weeks and can be prolonged in optimal condition. Compared to this bacterium, the gram-positive bacteria, *Staphylococcus aureus* and *Bacillus cereus* survived on the fabrics in smaller numbers, especially in the subsequent weeks of this experiment.

Keywords: textiles, surviving bacteria on textiles, indicator, monitoring of contamination

ASSESSMENT OF THE MICRO- AND MACROELEMENTS CONTENT IN INNOVATIVE PROTEIN BARS CONTAINING THREE TYPES OF BEANS

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Functional, health-promoting, and convenient foods have recently been in high demand among, among others, athletes and those who prioritize physical fitness, and they are also recommended for older adults. Such foods include high-protein bars that increase protein intake in the diet.

Beans (white, red, or black)—whether in the form of cooked beans, flour, or concentrate—are a good source of plant-based protein. Additionally, they are a source of fiber, B vitamins, and minerals. The objective of this study was to evaluate the content of micro- and macronutrients in proprietary bars containing three types of beans: *Vigna angularis*—adzuki, *Vigna radiata*—mung, and *Phaseolus vulgaris*—red kidney). The study was conducted on high-protein bars produced according to our own recipe. The type of bean was the main distinguishing feature of the three products tested (200 g per product), while the quantities of the other ingredients in the recipe remained constant.

The mineral content of the bars was determined using an Agilent MP-AES spectrometer following wet mineralization of the samples (with 65% HNO₃). The mineral content varied among the individual samples. The bars containing red beans had the highest potassium content (611.07 mg/100 g) and also the highest levels of iron (3.5 mg/100 g), magnesium (80.90 mg/100 g), manganese (1.17 mg/100 g), and calcium (60.86 mg/100 g). In contrast, the bars with mung beans had the highest sodium content at 116.973 mg/100 g. A high-protein bar is one in which 20 % of the energy comes from protein. The estimated protein content in individual portions of the bars was similar. The bar containing mung beans provides the highest percentage of energy from protein – 14,1%. The bar containing Red Kidney beans provides 13.6 %, whilst the bar containing Adzuki beans is estimated to provide the lowest percentage of energy from protein – 12,8%. According to Regulation (EC) No 1924/2006, these bars cannot be marketed as high-protein.

Keywords: convenient foods, functional foods, macro I microelements, protein bars

DESIGNING FOR EVERYONE: AN EVALUATION OF BOTTLE CAPS THROUGH UNIVERSAL DESIGN PRINCIPLES

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Universal design provides a framework for developing everyday products that can be used by people with diverse ages, abilities, and preferences, while improving accessibility, usability, safety, and user satisfaction. The seven principles of universal design—including equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and appropriate size and space for use—provide a valuable basis for evaluating the usability of packaging components.

This article explores the application of universal design principles to everyday products through the example of bottle caps and closures. Drawing on current trends in bottle-cap development, the study examines how emerging closure solutions address accessibility, ergonomics, safety, sustainability, convenience, and independent use. Particular attention is given to tethered caps, ergonomic and larger-grip closures, child-resistant designs, tamper-evident systems, re-closure mechanisms, smart caps, and closures designed for users with limited hand strength or dexterity. The market trends highlights the development of one-handed, low-force mechanisms caps, as well as tactile and information-enhancing features that support broader user needs. The article evaluates these developments against universal design principles to identify opportunities and limitations in current bottle-cap design. The analysis demonstrates that bottle caps, although small and often overlooked, can significantly influence the accessibility, safety, convenience, and environmental performance of everyday products. Applying universal design from the early stages of packaging development can therefore support more inclusive, intuitive, and sustainable solutions that enable a wider range of users to interact with products safely and independently.

Keywords: accessibility, bottle caps, closures, ergonomics, everyday products, sustainable packaging, universal design, usability.

RAPID QUALITY EVALUATION OF COMMERCIAL COCONUT WATER USING NEAR INFRARED SPECTROSCOPY AND MULTIVARIATE ANALYSIS

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Near infrared (NIR) spectroscopy has emerged as a valuable tool for sustainable food systems due to its rapid, non-destructive, and reagent-free nature. This technique enables the real-time assessment of food quality and composition while reducing environmental impact compared with conventional analytical methods. Coconut water has become an increasingly popular beverage because of its hydrating properties, nutritional value and potential health benefits including anti-inflammatory and antioxidant effects.

The aim of the study was to assess the selected quality parameters of commercially available coconut waters using NIR spectroscopy and multivariate analysis. The beverages, produced by different manufacturers, originated from the Philippines, Sri Lanka, Thailand, and Vietnam. According to the manufacturers' declarations, some products were labelled as organic, some were produced from green young coconuts, and others from young coconuts. For some products, coconut maturity was not specified. NIR spectra were measured in transmittance mode using Fourier transform spectrophotometer. The total soluble solids (TSS), dry matter (DM), and turbidity (T) were determined using standard laboratory methods.

The coconut waters analysed exhibited considerable differences in their physicochemical properties. Partial least squares (PLS) regression was used to predict quality parameters based on NIR spectra. Different pre-processing methods were tested to optimize the models. Models with high performance were obtained for TSS and DM, whereas the model for turbidity demonstrated moderate predictive ability. The results indicate that NIR spectroscopy combined with multivariate analysis is a promising tool for the simultaneous assessment of multiple quality parameters in commercial coconut water, enabling efficient quality control.

Keywords: coconut water, NIR spectroscopy, non-destructive analysis, partial least squares regression

CLOUDING PHENOMENA IN AQUEOUS SOLUTIONS OF NONIONIC SURFACTANTS

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Surface active agents (surfactants) are chemical structures consisting of two main parts: a polar head group and a nonpolar hydrophobic chain called as the surfactant's tail. One of the most important parameters characterizing a practical suitability of nonionic surfactants in aqueous solutions is the cloud point (CP) or cloud temperature. This is the temperature (or more precisely, the narrow range of temperatures) above which the solubility of a given nonionic surfactant in water decreases rapidly resulting in turbidity of the product. Therefore, the knowledge of the cloud point of any nonionic surfactant is required to design a composition of new domestic detergents, shampoos, and cosmetic products of high quality in which a given surfactant can be used as an active ingredient.

In this work we report results of our study on the relationship between the cloud point value in aqueous solutions of various nonionic surfactants containing polyoxyethylene or polyoxypropylene moiety and their molecular structure. Here, we propose a novel set of 10 group contributions that can be applied for calculation the cloud point of the nonionic surfactants in aqueous solutions. Using them, the CP values in aqueous solutions for 553 nonionic surfactants with polyoxyethylene or polyoxypropylene groups were calculated and the estimated values obtained in this way were compared with experimental values. We have shown that the newly developed set of numerical values structural group contributions of the surfactants allows correct estimation of the CP values for various types of nonionic surfactants with polyoxyethylene or polyoxypropylene groups in aqueous solutions with the mean square error of 4.7°C. Moreover, we have also derived the empirical equation for 32 aqueous solutions of normal poloxamers as well as reversed poloxamers which can correctly predict CP values with the means square error of 4.5°C.

Keywords: cloud point, nonionic surfactants, poloxamers, reversed poloxamers

SENSORY ANALYSIS AND STATISTICAL TOOLS FOR FINDING THE RELATIONSHIP OF SENSORY FEATURES WITH THE BOTANICAL ORIGIN OF HONEYS

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Sensory characteristics are important attributes for differentiating varietal honeys and may provide complementary information for assessing botanical origin. The aim of this study was to determine the relationship between sensory features and the botanical origin of Polish honeys and to evaluate the potential of statistical methods for their classification.

A total of 84 fresh honey samples representing eight varieties — acacia, phacelia, buckwheat, linden, dandelion, rapeseed, honeydew-needle and heather — collected from beekeepers throughout Poland in 2020–2024 were evaluated by a trained ten-member sensory panel. Taste, aroma, color, turbidity and smoothness were assessed using a five-point intensity scale. Descriptive statistics and the Kruskal–Wallis test were used to identify differences among honey varieties, while canonical discriminant analysis was applied to determine the discriminatory power of sensory descriptors and construct a classification model.

Statistically significant differences among varieties were found for all seven descriptors included in the classification model ($p < 0.05$). Distinctive sensory profiles were identified for the investigated botanical types. Buckwheat honey exhibited the highest variety-specific taste and aroma scores, phacelia honey showed the highest sweetness score, and heather honey had the highest overall taste intensity. Buckwheat and honeydew-needle honeys were characterized by dark color, whereas rapeseed honey was the lightest and acacia honey showed the highest transparency. Canonical discriminant analysis confirmed a highly significant discriminatory effect of the sensory variables (Wilks' $\lambda = 0.0001$; $F = 5.724$; $p < 0.05$), and the classification matrix yielded 100% correct classification of the tested varieties.

The results demonstrate that sensory analysis combined with multivariate statistical methods can effectively differentiate Polish varietal honeys according to their botanical origin. The proposed discriminant model may support sensory-based classification and botanical authenticity assessment of honey, although further validation using larger and more diverse datasets is required.

Keywords: authenticity of honey, botanical origin, discriminant analysis, honey varieties, sensory analysis

ANALYSIS OF THE QUALITY OF SHAMPOOS WITH THE ADDITION OF SELECTED PLANT EXTRACTS

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The aim of the study was to analyze the antioxidant properties of selected vegetable extracts and the functional and physicochemical characteristics of shampoos containing them. The study included both testing the vegetable extracts themselves and analyzing the performance of shampoos containing them.

As part of the study, the antioxidant capacity of carrot, parsley, and beetroot extracts was determined using a spectrophotometric method. Shampoos enriched with selected vegetable extracts were then prepared and their functional and physicochemical properties were assessed. A beneficial effect of vegetable extracts on the foaming properties of the tested shampoos was demonstrated. The addition of extracts also allowed for achieving the appropriate pH, density, and dynamic viscosity of the shampoos. Furthermore, a correlation was observed between density and viscosity. Shampoos with higher density (products containing parsley and beetroot) were also characterized by higher viscosity. When examining skin hydration levels and the rate of water loss after washing with the tested shampoos, varying but satisfactory results were obtained, depending on the extract used. Sensory testing results also showed that cosmetic shampoos containing vegetable extracts were largely rated positively by users, and the addition of natural ingredients positively influenced the overall acceptance of the tested products.

The tests performed and the results obtained demonstrated a positive impact of the addition of vegetable extracts on the functional and physicochemical properties of shampoos and confirmed their potential use as active ingredients in cosmetics.

Keywords: shampoos, plant extracts, properties, product quality

SUSTAINABLE UV PROTECTION: EVALUATING THE FUNCTIONAL PERFORMANCE, SENSORY ATTRIBUTES AND CONSUMER ACCEPTANCE OF RENEWABLE-BASED SUNSCREEN EMULSIONS

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The cosmetic industry is shifting towards "Green Beauty" by seeking renewable alternatives to synthetic UV filters. However, natural ingredients often face challenges regarding their aesthetic appeal and skin-feel.

This study aims to evaluate the functional performance and consumer sensory perception of sunscreen emulsions formulated with renewable-based functional materials. Formulations were tested for their photoprotective efficacy (in vitro SPF) and physical stability. A sensory panel of 20 participants evaluated the emulsions based on spreadability, stickiness, absorption rate, and overall skin-feel using a 5-point Hedonic scale. The results demonstrated that renewable-based filters not only provided competitive SPF values but also significantly improved the caring properties of the emulsions. While some natural ingredients affected the initial color, overall consumer acceptance remained high, with 70% of participants preferring the bio-based formula over synthetic benchmarks due to its non-greasy after-feel.

Integrating renewable functional materials into sunscreens is a viable strategy to meet both regulatory safety standards and the increasing consumer demand for sustainable, high-quality cosmetic products.

Keywords: sustainable cosmetics, sunscreen emulsions, quality, sensory profiling, consumer acceptance, Sun Protection Factor (SPF), renewable UV filters

APPLICATION OF STRAWBERRY SEED OIL AS A SEASONALLY SOURCED PLANT-DERIVED INGREDIENT IN BALM-TO-OIL COSMETIC FORMULATIONS

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The aim of this study was to evaluate the potential of strawberry seed oil as a seasonally sourced, plant-derived ingredient in balm-to-oil cosmetic formulations and to assess the physicochemical, functional, and application properties of the developed products. Balm-to-oil formulations represent an innovative category of cosmetic products that transform from semi-solid balms into lightweight oils upon contact with the skin. They provide a pleasant application experience while forming a protective lipid film that may help reduce transepidermal water loss. Strawberry seed oil is a valuable plant-derived raw material rich in unsaturated fatty acids and naturally occurring antioxidant compounds, making it a promising ingredient for modern skincare formulations.

As part of the study, formulations containing different concentrations of strawberry seed oil were prepared and evaluated in terms of physical stability, rheological properties, antioxidant activity, oxidative stability, and storage stability under various conditions. In addition, colour changes, thermal properties associated with the balm-to-oil transformation, and the effects of the formulations on skin hydration and transepidermal water loss (TEWL) were assessed. A sensory evaluation of the developed formulations was also conducted.

The study demonstrated that the incorporation of strawberry seed oil had a beneficial effect on the functional performance and overall quality of the developed cosmetic formulations. The formulations exhibited satisfactory stability, favourable application properties, and high consumer acceptance in the sensory evaluation. Furthermore, the use of strawberry seed oil contributed positively to the functional characteristics and skincare potential of the balm-to-oil products.

The results confirmed the suitability of seasonally sourced, plant-derived ingredients for the development of innovative cosmetic formulations and highlighted the potential of strawberry seed oil as a valuable ingredient in skincare products.

Keywords: antioxidant properties, balm-to-oil, cosmetic formulations, seasonally sourced plant-derived ingredients, strawberry seed oil

THE INFLUENCE OF IRON NANOOXIDE ON SELECTED PROPERTIES OF PACKAGING MATERIAL OBTAINED FROM POLY(LACTIC ACID)

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This study evaluates the impact of iron oxide nanoparticles (Fe_3O_4) and thermal crystallization on poly(lactic acid) (PLA) films for food packaging, specifically cottage cheese preservation. Four types of films (PLA, crystallized PLA, PLA+ Fe_3O_4 , crystallized PLA+ Fe_3O_4) were prepared via solvent casting and analyzed for their physical, mechanical, barrier, and antimicrobial properties.

Film thickness varied between 31 and 115 μm due to manual casting constraints and was unaffected by the nanofiller.

Pure PLA was transparent, but crystallization and Fe_3O_4 significantly altered its appearance. Crystallized PLA+ Fe_3O_4 reached the highest total color difference and the lowest light transmittance, meaning nanofiller-modified films would require artificial tinting for commercial use. Light transmittance increased with wavelength across all samples.

Amorphous PLA showed the highest tensile strength (60.98 MPa). Paradoxically, both thermal crystallization and the 3% Fe_3O_4 addition reduced tensile strength, contradicting typical literature data. This anomaly is likely due to the incorporated Fe_3O_4 particles being larger than specified by the manufacturer.

Thermal crystallization significantly enhanced barrier performance, reducing both oxygen and water vapor permeability. Conversely, adding Fe_3O_4 nanoparticles slightly decreased oxygen barriers and had no significant impact on water vapor transmission, likely due to low nanoparticle content in the polymer matrix.

Due to structural stiffness, final food tests utilized PLA films cast directly onto parchment paper. Microbiological indentation cultures on packaged cottage cheese stored at 8°C demonstrated that the PLA+ Fe_3O_4 composite effectively inhibited microbial growth, extending cheese freshness up to 7 days compared to pure PLA. By day 10, both groups showed visible sensory signs of spoilage.

Induced crystallization improves oxygen and water vapor barriers but reduces light transmission and mechanical strength. Although the Fe_3O_4 nano-additive compromised tensile strength and transparency, it provided crucial antimicrobial activity that successfully extended food shelf life.

Keywords: PLA, iron oxide, nanocomposite, barrier properties, shelf life

BIOPOLYMER-BASED COATINGS FOR 3D-PRINTED ARTICLES

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The research is devoted to the development and comprehensive commodity science estimation of biopolymer paint and coatings based on polylactide (PLA) for the protective and decorative painting of different materials, including 3D-printed articles, from the standpoint of environmental friendliness and sustainable development.

Global trends stimulate the transition of the paint and coatings industry to a circular economy using renewable raw materials. Therefore, we used the following bio-based renewable materials: binder and film-former - biopolymer polylactide (PLA), plasticizer — polyethylene glycol (PEG-400), mineral fillers — Ukrainian kaolins (KNF-86, KNF-90 grades) and chalk (KNN grade), wollastonite, grinded marble, bio-based cellulose fibers Technocel 500 and carbonized coffee grounds. Hydrophobic treatment of used fillers with optimal modifiers was carried out to ensure effective compatibility with the biopolymer and film-former in the coatings.

It has been established that PLA is the most suitable film-former for the development of coatings for 3D-printed articles. Using of PEG-400 significantly increases the elasticity of the coatings, while carbonized coffee grounds extend the photoaging time and the service life of the coatings. Rational ranges of 5–10 wt.% plasticizer and 20–40 wt.% fillers provide an optimal combination of elasticity and abrasion resistance.

Basic and final formulations of biopolymer paint and coatings with a bio-based carbon content in the range of 88–95% have been developed. The final coatings are characterized by adhesion of 0 points (ensured by the mechanism of cohesive bonding on the surface of PLA-based articles), weather resistance of up to 23 h of accelerated UV aging, and high stability of other performance properties. The developed compositions possess high bio-based content, since biopolymers are used as film-formers along with mineral and bio-based fillers. This ensures the production of paints and coatings that comply with the principles of the circular economy, contribute to environmental safety and the sustainable development of the paint and varnish industry.

Keywords: 3D-printed articles, adhesion, bio-based fillers, biopolymer coatings, circular economy, environmental friendliness, mineral fillers, paint and coatings, plasticizer, polylactide (PLA), weather resistance

DEVELOPMENT OF COSMETIC OIL FORMULATIONS USING SUSTAINABLE RAW MATERIALS

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Development of cosmetic formulations based on sustainable raw materials is a major challenge for R&D departments. The sustainable strategies used in cosmetics industry are natural and organic ingredients, vegan raw materials, awareness of sustainable safety of ingredients, minimalist and multifunctional formulations. One of the categories of cosmetic products that require replacing conventional, but often unsustainable ingredients, is care oils. Care oils containing ingredients of natural origin, high concentration of vegetable oils or plant extracts are a challenge for formulators due to the varying stability of these products. The study aimed to evaluate the possibility to replace the conventional soybean oil into organic one while maintaining product stability.

The effect of different antioxidants on the physicochemical and oxidative stability of care oils containing conventional and organic soybean oils was studied. The visual assessment, density and peroxide values were monitored within 12 weeks of storage test at different temperature conditions. The results of the present study have shown that all tested care oils remained clear, homogeneous oils, without mechanical impurities during whole test. No statistically significant differences were found between the oxidative and physicochemical stability of tested care oils based on conventional and organic soybean oils.

Keywords: oxidative and physicochemical stability of care oils, organic soybean oil, antioxidants

ANTIOXIDANT AND ANTIMICROBIAL POTENTIAL OF ONION PEEL PREPARATIONS

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The valorization of food-processing by-products is an important challenge for the modern economy. Onion peel, commonly generated as waste during food production, is a rich source of bioactive compounds, including polyphenols and flavonoids with potential antioxidant and antimicrobial properties. Such materials may provide a valuable basis for developing innovative and environmentally friendly ingredients for the cosmetics industry. The aim of this study was to assess the potential of onion peel as a raw material for bioactive preparations and to evaluate how different processing methods affect their antioxidant and antimicrobial properties. Onion peels obtained from different sources were cleaned, dried, ground, extracted using ultrasound-assisted extraction, fermented, and freeze-dried. Different extraction solvents and fermentation variants involving selected lactic acid bacteria or spontaneous fermentation were investigated. The resulting preparations were evaluated in terms of total phenolic content, antioxidant capacity, microbiological quality, and antimicrobial activity against selected bacteria, yeasts, and filamentous fungi.

The biological activity of onion peel preparations depended strongly on the processing method and extraction solvent. Extracts generally exhibited stronger antimicrobial activity than freeze-dried fermented preparations. The most effective extracts inhibited the growth of both Gram-positive and Gram-negative bacteria, as well as selected yeasts and filamentous fungi. All tested extracts demonstrated antioxidant potential, although a higher total phenolic content did not always correspond to stronger antioxidant or antimicrobial activity. Fermentation reduced the pH of the material but required further optimization to improve its microbiological quality and biological activity. Processed onion peel shows potential as a source of natural antioxidant and antimicrobial ingredients. Its valorization may support the development of environmentally friendly cosmetic ingredients and contribute to circular economy objectives. Further research should focus on process optimization, application-compatible extraction solvents, safety assessment, and product formulation.

Keywords: antimicrobial activity, antioxidant activity, extraction, food by-products, lactic acid fermentation, onion peel

ECO-FRIENDLY AND BIODEGRADABLE COMPOSITES BASED ON MYCELIUM FUNGI AND TEXTILES

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Growing environmental impact of textile and leather industries has intensified interest in sustainable material alternatives and circular economy strategies. Modern textile production and traditional leather processing generate severe ecological burdens, including high greenhouse gas emissions, hazardous wastewater, and vast volumes of non-biodegradable synthetic waste. Addressing these challenges requires innovative material design approaches that replace conventional textiles and animal leather with biodegradable, bio-based alternatives. This study examines development of mycelium-based biocomposites, focusing on the integration of fungal hyphae with diverse textile scaffolds as a viable strategy for sustainable material design.

The structural performance and functional versatility of mycelium-based composites depend heavily on the interaction between the fungal matrix and the underlying substrate. In this work, *Ganoderma lucidum* was cultivated directly onto woven, knitted, and nonwoven textile scaffolds, achieving three-dimensional colonization of the fabric weave. To overcome typical limitations associated with low mechanical repeatability and poor functional stability, a novel post-growth modification strategy was applied. Without prior deacetylation of chitin, the biocomposites underwent targeted metallic ion cross-linking (Zn^{2+}) combined with glycerol plasticization to optimize matrix flexibility and strength. Microstructural and chemical characterization (SEM, EDS) confirmed successful metal ion integration into the fungal cell wall, while mechanical evaluations demonstrated strength enhancements up to a 16% increase in ultimate tensile strength for cotton-reinforced biocomposites.

This presentation demonstrates bio-fabrication workflow, microstructural properties, and mechanical performance of fungal-textile biocomposites, emphasizing the role of chemical modification in tailoring material behavior. The findings highlight that controlled cell wall cross-linking serves as a powerful tool in sustainable product design, enabling the creation of high-performance, fully biodegradable materials that support the transition toward an eco-friendly textile and leather industry.

Keywords: mycelium, composites, biodegradable, cross linking, circular economy, sustainability

THE ROLE OF PLANT MATERIALS IN SHAPING THE SENSORY QUALITY AND ACCEPTANCE OF ISOTONIC BEVERAGES

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The growing demand for functional beverages creates opportunities for using plant materials as ingredients that can shape the sensory quality and acceptance of isotonic drinks. The aim of the study was to assess the role of selected plant materials of Polish origin in shaping the sensory characteristics and acceptance of isotonic beverages.

The beverages were prepared from infusions of selected plant materials, including lemon balm, walnut, birch, peppermint, sage, roseroot, wild thyme, hawthorn, goldenrod and dock. Glucose and salt were added in proportions established during preliminary trials to obtain an osmolality of 280–300 mOsm/kg H₂O, verified using a cryoscopic osmometer. A commercially available isotonic drink was used as a reference. Sensory profiling was conducted under controlled laboratory conditions by 45 selected assessors screened for sensory sensitivity and trained in the applied methods. Samples were served individually and evaluated using 11-point structured scales. Acceptance was assessed by 125 physically active consumers who regularly consumed isotonic beverages, using 11-point structured hedonic scales.

The type of plant material clearly differentiated the sensory profiles and acceptance of the beverages. Products based on familiar plant materials were more highly accepted, whereas bitter or bland beverages were less preferred. Sweet and bitter tastes were important attributes influencing overall assessment, and all experimental beverages were perceived as insufficiently sour. The peppermint-based drink achieved the highest overall acceptance among the formulated beverages (approximately 6.8/10), compared with approximately 7.1/10 for the commercial reference.

The findings indicate that the development of plant-based isotonic beverages depends not only on achieving the required osmolality but also on appropriate selection of plant materials and optimization of their sensory profiles. Familiarity with the raw material may support acceptance, while excessive bitterness, blandness and insufficient acidity may limit product appeal.

Keywords: acceptance, functional beverages, isotonic beverages, plant materials, sensory evaluation

POTATO PEEL EXTRACTS AS NATURAL ANTIOXIDANTS FOR SHELF-LIFE EXTENSION

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Potato peels are an abundant by-product of the food industry that remains largely underutilised despite being a potential source of biologically active compounds. Due to the growing demand for shelf-life extension, potato peel extracts have attracted attention as possible alternatives to synthetic antioxidants. However, their effectiveness in stabilising lipid-containing food systems still requires further investigation.

The aim of this study was to evaluate the potential of potato peel extracts as natural antioxidants using an in vitro DPPH radical scavenging assay and in a food model system subjected to accelerated storage conditions. Peel samples from two potato tubers (*Solanum tuberosum*) were extracted with 80% and 96% ethanol. The antiradical activity of the extracts against the DPPH radical was evaluated, and $t = 10$ min was selected to determine the half maximal inhibitory concentration (IC_{50}). The 96% ethanolic extracts were selected for the subsequent part of the experiment, in which peanut samples were treated with a model starch coating containing antioxidants and stored at 40°C. Lipid stability was assessed based on peroxide value measurements.

The DPPH assay showed that potato peel extracts obtained with 96% ethanol exhibited stronger radical scavenging activity than those obtained with 80% ethanol, with the *Jazzy* extract showing higher activity ($IC_{50} = 63.0 \pm 3.5 \mu\text{g}/\text{cm}^3$) than the *Gala* extract ($IC_{50} = 78.6 \pm 4.9 \mu\text{g}/\text{cm}^3$). The antiradical activity of the extracts showed a positive, non-linear concentration dependence. Both extracts significantly improved the oxidative stability of lipids in coated peanuts compared with peanuts coated with starch coating without the addition of extracts. The findings of this study demonstrate that potato peel extracts can effectively retard lipid oxidation in the tested food model system. The results also suggest that potato processing by-products may represent a promising source of natural antioxidants for food preservation applications and support further research into their practical use in shelf-life extension strategies.

Keywords: antioxidant activity, food quality, potato peel extracts, shelf-life extension, sustainable food systems

The research was financed by the Poznan University of Economics and Business as part of a subsidy received from the Ministry of Science and Higher Education.

THE IMPORTANCE OF LOAN MICELLAR EXTRACTION IN THE DESIGN AND MANUFACTURING OF SUSTAINABLE COSMETICS

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Natural cosmetics have been attracting significant interest among consumers for many years. Manufacturers, in an effort to meet consumer needs, are seeking solutions that offer a high level of safety and appropriate functionality. Modern cosmetics must be highly effective, affordable, meet the criteria of so-called sustainable products, and have a limited negative impact on the environment. The paper presents the results of research on the possibilities of using the Loan Micellar Extraction (LME) concept to produce natural cosmetics intended for hygiene. The essence of the method consists in borrowing components from the target cosmetic, preparing an extraction medium with their participation, carrying out the extraction (in the presented studies, micellar extraction was carried out), and then returning the obtained extract to the cosmetic mass. As a result - in the composition of a given preparation there appear ingredients isolated from the plant material, while the cosmetic mass does not contain any auxiliary substances (e.g. commonly used solvents).

The presentation discussed the advantages and disadvantages of the new concept. The new method of producing natural cosmetics was illustrated with specific examples. It was shown that the obtained product prototypes have high application potential and are an interesting alternative to currently used solutions.

Keywords: sustainable development, sustainable product, cosmetics, loan extraction

SUSTAINABLE PROCESS TRANSFORMATION THROUGH ESG PRACTICES IN POLISH ENTERPRISES

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ESG is becoming an increasingly important approach to implementing the principles of sustainable development in enterprises. In practice, however, its significance is not limited to reporting, regulatory compliance or communicating organisational responsibility. What is particularly important is whether ESG practices translate into improvements in the quality of organisational and operational processes, including processes related to resource use, emission reduction, waste management, working conditions and management transparency. Previous studies have often focused on ESG disclosure, sustainability strategies or the relationship between ESG and financial performance. Less attention has been paid to which ESG practices are actually implemented in enterprises and how they may support sustainable process transformation.

The aim of the research was to determine how ESG practices implemented in Polish enterprises support the sustainable transformation of organisational processes. The research was conducted using a survey questionnaire among 154 respondents representing enterprises with different business profiles, sizes and market scopes. The analysis covered environmental, social and governance practices, areas requiring further strengthening, planned ESG-related activities, perceived benefits, and tools for measuring and monitoring ESG effects.

The results showed that ESG practices were present in all three dimensions, but their intensity varied. The social component was the most strongly developed, mainly in relation to working conditions, safety, employee development and internal relations. Sustainable process transformation was most often associated with energy efficiency, investments in renewable energy, CO₂ emission reduction, waste management and process modernisation aimed at reducing energy use and emissions. Respondents also indicated the importance of ESG for improving company reputation, regulatory compliance, innovation and access to financing.

The findings suggest that ESG practices may support quality improvement and sustainable transformation of organisational processes when they are implemented in a measurable way, systematically monitored and linked to actual operational and social changes. The key challenge is to move from fragmented ESG initiatives towards an integrated, measurable and process-oriented approach to sustainability management.

Keywords: ESG, ESG practices, sustainable process transformation, process management, process quality, enterprises

SELECTED FACTORS ASSOCIATED WITH PERCEIVED QUALITY OF PRIMARY HEALTH CARE SERVICES AMONG PATIENTS IN THE WARMIAN-MASURIAN VOIVODESHIP

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The aim of the study was to identify selected factors associated with patients' perceptions of primary health care (PHC) service quality in the Warmian-Masurian Voivodeship. The analysis covered access to and organisation of services, the quality of interactions with staff, infrastructure, teleconsultations, and the degree of service digitalisation. Preferred methods of contact and appointment booking, frequency of service use, and priorities for improvement were also examined.

A cross-sectional survey was conducted among 387 respondents using a purpose-designed questionnaire. The data were analysed using descriptive statistics, one-way analysis of variance (ANOVA), and the independent-samples t-test.

Teleconsultations, infrastructure and safety, and staff and communication received the highest ratings, whereas access to and organisation of services and digitalisation were rated lowest. Overall facility ratings differed significantly according to the frequency of PHC use. The mean rating was 3.45 among occasional users and 4.06 among patients who used services frequently or regularly ($F = 12.12$; $p < 0.001$). Respondents who used online appointment booking rated clinic organisation more highly than non-users (3.61 vs. 3.10; $t = 3.54$; $p < 0.001$). The areas most frequently identified as requiring improvement were telephone access to appointment booking, digitalisation, and waiting times for appointments.

The findings showed that the frequency of service use significantly differentiated overall facility ratings, while the use of online appointment booking significantly differentiated ratings of clinic organisation. Together with the barriers reported by patients, these results indicate the need to improve initial contact with PHC facilities and reduce barriers to obtaining an appointment.

Keywords: primary health care, service quality, patient experience, patient satisfaction, online appointment booking, digitalisation of health care services.

THE EVOLUTION OF THE INSTITUTE OF COMMODITY SCIENCE IN KRAKOW IN THE YEARS 1924–2026

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This article presents a comprehensive overview of the history, as well as the structural and scientific evolution, of the Institute of Commodity Science in Krakow (currently the Institute of Quality Sciences and Product Management at the Krakow University of Economics) spanning the years 1924 to 2026. The paper outlines the key stages of the academic unit's development, beginning with its establishment in 1924 by Professor Arnold Bolland. It explores the institution's resilience through the difficult experiences of the Second World War and the period of secret underground teaching, leading into the post-war reconstruction efforts. The narrative further details the nationalization process and the dynamic organizational transformations within the Academy of Economics, which eventually evolved into the Krakow University of Economics.

In subsequent sections, the author discusses the continuous evolution of the educational offerings, alongside the systematic expansion of the institution's physical premises and laboratory facilities. Special attention is given to the outstanding scientific achievements of the academic staff. This includes their active involvement in the prominent activities of domestic and international commodity science associations, notably the Polish Society of Commodity Science (PTT) and the International Society of Commodity Science and Technology (IGWT). Furthermore, the extensive historical documentation presented covers the modifications of the unit's official name and the complex evolution of its internal structures. This journey traces the transition from a centralized institute, through specialized departments, and back to an institutional framework following the Polish higher education reform in 2018. The article also honors the legacy of the directors and deans whose leadership shaped the unique identity of the Krakow commodity science center over the past century. Ultimately, this article serves as a profound synthesis of the century-long effort and intellectual dedication of multiple generations of scientists and researchers toward the advancement of quality sciences and modern product management.

Keywords: commodity science, history of science, product management, quality sciences, structural evolution

EFFECTIVENESS OF SELECTED QUALITY MANAGEMENT TOOLS IN IMPROVING NON-DESTRUCTIVE TESTING PROCESSES

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The aim of the paper was to evaluate the effectiveness of selected quality management tools, namely the 5 Why method, Ishikawa and Pareto-Lorenz diagrams in analysing the non-destructive testing (NDT) process within an organisation. The study also sought to develop appropriate corrective, corrective-action and preventive measures addressing identified and potential nonconformities.

Based on a review of relevant literature, the paper presents key issues related to quality management in enterprises. Particular attention was given to the manufacturing processes of pressure and low-pressure vessels normobaric chambers and the NDT activities performed by the organisation.

The analysis enabled the identification of the root causes of nonconformities assessment of potential risk and evaluation of their actual impact, particularly regarding leakage occurrence. On this basis appropriate corrective and preventive measures were proposed, demonstrating the practical utility and effectiveness of the selected quality management tools.

Keywords: management, quality, non-destructive testing, processes, continuous improvement

INTEGRATING COMMODITY SCIENCE INTO THE PROJECT-BASED PRACTICE DAY IN AUSTRIAN VOCATIONAL COMMERCIAL SCHOOLS

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The new Austrian curriculum introduces Applied Natural Sciences and Commodity Science as an integrated subject in upper secondary vocational commercial schools (Handelsschulen, HAS). These three-year programmes, attended by students in Grades 9 – 11 (typically aged 15 – 18 years), prepare learners for direct entry into professional careers while developing vocational, scientific, and entrepreneurial competencies.

A key innovation is the Project-Based Practice Day, an interdisciplinary learning format primarily embedded in German, English, Business Administration, and IT-Business. It connects theoretical knowledge with authentic professional tasks, fostering inquiry-based learning, teamwork, problem-solving, entrepreneurial thinking, digital competencies, and reflective practice.

Within this framework, Applied Natural Sciences and Commodity Science provide opportunities to integrate scientific investigations into authentic commercial contexts. Competence development follows a structured progression:

- Grade 9: product life cycles, food commodities, nutrition, food labelling, recycling and separation techniques;
- Grade 10: ecosystems, sustainability, climate change, energy resources, organic and inorganic materials, buildings, and experimental investigations;
- Grade 11: occupational health, workplace safety, mobility, environmental hazards, and family planning.

These topics can be explored through laboratory investigations, product analyses, sustainability projects, company visits, field studies, and interdisciplinary collaboration. Students evaluate products from scientific, ecological, economic, and consumer-oriented perspectives while linking scientific methods with commercial practice, sustainability, consumer protection, and entrepreneurship. This approach strengthens analytical thinking, evidence-based decision-making, and problem-solving, demonstrating the continuing relevance of Commodity Science as an integrative discipline in contemporary vocational education.

Keywords: Commodity Science, Competence-Based Education, interdisciplinary learning, Education for Sustainable Development (ESD), vocational education and training

ISO/IEC 42006:2025 AS A NEW STANDARD FOR AUDITING AND CERTIFICATION OF ARTIFICIAL INTELLIGENCE MANAGEMENT SYSTEMS: IMPLICATIONS FOR RESPONSIBLE ARTIFICIAL INTELLIGENCE GOVERNANCE

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The increasing use of artificial intelligence in organizational processes has heightened the need for independent verification of how organizations manage AI-related risks. This article examines ISO/IEC 42006:2025 in terms of requirements for certification bodies, its relationship with the European Union's Artificial Intelligence Act, and its significance for responsible AI governance. The study applies analysis, synthesis, and comparison of normative and legal documents and addresses four research questions. ISO/IEC 42006 supplements ISO/IEC 17021-1 with requirements specific to the auditing and certification of artificial intelligence management systems, particularly regarding personnel competence and audit time. An AIMS certificate under ISO/IEC 42001:2023 confirms that an organization has implemented an AI management system, but it does not demonstrate that a specific AI system complies with all obligations under Regulation (EU) 2024/1689, including conformity assessment and, where applicable, fundamental rights impact assessment. For seven of the eight categories of high-risk AI systems listed in Annex III, conformity assessment is based on internal control without mandatory involvement of a notified body. AIMS certification may therefore provide complementary external assurance, although its value remains limited to the defined scope of certification.

Keywords: ISO/IEC 42006, ISO/IEC 42001, artificial intelligence management system, management system certification, responsible artificial intelligence governance

ARTIFICIAL INTELLIGENCE AS A TOOL SUPPORTING ENTERPRISE INNOVATION IN THE PROCESS OF NEW PRODUCT DEVELOPMENT

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The contemporary development of digital technologies significantly influences the transformation of design and production processes in enterprises, with artificial intelligence playing a particularly important role in this area. AI is increasingly becoming an integral element of new product development strategies, supporting process automation, data analysis, and the generation of innovative solutions. The aim of this study is to analyze the impact of artificial intelligence on the process of creating and implementing new products and to determine its importance in the context of enterprise innovation. The research problem focuses on the question of how AI affects the process of product design, evaluation, and implementation from the perspective of commodity science and innovation.

The study employed the diagnostic survey method using an original questionnaire conducted in electronic form. The research tool included both closed-ended and open-ended questions addressed to respondents representing various sectors of the economy. The analysis of the results was supported by statistical methods, including the chi-square test, which enabled the identification of relationships between qualitative variables. The obtained results contribute to a better understanding of the importance of artificial intelligence as a factor supporting product innovation and indicate directions for the further development of AI technologies in enterprises.

Keywords: artificial intelligence, product innovation, new product development, enterprise, design process, commodity science.

LIFE CYCLE ASSESSMENT OF ENVIRONMENTAL IMPACTS AND MITIGATION OPTIONS IN POTATO STARCH PROCESSING SYSTEMS

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LCA has been widely applied in agri-food systems, but single-case studies fail to account for how scale, technology, and resource use jointly shape environmental performance. To address this, this study develops a detailed process-level LCA model for potato starch processing using primary data from real industrial conditions. It analyzes how environmental performance varies with operational scale and technological configuration, and evaluates mitigation pathways for energy, wastewater, and byproducts through scenario analysis.

Following ISO 14040/14044 standards, this gate-to-gate attributional LCA utilizes primary data from 3–6 enterprises. Background data are modeled using Sphera LCA for Expert, Ecoinvent, and the Chinese Life Cycle Database, applying the ReCiPe 2016 midpoint method (climate change, eutrophication, water use). A multi-case comparison uses normalized vectors and Euclidean distance to quantify burden distribution patterns across different scales and technologies. Sensitivity is assessed via allocation methods and Monte Carlo simulation.

The study expects to reveal how scale and technology shape burden structures and to quantify mitigation potentials, supporting global benchmarking and low-carbon transitions in the sector.

Keywords: Life Cycle Assessment (LCA), mitigation scenarios, potato starch processing

**QUALITY IN THE PRODUCT LIFE CYCLE: CONTEMPORARY RESEARCH
DIRECTIONS IN COMMODITY AND QUALITY SCIENCES
AT POZNAŃ UNIVERSITY OF ECONOMICS AND BUSINESS**

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This study explores contemporary research directions in commodity and quality sciences at the Institute of Quality Science of Poznań University of Economics and Business in the framework of the product life cycle. The analysis is based on a review of publications indexed in Scopus and published over the last decade. The publications were classified according to four key phases of the product life cycle: product design, manufacturing and processing, use and consumption, and end of life management.

The analysis reveals that the largest volume of publications is concentrated in the product design and use and consumption phases, indicating that these areas currently constitute the core of research activity within the Poznań school of commodity and quality sciences. Research in the design phase focuses on innovative materials, sustainable packaging, functional products, and bioactive solutions that enhance product safety, functionality, and environmental performance. These studies contribute to the design of products and packages that better meet contemporary sustainability and consumer requirements. In the manufacturing phase, studies emphasize nanotechnology and digital solutions associated with Industry 4.0. Research related to the use and consumption phase concentrates on quality assessment, the nutritional value of food, authenticity, durability, consumer behavior, and the development of non-destructive analytical methods. The end of life phase is dominated by studies related to the circular economy, including waste valorization, metal recovery, environmental protection technologies based on materials derived from waste, and environmental assessment of circular solutions.

Overall, the findings demonstrate a clear evolution of commodity science from a traditional discipline focused on product quality toward an interdisciplinary field integrating materials science, food science, environmental engineering, digital technologies, and sustainability studies. The results reveal that quality is increasingly understood as a multidimensional concept encompassing technological, environmental, social, and economic dimensions and requiring an integrated approach throughout all stages of a product's life cycle.

Keywords: commodity science, product life cycle, product quality, quality science, research area

COMMODITY SCIENCE IN BULGARIA - DEVELOPMENT AND TOPICALITY

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The topicality of knowledge about commodities determines the role of commodity science for the development of economics, market relationships, protection and satisfaction of the customers. The establishment of the “Commodity Science” Department at the first higher school of commerce (now University of Economics – Varna) in Bulgaria dates back from 19 October 1948. From its beginning till now for 78 years the “Commodity Science” specialty is the only one so-named specialty in Bulgaria. Department has been developing dynamically and has provided solutions to problems faced by the national and international business.

The main directions for the development of commodity science in Bulgaria are: Expanding the scope of scientific research to encompass the entire product life cycle; Refining and applying methods for the assessment, quality control, identification, and detection of counterfeit goods; Packaging, storage, and storage-related changes affecting homogeneous product groups; Investigating the utility properties of goods and opportunities for their enhancement; Studying the durability of goods and packaging, as well as possibilities for recycling and the creation of secondary products; Development and maintenance of management systems; improvement of standardization policy; development of voluntary and product certification; protection of consumer interests; training of specialists in the field of commodity science.

Keywords: commodity science, development, topicality

THE APPLICATION OF NEUROMARKETING TECHNIQUES TO THE STUDY OF FOOD PACKAGING

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Understanding how the consumer brain works during all interactions with a product, packaging, or service is crucial for marketers – this allows them to create better consumer experiences. Especially, food packaging design plays a crucial role in the success of food products in the modern market because it not only protects and preserves the product but also serves as a powerful marketing tool that communicates the brand's message and attracts consumers.

Packaging has become more than just a food container. As a powerful marketing tool, it shapes first impressions, attracts attention, and influences purchasing decisions.. Therefore, to compete effectively, brands rely heavily on packaging design that communicates quality, trust, and value. Understanding the impact of food packaging on consumer thinking and behavior has also become an important area of research using neuromarketing tools.

This review demonstrates how, through the use of neuromarketing techniques, we can achieve a more holistic approach to assessing consumer reactions to different food packaging elements. A brief description of three modern techniques (electroencephalography, galvanic skin response and eye-tracking) is also presented as well as the useful neurophysiological metrics they yield.

It is highly probable that in the near future, combining EEG, GSR and eye-tracking data in packaging designs will be enhanced through AI, eliciting significantly higher levels of consumer engagement compared to their original counterparts. It means that packaging, as a key touchpoint in the consumer decision-making process, can be meaningfully improved through the integration of neurophysiological metrics and machine learning techniques.

Combining neuroimaging devices and AI for research opens up significant opportunities for a deeper understanding of consumer responses and optimising activities in consumer behaviour.

Key words: electroencephalography, eye-tracking, galvanic skin response neurophysiological metrics, packaging design

FOOD SAFETY MANAGEMENT IN SUPPLY CHAIN AS THE FOUNDATION OF FOOD SECURITY

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Food safety is one of the fundamental prerequisites for ensuring food security and achieving the sustainable development of food systems, and its attainment requires an approach consistent with the One Health concept. The aim of this paper is to present the interrelationships between food safety, food security, and the challenges facing sustainable food supply chains.

The sustainability of food supply chains requires consideration of pressures arising from urbanization, migration, and demographic change, as well as climate change, natural resource scarcity, soil degradation, declining agricultural land availability, food losses, and increasing energy demand. The economic and social consequences of food system transformation are also of considerable importance, including rising production costs, difficulties in scaling up sustainable practices, and social inequalities. Building sustainable and resilient supply chains necessitates addressing trade-offs, including tensions between intensive and sustainable agriculture, production scale and quality, modern technologies and traditional practices, globalization and support for local communities, and innovation and existing regulatory frameworks. However, the implementation of measures aimed at enhancing the sustainability of production may generate new food safety hazards, highlighting the need for deliberate management of trade-offs among environmental, economic, social, and health objectives. Food safety should therefore be regarded as an integral component of a resilient and sustainable food system, while ensuring food security requires the integration of actions across the entire supply chain and consideration of the interdependencies among humans, animals, and the environment.

The One Health concept provides a systemic framework for addressing these issues by taking into account the interactions among environmental conditions, food production, animal health, and public health. Key priorities include the development of sustainable agriculture, reduction of food loss and waste, responsible use of technological innovations, development of alternative food sources, and coherent regulatory frameworks and investment. The ultimate objective should be to develop food systems that simultaneously ensure access to food, food safety, and adequate nutritional value, while protecting human and animal health and the environment.

Keywords: food safety, food security, food chain, sustainability

RAPID QUALITY ASSESSMENT OF DIVERSE FOOD PRODUCTS USING FT-IR SPECTROSCOPY AND CHEMOMETRIC MODELING IN THE CONTEXT OF ECONOMY 5.0

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This study proposes a non-destructive approach for the rapid quality assessment of diverse food products by integrating Fourier Transform Infrared (FT-IR) spectroscopy with chemometric methods. The research addresses the growing demand for efficient, reliable, and scalable analytical tools in the food industry, particularly in response to increasing product diversity and the need for enhanced quality control.

Spectral data were collected from selected categories of commercially available food products, including milk, energy drinks, and protein supplements. The data were analyzed using multivariate techniques such as principal component analysis (PCA) and partial least squares regression (PLS). The developed models enabled effective discrimination between distinct product categories, as well as the prediction of selected quality parameters, demonstrating high robustness and predictive performance.

From a food technology perspective, the proposed approach offers a rapid and non-destructive alternative to conventional analytical methods, significantly reducing analysis time and resource consumption. From a quality management perspective, it supports data-driven decision-making, enhances process control, and contributes to the digitalization of quality assurance systems.

The proposed methodology is consistent with the principles of Economy 5.0, supporting the development of human-centric, data-driven, and sustainable quality management systems in the food sector. In particular, the approach enables improved consumer protection, increased transparency of food products, and more efficient use of analytical resources.

The results indicate that the integration of FT-IR spectroscopy with chemometric techniques provides a versatile tool for improving product quality monitoring and ensuring compliance with regulatory and market requirements across different food categories. The study highlights the potential of incorporating advanced analytical methods into modern, digitally supported quality management frameworks within the food sector.

Keywords: FTIR, spectroscopy, quality, PLS, PCA, digitalization, chemometrics, quality management, Economy 5.0

ENVIRONMENTAL EQUIVALENT OF SELECTED CUTLERY MADE OF VARIOUS MATERIALS USING CAD & LCA TOOLS - SUSTAINABLE ANALYSES

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In recent years, the main problem has been the uncontrolled increase in waste generation. Recently, plastic waste has become one of the most difficult groups of materials to segregate, which is caused, among other factors, by the similar densities of different materials. One of the most problematic types of waste is disposable cutlery, which is used for food consumption. These items are often contaminated with vegetable and animal fats. During the processing of this type of waste, contaminated plastics have to be cleaned. This requires significant financial expenditure in the form of necessary intermediate operations and a comprehensive approach to this issue in order to ensure the appropriate quality of material preparation for recycling and processing.

For the analysis, one type of cutlery represented by a 3D model in “.STL” format was used. The created model served as the basis for conducting the LCA analysis. In the CAD software, three of the most popular material types from the main material groups were assigned: metal alloys, polymer materials, and a natural material (wood). The analyses performed using the “SOLIDWORKS Sustainable Module” include environmental impacts such as Carbon, Energy, Air, and Water. These calculations depend on factors such as material type, manufacturing region, use region (continent), transportation method (air, rail, or road transport), manufacturing process with additional operations (e.g., painting or other finishing processes), and End-of-Life conditions (share of recycled, incinerated, and landfill waste).

The obtained results provide an environmental assessment, present the results in chart form, and compare the differences between the selected materials. This type of output data allows the calculation of an environmental equivalent for three different material types used in the same cutlery design. Through this type of analysis, consumer awareness can be enhanced. Conscious decision-making and a realistic assessment of environmental impact in the form of an equivalent value enable informed choices in the context of sustainable consumption.

Keywords: environmental impact, environmental equivalent, cutlery, material selection, CAD, LCA

FROM SUSTAINABLE HRM TO IMPROVED QUALITY OF LIFE: CONSCIOUS BREATHING AS A SUSTAINABLE HRM MICRO-PRACTICE

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Contemporary work environments place increasing demands on employees. The pace of work and pressure for efficiency are growing, along with the risk of cognitive and emotional overload. This raises the question not only of how organizations can effectively use employees' capabilities, but also of how they can facilitate its preservation and development over the long term.

This approach is consistent with the idea of sustainable development, with the Sustainable Development Goals (SDGs) providing a framework for a better future for people and the planet. Sustainable Human Resource Management (Sustainable HRM) is one way of translating this idea into the workplace. Its practices should benefit both employees, by fostering competence development and protecting their resources from excessive depletion, and organizations, by reducing the risks of burnout, absenteeism, presenteeism, and turnover.

Sustaining human capital requires viewing employees not only as a set of competencies, but also as human beings with psychophysiological and biological capacities that are subject to depletion and restoration. The proposed perspective, "FROM SUSTAINABLE HRM TO IMPROVED QUALITY OF LIFE," shifts attention from employees as organizational resources towards the quality of human functioning, including health, well-being, self-regulation, recovery, and sustainable employability.

Although Sustainable HRM increasingly addresses employee well-being, greater attention is needed to the mechanisms and practices that enable resource recovery in everyday work. Intensive work requires not only the use of employee resources but also opportunities for their ongoing recovery, opening space for micro-recovery – brief practices undertaken during the working day.

Against this background, the paper proposes conscious breathing as a potential Sustainable HRM micro-practice, focusing on its potential to influence physiological processes underlying everyday functioning and support the biological resources that sustain work capacity. Its role in moment-to-moment self-regulation may help reduce emotional tension, support recovery, restore attention, and maintain psychophysiological balance.

The aim of the paper is to develop a conceptual framework linking conscious breathing, micro-recovery, and Sustainable HRM, and to identify potential mechanisms supporting the preservation and recovery of employee resources and sustainable employability.

Keywords: Sustainable Human Resource Management (Sustainable HRM), employee well-being, micro-recovery, conscious breathing, self-regulation, sustainable employability

TOWARDS AN INTEGRATED MULTI-CRITERIA DECISION-MAKING FRAMEWORK FOR ENERGY-AWARE UNIT AND SMALL-BATCH PRODUCTION MANAGEMENT

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The growing demand for customized products and increasing sustainability requirements create new challenges for unit and small-batch production systems. Unlike mass production, non-repetitive manufacturing is characterized by high product variety, low production volumes, frequent schedule changes, and operational uncertainty. At the same time, manufacturers face rising energy costs, dynamic electricity prices, decarbonization targets, and ESG reporting obligations. However, existing production planning models primarily focus on economic and operational objectives, while energy and environmental factors are rarely integrated into decision-making processes.

This study proposes a conceptual framework for a multi-criteria decision-making (MCDM) model supporting production management in non-repetitive manufacturing. The framework is developed through a systematic review of production strategies and MCDM approaches, followed by the identification of key decision criteria.

The proposed framework integrates three groups of criteria: production performance (scheduling, machine utilization, lead time, inventory, and manufacturing costs), energy management (electricity consumption, dynamic tariffs, renewable energy sources, energy storage, and demand-side response), and environmental performance (carbon emissions and sustainability indicators).

The framework provides the foundation for an integrated decision-support model capable of balancing operational efficiency, energy flexibility, and environmental objectives. It contributes to production management research by extending traditional planning approaches toward energy-aware and sustainable manufacturing systems.

Keywords: carbon emissions, energy management, environmental sustainability, make-to-order, multi-criteria decision making, production planning, unit and small-batch production

SUSTAINABLE STORMWATER MANAGEMENT AT AIRPORTS

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Airport stormwater represents an increasing environmental and management challenge, as aviation-related activities generate diverse contaminant loads on highly impervious surfaces. Key pollutant groups include suspended solids, trace metals, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, de-icing and anti-icing agents, corrosion inhibitors, surfactants and selected emerging contaminants, including per- and polyfluoroalkyl substances. These contaminants originate mainly from aircraft and pavement maintenance, runway and tyre wear, fuel combustion, accidental spills, winter operations and firefighting activities. Their discharge may adversely affect receiving waters, aquatic biota, soils and groundwater quality. Recent studies indicate that conventional drainage systems, designed primarily for rapid hydraulic conveyance, are often insufficient for integrated control of runoff quantity, pollutant loads and long-term environmental risk.

Sustainable airport stormwater management therefore requires an integrated approach combining pollution prevention, runoff control, treatment efficiency and infrastructure resilience. Nature-based and semi-natural systems, including constructed wetlands, reed beds, retention ponds, permeable pavements and vegetated biofilters, can reduce suspended solids, hydrocarbons and particle-bound pollutants while also supporting flood mitigation and local biodiversity. However, complex airport runoff may require hybrid treatment trains that combine green infrastructure with engineered processes, such as sedimentation, filtration, biological treatment, sorption-based polishing or other site-specific technologies. From an environmental quality management perspective, such systems should be supported by monitoring, contaminant fate assessment, maintenance planning and cost–benefit analysis. Integrated green and engineered solutions may provide long-term environmental and economic advantages over conventional grey infrastructure and contribute to the objectives of the 2030 Agenda for Sustainable Development.

Keywords: airport runoff water pollution, airport stormwater, airport sustainability, emerging contaminants (ECs), environmental quality management, sustainable stormwater management

COMPARATIVE ANALYSIS OF SORBENT TYPES FOR DRINKING WATER TREATMENT

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Sorption technologies play an important role in drinking water treatment, while process performance is determined not only by the technological scheme but also by the nature and properties of the sorption material. Sorbents should be compared using a set of characteristics, including their origin, specific surface area and pore structure, the presence of active functional groups, selectivity towards contaminants, stability in an aqueous environment, and the possibility of regeneration, reuse, or safe disposal.

Traditional carbon sorbents, primarily activated carbon, are characterised by a well-developed porous structure and a broad range of applications, however, they require regeneration or replacement after saturation. Natural mineral sorbents, including zeolites, clay minerals, vermiculite, and shungite, are attractive because of their availability, chemical stability, and ion-exchange properties, although their effectiveness depends on water composition and the type of contaminant. Ion-exchange and synthetic materials provide high selectivity and process controllability, but they may be more expensive and require more complex handling after use. Modified and composite sorbents combine the properties of several components, however, their stability and safety require separate confirmation. Biosorbents and biocarbon materials are distinguished by the possibility of using renewable or secondary raw materials and by their potential to reduce resource use.

Therefore, no universal sorbent exists for all water treatment conditions. Its selection should be based on its suitability for a specific water composition, target contaminants, treated-water quality requirements, and operating conditions. For drinking water, assessing sorption capacity alone is insufficient: the material should not create a risk of secondary contamination, impair the organoleptic properties of water, or lose stability during use.

Keywords: activated carbon, biosorbents, drinking water, ion-exchange materials, mineral sorbents, sorbent regeneration, sorption technologies, water treatment

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SUSTAINABILITY CHALLENGES IN BEEKEEPING: IMPACTS OF ENVIRONMENTAL STRESSORS ON APIARY MANAGEMENT

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Bees are foundational to global ecosystems, food systems, and human livelihoods. They pollinate over 80% of flowering plant species and are responsible for one-third of global food production, making them irreplaceable contributors to biodiversity and food security. However, modern beekeeping faces significant sustainability challenges that threaten these vital ecosystem services. The primary objective of this presentation was to analyse the impacts of environmental stressors on apiary management and to outline a framework for long-term beekeeping resilience. It explores the complex interactions between various threats and proposes adaptive management strategies and policy recommendations to protect bee health.

Several critical forces threatening bee colony health and apiary sustainability have been identified: climate change (causes heat waves, droughts, and extreme weather, leading to "phenological mismatch" where bloom timing and bee activity no longer align), pesticide exposure (sublethal doses of chemicals like neonicotinoids do not kill bees directly but erode the colony's capacity to survive by impairing navigation, visual processing, and immune function, pathogens and parasites (specifically the Varroa mite, which remains a high-level threat), habitat loss and agri-intensification (driven by monocultures and changing land use, resulting in nutritional stress and pollen scarcity). Stressors rarely act in isolation, their combined effects amplify colony vulnerability, often leading to colony collapse. To mitigate these risks, the presentation highlights adaptive management adaptations, such as digital hive monitoring (using connected sensors), transhumance (seasonal migration), and supplemental feeding.

The presentation concludes with several key takeaways for the future of apiculture: multiple chemical, biological, and environmental stressors compound to threaten bee health simultaneously. Climate change is a major and accelerating challenge that disrupts forage and colony stability. Integrated monitoring (sentinel hives and digital tools) and adaptive management are essential for reducing winter mortality and improving yield consistency. Because bee health underpins global food security, protecting pollinators is a foundational requirement for sustainable agricultural systems.

Keywords: sustainable beekeeping, environmental stressors, bee health, adaptive management

SUSTAINABLE PRODUCTION IN THE ALCOHOL INDUSTRY – A CASE STUDY OF A POLISH DISTILLERY

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The production of alcoholic beverages is an important segment of the agri-food industry in Poland and worldwide. Poland ranks among the leaders in the production and export of high-proof spirits. Due to growing environmental requirements, the assessment of greenhouse gas (GHG) emissions in the industry is becoming increasingly important. It is also becoming necessary to implement solutions that support sustainable and low-carbon production.

The aim of the study was to identify key technological processes generating GHG emissions and to determine the carbon footprint (CF) of a Polish distillery. The analysis of the distillery covered the entire production chain, from the cultivation of agricultural raw materials (corn, wheat, rye, triticale, sunflower, rapeseed) to the final product. Technological processes were characterized, individual production stages were identified, and measurement ranges were defined. The collected data were organized into a database. The analysis accounted for the consumption of raw materials and energy carriers at each stage of the process. A carbon footprint (CF) analysis of the spirit production process at the distillery was conducted, taking into account three greenhouse gas (GHG) emission scopes, in accordance with applicable standards. It was noted that the raw material cultivation stage was responsible for the highest GHG emissions. It was found that electricity was the main source of GHG emissions in the production process. It was demonstrated that the average carbon footprint of spirit production decreased by 80% (from 1.80 to 0.36 kg CO₂eq/l) over a three-year period. The distillery utilized a biogas plant as a renewable energy source (RES), which enabled a significant reduction in GHG emissions. The implementation of low-carbon solutions and improvements in energy efficiency can significantly reduce emissions throughout the product's entire life cycle. Measures aimed at reducing fossil fuel consumption, utilizing RES, improving efficiency, and implementing low-emission technologies contribute to reducing the distilling industry's negative environmental impact. In the context of growing climate requirements, it has been demonstrated that carbon footprint analysis is an effective tool for assessing progress in sustainable development initiatives.

Keywords: biogas plant, greenhouse gas emissions, distillery, renewable energy sources, carbon footprint, sustainable production

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