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Introduction to 'Advances in valorising underexplored biomasses to obtain food ingredients, additives, and products'

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The global food system is under increasing pressure to meet the nutritional needs of a growing population while reducing environmental impact and promoting circular bioeconomy strategies. In this context, the valorisation of underexplored biomasses (ranging from plant and marine sources to insects and agro-industrial by-products) offers a promising pathway to develop sustainable food ingredients, additives, and products. This themed collection in *Sustainable Food Technology* brings together five innovative studies that exemplify how novel processing technologies and interdisciplinary approaches can unlock the potential of these biomasses, contributing to the Sustainable Development Goals (SDGs) and the 2030 Agenda.

Green extraction for dual-component recovery

Mukherjee *et al.* present a compelling case for the sustainable extraction of bioactive compounds from tulsi (*Ocimum gratissimum*) leaves using a two-stage microwave hydro-diffusion and gravity (MHG) model. Their blended-mode MHG protocol enables the simultaneous extraction of essential oils and phenolic compounds from the same biomass, significantly improving yield and reducing processing time compared to traditional hydrodistillation. The study demonstrates that this solvent-free, energy-efficient method not only enhances the recovery of volatile and non-volatile bioactive components but also preserves the integrity of the residual biomass for further valorisation. This aligns directly with the theme of the collection by showcasing how a single biomass can be judiciously utilised to extract multiple high-value components, supporting circularity and reducing waste (**https://doi.org/10.1039/D4FB00177J**).

Functional beverages from fermented quinoa

Bordoni *et al.* explore the nutritional enhancement of quinoa-based beverages through semi-solid fermentation with kefir cultures, combined with mango–orange juice. Quinoa, a resilient Andean pseudocereal, is rich in protein and micronutrients but contains antinutritional factors that limit its bioavailability. The authors demonstrate that fermentation significantly increases protein content, antioxidant activity, and phytosterol levels while reducing antinutrients. The addition of fruit juice enriches the beverage with carotenoids and flavonoids, although it necessitates pH adjustment to optimise microbial growth. This study exemplifies how traditional fermentation techniques can be adapted to modern food systems to create probiotic-rich, plant-based functional beverages from underutilised grains and fruit by-products, contributing to both nutrition and sustainability (**https://doi.org/10.1039/D5FB00086F**).

Insect-derived chitosan as a functional ingredient

Psarianos *et al.* investigate the production of chitosan from house crickets (*Acheta domesticus*) using three different extraction methods: conventional chemical, biological (fermentation and enzymatic), and microwave-assisted extraction. All methods yielded chitosan with high purity and functional properties, including strong antioxidant and antimicrobial activity. Notably, the biological method, which combines fermentation with *Lactococcus lactis* and bromelain digestion, offers a greener alternative to traditional chemical extraction. The study highlights the potential of edible insects as a sustainable source of chitosan, a biopolymer with wide applications in food preservation and packaging. By valorising insect biomass, this work contributes to SDG 2 (Zero Hunger) and SDG 13 (Climate Action), demonstrating how alternative protein sources can also serve as

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platforms for functional food ingredients (https://doi.org/10.1039/D4FB00263F).

Encapsulation of fish oil using supercritical CO_2

Okur *et al.* address the challenge of stabilising omega-3-rich fish oil, which is prone to oxidation, by encapsulating it in natural wax-based solid lipid particles using supercritical carbon dioxide (SC–CO_2). This solvent-free, green encapsulation method enhances the oxidative stability, shelf life, and bioaccessibility of EPA and DHA fatty acids. The use of natural waxes such as candelilla and carnauba not only improves encapsulation efficiency but also aligns with clean-label and sustainability trends. This study illustrates how marine biomass can be effectively stabilised and incorporated into functional foods using environmentally friendly technologies, supporting the development of health-promoting ingredients with minimal ecological impact (https://doi.org/10.1039/D4FB00345D).

Mulberry leaf extract for functional beverages

Masoodi *et al.* explore the valorisation of mulberry leaves, a traditionally underutilised biomass, by formulating an instant freeze-dried functional beverage. The authors use gas chromatography-mass spectrometry (GC-MS) to identify key bioactive compounds in the leaf extract and encapsulate it in protein-rich skim milk powder. The resulting beverage exhibits significant antioxidant, antidiabetic, and anti-obesity activities under simulated gastrointestinal conditions. The addition of rose flavour and sea-buckthorn anthocyanins enhances both bioactivity and consumer acceptability. This work demonstrates how plant-based biomasses can be transformed into shelf-stable, health-oriented products through innovative formulation and encapsulation strategies, contributing to SDG 3 (Good Health and Well-being) and SDG 12 (Responsible Consumption and Production) (https://doi.org/10.1039/D4FB00203B).

A shared vision for sustainable food systems

Together, these five studies exemplify the core aim of this themed collection: to advance the valorisation of underexplored biomasses through sustainable, scalable, and health-promoting food technologies. Whether through green extraction, fermentation, encapsulation, or biopolymer recovery, each contribution highlights the importance of interdisciplinary innovation in building a resilient and circular food system.

The diversity of biomasses explored, from tulsi leaves and quinoa to insects, fish oil, and mulberry leaves, reflects the enormous unexploited potential of natural resources that are often overlooked or discarded. By applying novel processing techniques that minimise environmental impact and maximise nutritional value, these studies pave the way for a new generation of food ingredients and products that are not only functional and safe but also aligned with global sustainability goals.

We extend our sincere thanks to all contributing authors for their high-quality submissions and to the reviewers for their valuable insights. We also acknowledge the editorial team at the Royal Society of Chemistry for their support in curating this important collection.

We hope this themed issue inspires further research and collaboration in the field of sustainable food technology and encourages the continued exploration of novel biomasses as valuable resources for the future of food.

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