EDITORIAL

Food-Derived Bioactive Peptides: A New Paradigm from Fundamental Research to Industrial Translation

Chunming Xu[1,*]

[1] School of Light Industry Science and Engineering, Beijing Technology and Business University, Beijing 100048, China

Editorial

As functional foods and precision nutrition are increasingly taking center stage in food science, bioactive peptides are transitioning from conceptual validation in the laboratory to the forefront of industrial application. As specific amino acid sequences released from proteins through enzymatic hydrolysis, fermentation, or food processing, bioactive peptides not only possess favorable digestibility and absorption characteristics but also exhibit a broad spectrum of physiological functions, including antioxidant, antihypertensive, hypoglycemic, anti-inflammatory, immunomodulatory, and even neuroprotective activities. For the agricultural and food processing sectors that this journal addresses, peptide research is not an isolated sub-discipline but rather a critical nexus connecting three major pillars: high-value utilization of raw materials, innovation in processing technologies, and the development of health-oriented food products. This editorial aims to systematically review the latest advances in this field, identify core bottlenecks, and issue a research call to our readership.

1 The Raw Material Front: Value Transformation from Byproducts to Functional Factors

The first strategic significance of bioactive peptides lies in their capacity to unlock high-value utilization pathways for agricultural byproducts and low-value protein resources. For a long time, the economic potential of wheat processing byproducts, soybean meal, walnut cake, and similar materials has been severely underestimated. Recent research has demonstrated that these very materials are rich sources of high-quality bioactive peptides.

Take wheat oligopeptides as an example: they are abundant in glutamic acid and proline, and after enzymatic preparation, they have demonstrated antioxidant, anti-inflammatory, immunomodulatory, antihypertensive, and neuroprotective activities in both in vitro and in vivo models [1]. Progress on soybean peptides is equally notable—research has systematically documented the diverse functional significance of soybean-derived bioactive peptides, encompassing antioxidant, antihypertensive, antimicrobial, and immunomodulatory activities, demonstrating their potential as high-value-added ingredients for both the feed and food industries [2]. Beyond these specific sources, systematic research progress has been achieved across a broad range of plant-derived protein hydrolysates, with extensive

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***Corresponding author:**
✉ Chunming Xu
xucm@btbu.edu.cn

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evidence documenting their production processes, biological activities, and applications in foods and health promotion [3].

This trend sends a clear signal: the value chain of agriculture and food processing is being redefined. Byproducts or "low-value" materials, traditionally regarded as waste, can be transformed into core components of functional foods, nutritional supplements, and even drug delivery systems through the enabling power of enzyme engineering and separation-purification technologies. This places new demands on processing technology research within our journal's scope—not only focusing on yield and cost, but also on function-oriented preparation and precise regulation of structure-activity relationships of peptides.

2 The Technology Front: Enzymatic Hydrolysis, Fermentation, and AI-Driven Precision Design

Achieving the conversion from raw materials to active peptides hinges critically on breakthroughs in processing technologies. The current mainstream preparation routes include enzymatic hydrolysis, microbial fermentation, and chemical methods. Among these, enzymatic hydrolysis has become the preferred choice for research and application due to its high specificity, mild reaction conditions, and superior product safety. A representative example is the enzymatic processing of soybean meal: by combining anti-nutritional factor removal with controlled hydrolysis, researchers have established efficient preparation protocols for soybean meal-derived bioactive peptides that meet both feed and food industry standards [4].

However, the bottlenecks facing industrial development are equally significant. Food-derived bioactive peptides generally suffer from poor gastrointestinal stability and low bioavailability, often degraded by digestive enzymes before reaching their target sites [5]. To address this challenge, two noteworthy technological breakthroughs have emerged in recent years:

First, bioactive peptide self-assembly technology. Studies have found that by regulating environmental factors such as temperature and pH, and by designing peptide sequences rich in aromatic amino acids or proline, bioactive peptides can spontaneously form ordered nanostructures including nanofibers, micelles, and hydrogels. These self-assembled structures effectively resist degradation under gastrointestinal digestive conditions, significantly enhancing peptide stability and bioavailability while preserving biological activity. This discovery offers a completely new paradigm for precision delivery in functional food design.

Second, artificial intelligence-assisted peptide screening and design. Traditional active peptide screening relies heavily on extensive in vitro experiments, which is inefficient. Computational (*in silico*) approaches—including molecular docking, quantitative structure-activity relationship (QSAR) modeling, and machine learning-based prediction—are dramatically accelerating the discovery process of active peptides [6]. AI not only predicts the biological activity of peptide sequences but also assists in designing peptides with specific self-assembly capabilities and targeted release properties. It is fair to say that AI + peptide engineering is propelling this field from a trial-and-error approach to a new stage of rational design.

3 The Application Front: From Functional Foods to Precision Nutritional Interventions

From the perspective of end-use applications, the market value of bioactive peptides is being rapidly unlocked. In the functional food arena, products such as collagen peptides and whey protein peptides have already gained broad market recognition. More forward-looking directions include:

Appetite regulation and weight management: Plant-derived protein hydrolysates and peptides have been shown to modulate the secretion of intestinal hormones such as GLP-1, CCK, and PYY, influencing hypothalamic appetite-regulating centers via the vagal nerve pathway. This multi-target mechanism offers a novel strategy for obesity prevention and treatment that differs from conventional pharmaceuticals. Given the alarming projection that the global obese population will exceed 4 billion by 2035, the development of peptide-based appetite modulators carries enormous public health significance [7].

Adjuvant intervention for chronic diseases: Bioactive peptides derived from fermented milk, plant proteins, and other sources have demonstrated antihypertensive, hypoglycemic, and hypolipidemic effects in multiple studies. In particular, angiotensin-converting enzyme (ACE) inhibitory peptides have well-defined mechanisms of action, with several products already

commercialized.

Active packaging and food preservation: Peptide-loaded biodegradable active packaging films are emerging as a research hotspot. Incorporating antimicrobial or antioxidant peptides into biopolymer films can effectively extend food shelf life while aligning with the principles of the circular bioeconomy.

4 Challenges and Call to Action: Research Priorities for This Journal

Despite the promising prospects, the journey from laboratory to large-scale industrialization for bioactive peptides faces a series of practical challenges: reduction of production costs, optimization of scalable processes, further improvement of peptide stability and bioavailability, refinement of regulatory standards, and validation of efficacy through more high-quality clinical trials.

As Editor-in-Chief of this journal, I extend the following calls to researchers in the agricultural and food processing fields:

First, prioritize diversification and sustainability of raw materials. Encourage the exploration of novel active peptide resources from traditionally underutilized plant sources, agricultural byproducts, and processing wastes, thereby advancing the circular agricultural economy.

Second, embrace interdisciplinary approaches. Integrate cutting-edge tools—including enzyme engineering, fermentation technology, nanoencapsulation, and AI-assisted design—into peptide preparation and optimization research, driving a paradigm upgrade in processing technologies.

Third, focus on the validation chain from in vitro activity to in vivo efficacy. Encourage studies employing cellular models, animal models, and preliminary human intervention trials to accumulate high-quality translational evidence.

Fourth, strengthen research on peptide digestive behavior and delivery mechanisms. The in vivo self-assembly behavior of bioactive peptides and their interactions with the gut microbiota represent critical scientific questions for understanding their true health effects and merit prioritized attention [8].

We envision this journal as a premier platform bridging fundamental peptide science and agricultural-food processing industrial practice. Whether it involves the discovery of novel peptides, development of efficient preparation processes, elucidation of structure-activity relationships, or design of functional products and clinical validation, we welcome high-quality original research and review submissions. At a time when human health and planetary sustainability are increasingly intertwined, food-derived bioactive peptides offer a pathway that combines scientific depth with industrial relevance. Let us work together to advance the prosperity and maturation of this vital field.

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AI Use Statement

The author declares that no generative AI was used in the preparation of this manuscript.

Ethical Approval and Consent to Participate

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Chunming Xu received the B.S. and M.S. degrees in Bio-engineering and Ecology from Northwest A&F University and the Ph.D. degree in Biochemical Engineering from Institute of Process Engineering, Chinese Academy of Sciences. Chunming-Xu is a professor at the School of Light Industry Science and Engineering at Beijing Technology and Business University. He is a green factory evaluation expert of the Ministry of Industry and Information Technology of China, a project expert of the China National Light Industry Council, and a reviewer of many journals such as Journal of Chinese Institute of Food Science and Technology and Science and Technology of Food Industry. His research focuses on agricultural intelligent systematics, food big data technology, multi-omics analysis. He has published over 50 relevant papers in areas such as metagenomics, transcriptomics, screening of resistance genes, screening of bioactive peptides, and virtual screening of enzyme inhibitors. He has also filed 8 related patents and serves as a reviewer for multiple journals. (Email: xucm@btbu.edu.cn)