Beijing Dilun Biotechnology Co., Ltd.
Specializes in R&D and manufacturing of peptide synthesis equipment, providing comprehensive technical solutions and services.
Web: www.peptidescientific.com.   Email: chengchao.wei@dilunbio.com

From "Chief of Grains" to "Active Essence": A New Chapter in the Preparation and Application of Millet Peptides

Millet, a traditional staple grain in northern China, has long been hailed as the "king of grains" for its highly valued nutritional properties. However, public awareness of millet often focuses solely on its carbohydrates, vitamins, and minerals, with relatively little attention given to its protein content—which accounts for approximately 10% of the grain's weight. In recent years, with the rise of bioactive peptide research, millet protein has emerged as a potential high-value raw material, demonstrating new vitality. Modern biotechnology transforms it into millet peptides, unlocking its hidden biological functions and paving the way for its evolution from a traditional grain to a modern health ingredient.

I. Potential and Starting Point: Why Choose Xiaomi Protein?

Millet protein possesses unique advantages as a high-quality peptide precursor:

1. Nutrient-balanced with low allergenicity: Compared to common wheat (gluten-containing) and soybeans, millet protein exhibits extremely low allergenicity, making it an ideal foundation for developing hypoallergenic

functional foods. Its amino acid composition is relatively balanced, particularly with higher sulfur-containing amino acids (methionine, cysteine) than most grains.

2. A Natural Treasure Trove of Bioactive Compounds: Millet itself is rich in antioxidants such as polyphenols and flavonoids. During processing, these components may synergize with peptides or be co-extracted, thereby endowing millet peptide complexes with health benefits that surpass those of simple hydrolysates.

3. Abundant resources aligned with sustainable development: Millet is drought-resistant and thrives in poor soils, with an environmentally friendly growth process. Developing its value-added products supports efficient agricultural resource utilization and food security strategies.

However, challenges remain: the extraction rate of xanthan gum is constrained by its strong binding to starch; improper control of the enzymatic hydrolysis process can easily produce an unpleasant bitter taste; and its functional activity spectrum still requires broader scientific research to fully elucidate.

II. From Millet to Peptides: A Detailed Breakdown of the Preparation Process

The conversion of whole millet grains into highly active, high-purity peptides is a systematic process comprising three major stages: protein preparation, precise enzymatic hydrolysis, and purification.

Stage 1: Protein Acquisition and Pretreatment

This forms the foundation for the efficiency and quality of all subsequent processes.

Dehulling and Micronization: Millet grains must first undergo dehulling to obtain millet kernels, which are then processed using micronization technology. Micron-level fine powder significantly disrupts the structure of starch granules and protein bodies, increasing surface area to create optimal conditions for subsequent protein extraction.

Starch Separation and Protein Enrichment: This is the core step. Millet contains over 70% starch, which must be effectively separated.

The alkali-soluble acid-precipitable method is currently the mainstream and highly efficient technique for laboratory and pilot-scale applications: millet flour is stirred in a weakly alkaline solution (pH 9.0–10.0) to dissolve proteins while precipitating starch. After centrifuging the supernatant, the pH is adjusted to the isoelectric point of millet protein (approximately pH 4.0–5.0), causing the protein to precipitate. Following washing, neutralization, and drying, millet protein isolate powder is obtained. The key to optimizing this process lies in precisely controlling temperature (typically 50–60°C), time, and solid-to-liquid ratio to ensure high extraction rates while preventing excessive protein denaturation.

The hydrolytic enzymatic method represents a more promising green process: it simultaneously utilizes amylase and protease to break down starch and release proteins under mild conditions, thereby better preserving the natural activity of proteins. However, it involves higher costs and greater control challenges.

Phase Two: Precise Enzymatic Cleavage of Proteins—The Key to Releasing Activity

Enzymatic digestion is the core process that “cuts” inactive macromolecular proteins into small peptide fragments with specific functions.

1. Selection Strategy for Proteases: Different proteases yield distinctly different peptide mixtures due to their varying cleavage sites (specificity), directly impacting the activity and flavor of the final product.

2. Alkaline Proteases vs. Trypsin:

Alkaline proteases exhibit strong hydrolytic capacity, rapidly generating large quantities of small-molecule peptides. They are commonly chosen for achieving high degree of hydrolysis and high yield, but are prone to producing bitter peptides.

3. Flavor Proteases and Complex Enzyme Systems:

This combination represents the optimal approach for enhancing both flavor and functionality. A “deep hydrolysis followed by refinement” strategy is often employed: Alkaline proteases perform extensive hydrolysis to achieve a certain degree of hydrolysis, after which flavor proteases are added. Flavor proteases specifically remove hydrophobic amino acids at peptide chain termini (the primary source of bitterness), significantly improving product palatability and potentially exposing new active sites.

4. Mathematical Modeling for Process Parameter Optimization: Enzymatic hydrolysis outcomes are influenced by multiple interacting factors including temperature, pH, enzyme-substrate ratio, time, and substrate concentration. Modern research commonly employs response surface methodology. Through designed experiments, mathematical models are established linking multiple factors to key indicators (e.g., degree of hydrolysis, peptide yield, ACE inhibition rate), enabling precise identification of the globally optimal process parameter window. For instance, studies on millet protein from specific sources may determine that the optimal conditions are pH 8.5, 55°C, an enzyme-to-substrate ratio of 4%, and a reaction time of 3 hours.

Stage Three: Purification and Stabilization of Peptides

The crude enzymatic hydrolysate is complex and requires purification to yield high-quality products.

Debittering and desalting: Activated carbon adsorption or specific resin chromatography effectively adsorbs bitter peptides and small-molecule impurities. Nanofiltration or electrodialysis efficiently removes salts, enhancing product purity.

Enrichment and Separation of Active Peptide Segments: Molecular weight fractionation via ultrafiltration systems is employed based on target functionality. Extensive research indicates that peptides with molecular weights below 3 kDa, particularly those under 1 kDa, often exhibit stronger antioxidant and antihypertensive activities. Combining ultrafiltration membranes with different molecular weight cut-offs enables targeted enrichment of specific components.

Drying and Protection: Spray drying is the preferred method for industrial production, where critical factors include controlling inlet air temperature (typically 150-180°C) and outlet air temperature (80-90°C) to achieve rapid drying while minimizing loss of heat-sensitive activity. For ultra-high-value products, vacuum freeze-drying maximizes preservation of the peptide's natural conformation and biological activity.

III. Unlocking the Functional Landscape: Diverse Applications of Xiaomi Peptides

Millet peptides prepared through an optimized process have demonstrated remarkable biological activity, laying the foundation for their application across multiple fields.

1. Antioxidant and Anti-Aging Effects: This represents one of millet peptides' most prominent functions. Their rich content of hydrophobic amino acids and peptide sequences effectively scavenges free radicals (such as DPPH radicals and hydroxyl radicals) and inhibits lipid peroxidation. This not only enables their use as natural antioxidants and

food preservation ingredients but also provides scientific rationale for their application as active anti-aging and anti-photoaging ingredients in skincare cosmetics.

2. Hypotensive (ACE Inhibition) Activity: Studies reveal that millet protein, when appropriately enzymatically hydrolyzed, produces potent angiotensin-converting enzyme (ACE) inhibitors. These peptides competitively inhibit ACE, preventing the conversion of angiotensin I into angiotensin II—a potent vasoconstrictor—thereby aiding blood pressure regulation. This opens avenues for developing natural functional foods or ingredients with auxiliary blood pressure-lowering properties.

3. Immune Enhancement and Anti-Inflammation: Preliminary cellular studies indicate that certain millet peptide components stimulate the proliferation and activity of immune cells (e.g., macrophages) while regulating inflammatory factor secretion. This suggests potential for regulating immune balance and developing nutritional supplements that boost resistance.

4. Multifunctional Ingredient in Food Industry: Benefiting from its excellent solubility, emulsifying properties, and foaming capacity, millet peptides themselves serve as high-quality protein fortifiers for beverages, nutrition bars, and medically tailored foods. Their antioxidant properties also function as natural preservatives in meat products and oils, extending shelf life.

IV. Challenges and Future Directions

Despite promising prospects, the industrialization of Xiaomi Peptide still faces challenges: the cost-effectiveness of protein extraction and enzymatic hydrolysis during large-scale production requires further optimization; the mechanisms of peptide absorption in vivo, long-term consumption safety, and dose-response relationships demand deeper preclinical and clinical research; and how to seamlessly integrate its distinctive flavor (even after de-bittering) into end products remains a practical application issue.

Looking ahead, Xiaomi's peptide research will delve into deeper dimensions:

• Precision mining based on omics: Utilizing proteomics analysis of millet protein sequence libraries, bioinformatics predicts potential active peptides, then guides targeted enzymatic digestion, achieving a shift from “random discovery” to “rational design.”

• Linking Microstructure to Macrofunction: Deeply investigating the “structure-activity relationships” between peptide secondary structures, hydrophobicity, charge distribution, and biological activity, providing a theoretical foundation for customized production.

• Cross-Boundary Convergence Innovation: Exploring broader application possibilities for millet peptides in sports nutrition, geriatric nutrition, gut health, and as bioactive materials.

V.Conclusion

From the golden millet grains that have nourished the Chinese nation for millennia in the fields, to the bioactive peptide extracts refined through modern biotechnology in laboratories, millet's value has evolved from a basic energy source to a precise health intervention. The continuous refinement of millet peptide extraction techniques and ongoing exploration of functional applications represent not only the deep development and value repositioning of this ancient crop resource, but also a vivid demonstration of modern food science sustainably uncovering future health solutions from traditional ingredients. This journey reveals that within ordinary foods may lie extraordinary health codes, waiting to be unlocked one by one with the key of science.