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From Discarded Rice Bran to Hypertension Treasure: The Active Secrets and Application Prospects of Rice Bran Peptides

During millet processing, rice bran accounting for approximately 8%-12% of the grain weight is produced. For a long time, this valuable byproduct has mostly been used as animal feed or discarded directly. However, scientific research has revealed that millet bran is a rich source of protein. Through modern biotechnology, it is being transformed into bioactive peptides. This once-discarded “processing waste” is now demonstrating remarkable health benefits, particularly in assisting blood pressure regulation, emerging as a rising star in the functional food sector.

I. Resource Awakening: Why Focus on Xiaomi Bran Peptide?

The rise of millet bran peptides stems from their unique resource advantages and physiological characteristics:

1. Turning waste into treasure, upgrading value: Utilizing millet bran aligns with the concept of value enhancement and sustainable development across the entire agricultural product supply chain, significantly boosting the economic benefits of millet processing.

2. Nutritional and Bioactive Enrichment: Millet bran represents the "nutritional essence layer" of millet, with protein content (approximately 12%-18%) even exceeding that of polished rice. Crucially, during processing, proteins tightly bind with natural bioactive components like dietary fiber, polyphenols, and γ-oryzanol. The peptide fractions obtained through enzymatic hydrolysis often inherit the synergistic effects of these accompanying compounds, potentially exhibiting superior biological activity.

3. Unique Functional Potential: Preliminary research indicates that millet bran protein may exhibit distinct amino acid compositions and enzyme-hydrolyzed product activity profiles compared to millet endosperm protein. This suggests potential for developing peptide raw materials with unique functional properties.

II.Core Mechanism: How Does Millet Bran Peptide Lower Blood Pressure?

The antihypertensive activity of millet bran peptides is not achieved through a single pathway, but rather functions like a sophisticated "multiple pathway regulation system," primarily acting on the following key mechanisms:

1. Core Pathway: Angiotensin-Converting Enzyme (ACE) Inhibition

This represents the most thoroughly researched, clinically applied, and mechanistically understood antihypertensive pathway.

Target: Angiotensin-converting enzyme is the pivotal enzyme in the renin-angiotensin system. It catalyzes the conversion of inactive angiotensin I into angiotensin II, which possesses potent vasoconstrictive effects, while simultaneously degrading bradykinin, a vasodilator.

Mechanism of Action: Specific short peptides within millet bran peptides (typically oligopeptides containing 2-12 amino acids) share structural similarity with ACE's substrate (angiotensin I) or its natural inhibitors. These peptides competitively bind to ACE's active site, acting like a “wrong key” that jams the lock, thereby blocking ACE's normal catalytic function.

Final Effect: Reduced angiotensin II production and slowed vasopressin degradation work in tandem to induce vasodilation, decrease peripheral resistance, and ultimately lower blood pressure.

2. Auxiliary and Synergistic Pathways: Multifaceted Regulation Beyond ACE Inhibition

Beyond directly inhibiting ACE, studies indicate that millet bran peptides may exert synergistic effects through additional mechanisms:

Antioxidant and Endothelial Protection: The polyphenolic compounds abundant in millet bran may be partially integrated into peptide components or act synergistically with them. These constituents effectively scavenge excess free radicals in the body, mitigating oxidative stress damage to vascular endothelial cells. Healthy endothelial cells can

normally synthesize and release vasodilatory substances like nitric oxide, which is crucial for maintaining vascular tone and stable blood pressure.

Potential Calcium Channel Blocking Effects: Some plant-derived peptides have been shown to exhibit mild voltage-dependent calcium channel blocking activity. This may reduce calcium ion influx, inhibit excessive contraction of vascular smooth muscle, and thereby assist in lowering blood pressure.

Improved insulin sensitivity: Metabolic syndrome and hypertension often coexist in a bidirectional relationship. Certain bioactive peptides have been shown to help improve insulin resistance, indirectly promoting stable blood glucose and blood pressure levels.

III.From Mechanism to Product: Functional Application Development

Based on the aforementioned well-defined antihypertensive mechanism, the application pathway of millet bran peptides in the health industry is becoming increasingly clear:

1. Core Ingredients for Hypertension-Lowering Functional Foods and Special Dietary Foods

This represents the primary and most direct application direction. Millet bran peptide extracts with high ACE inhibitory activity can be incorporated as core functional factors into various food carriers:

Solid Foods: Such as pressed candies, powdered beverages, nutrition bars, cookies, noodles, etc. The key lies in maintaining peptide stability

during processing and storage.

Liquid Foods: Such as functional beverages, yogurt, dairy products, etc. Addressing potential taste issues (e.g., slight bitterness) and system stability concerns associated with peptides is necessary.

Special Dietary Foods: Develop special dietary foods with explicit claims for auxiliary blood pressure regulation targeting high-risk populations or early-stage hypertension patients.

2. As a Natural Source for Health Food Ingredients

Developing health food capsules or tablets primarily composed of millet bran peptides offers consumers a convenient, precisely dosed option for daily blood pressure management. This requires rigorous efficacy evaluations, safety assessments, and ultimately regulatory approval.

3. Key Component in Multi-Functional Formulations

Scientifically combine millet bran peptides with other natural ingredients possessing synergistic antihypertensive effects (e.g., celery seed extract, hawthorn extract, potassium-rich/sodium-poor minerals) to develop more comprehensive and consistently effective multi-functional products.

4. Application in Foods for Special Medical Purposes

For patients with specific conditions accompanied by hypertension (e.g., renal disease, post-cardiovascular surgery), millet bran peptides can serve as one of the functional protein sources in medical foods under

physician or clinical nutritionist guidance. This approach provides nutritional support while aiding blood pressure management.

IV. Key Technologies and Future Challenges

Transforming the potential of the laboratory into safe and effective products on the shelves still requires overcoming a series of scientific and engineering challenges:

1. Precise Preparation and Enrichment of Active Peptide Segments

Optimization of Enzymatic Hydrolysis Process: Not all enzymatic hydrolysis products exhibit high ACE inhibitory activity. Specific proteases (e.g., alkaline protease, flavor protease, pepsin-mimetic digestion) must be screened, and enzymatic digestion parameters optimized to selectively release C-terminal short peptides rich in hydrophobic amino acid residues like proline, phenylalanine, and tyrosine—common signature sequences of ACE-inhibitory peptides.

Separation and Purification Techniques: Ultrafiltration, chromatography, and similar technologies are required to enrich high-activity peptide segments with molecular weights below 1000 Dalton, removing large macromolecular proteins and impurities to enhance the product's specific activity (hypotensive efficacy per unit mass of product).

2. In Vivo Efficacy and Stability Validation

Animal Models and Clinical Trials: High in vitro ACE inhibition does not fully equate to effective in vivo blood pressure reduction. Validation

must be conducted using animal models such as spontaneously hypertensive rats, with final confirmation of safety and efficacy through human clinical trials.

Gastrointestinal Stability: Orally administered peptides must withstand degradation by gastric acid and intestinal proteases to be absorbed into the bloodstream with intact or partially active forms. Moderate modifications such as cyclization or lipidation of millet bran peptides, or encapsulation via microencapsulation technology, are key to enhancing their oral bioavailability.

3. In-Depth Exploration of Mechanism of Action

Current research on millet bran peptides remains relatively limited and primarily focuses on the ACE inhibition pathway. Future research should delve deeper into:

Structure-activity relationships of peptide sequences: Identifying specific amino acid sequences responsible for activity, achieving a cognitive leap from “mixture” to “defined entity.”

Multi-target interaction networks: Utilizing omics technologies to systematically investigate their comprehensive regulatory networks in vivo, including effects on vascular endothelial function, other components of the renin-angiotensin system, and the autonomic nervous system.

V. Conclusion and Outlook

The discovery and application of millet bran peptides exemplify the

successful integration of the “turning waste into treasure” concept with modern nutritional science. This transformation from an overlooked processing byproduct to a potential functional ingredient with a well-defined antihypertensive mechanism not only enhances the added value of agricultural products but also offers a new natural option for dietary prevention and non-pharmacological intervention of hypertension.

Looking ahead, with deeper research into millet bran polypeptide's amino acid sequence, structural characteristics, metabolic pathways in the body, and its interaction mechanisms with humans, we can expect to achieve an industrial upgrade from “crude extracts” to “standardized bioactive peptides.” Through interdisciplinary collaboration integrating biotechnology, food engineering, and clinical nutrition, millet bran peptides are poised to play a safe, effective, and sustainable role in the emerging markets of precision nutrition and personalized health management. This will breathe new vitality into this ancient crop as it addresses modern health challenges.