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Popular Article

Bioactive Peptides: Tiny Molecules with Big Benefits for Human Health

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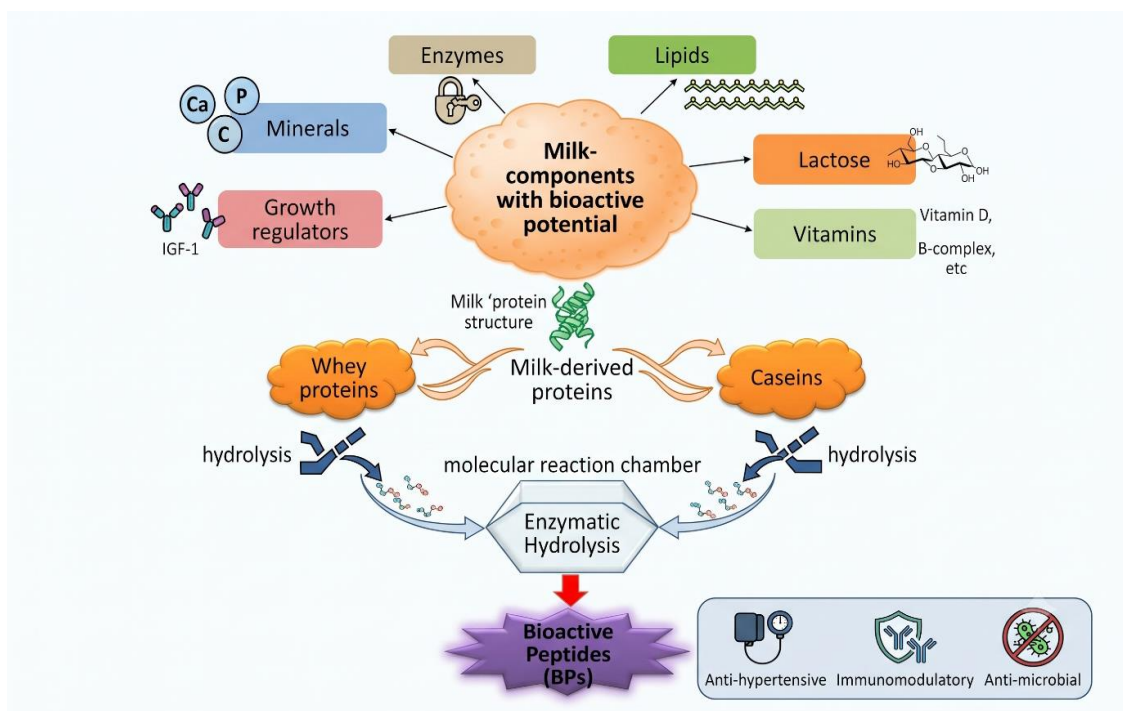
INTRODUCTION

Bioactive peptides are small protein fragments that can produce beneficial biological effects in the body. They are generally inactive when they are part of a larger protein molecule, but during digestion or food processing, proteins can be broken down into smaller peptide fragments. Some of these fragments can then act like tiny biological messengers, influencing important processes such as blood pressure regulation, antioxidant defense, immunity, and metabolism. Interestingly, foods that we consume every day—including milk and dairy products, eggs, meat, fish, cereals, pulses and fermented foods—can be sources of bioactive peptides.

Bioactive peptides

Proteins are made up of chains of amino acids. When digestive or microbial enzymes break down proteins, they produce shorter chains called peptides. Some of these peptides have biological activities beyond their nutritional role and are therefore called bioactive peptides.

A peptide's biological activity depends on its amino acid sequence, length, structure, and ability to interact with specific biological targets.

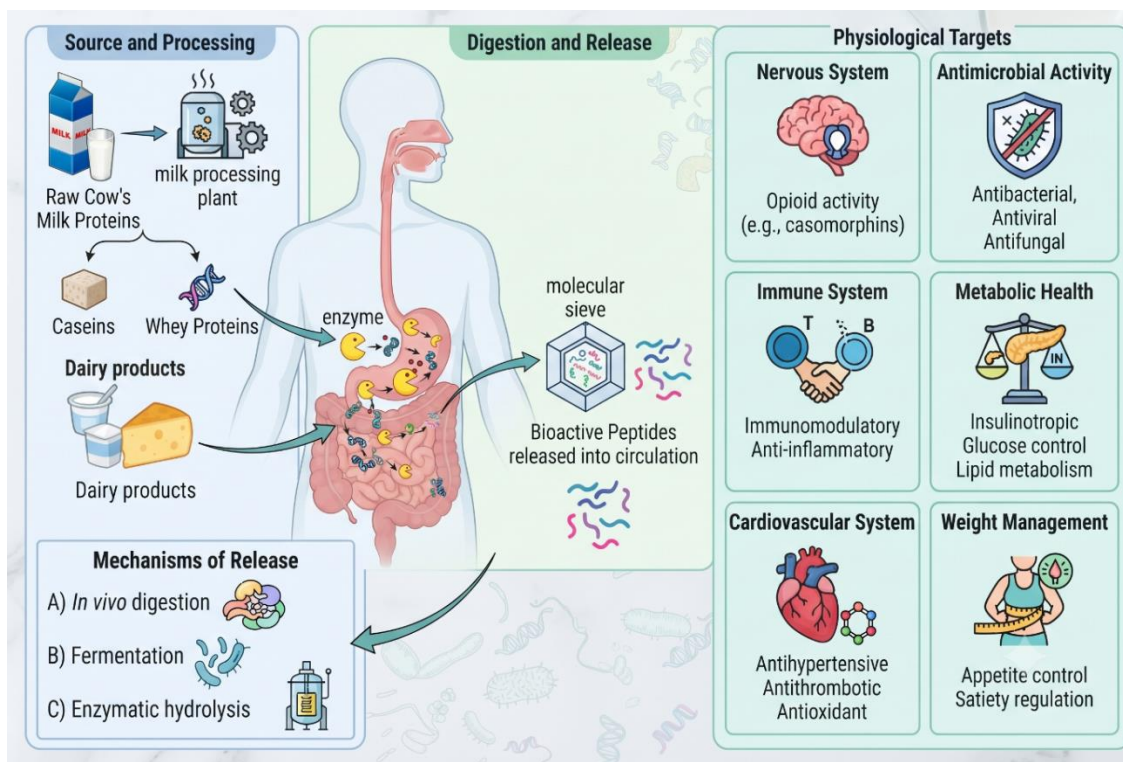


Production of Bioactive peptides

Bioactive peptides can be released from food proteins through several routes:

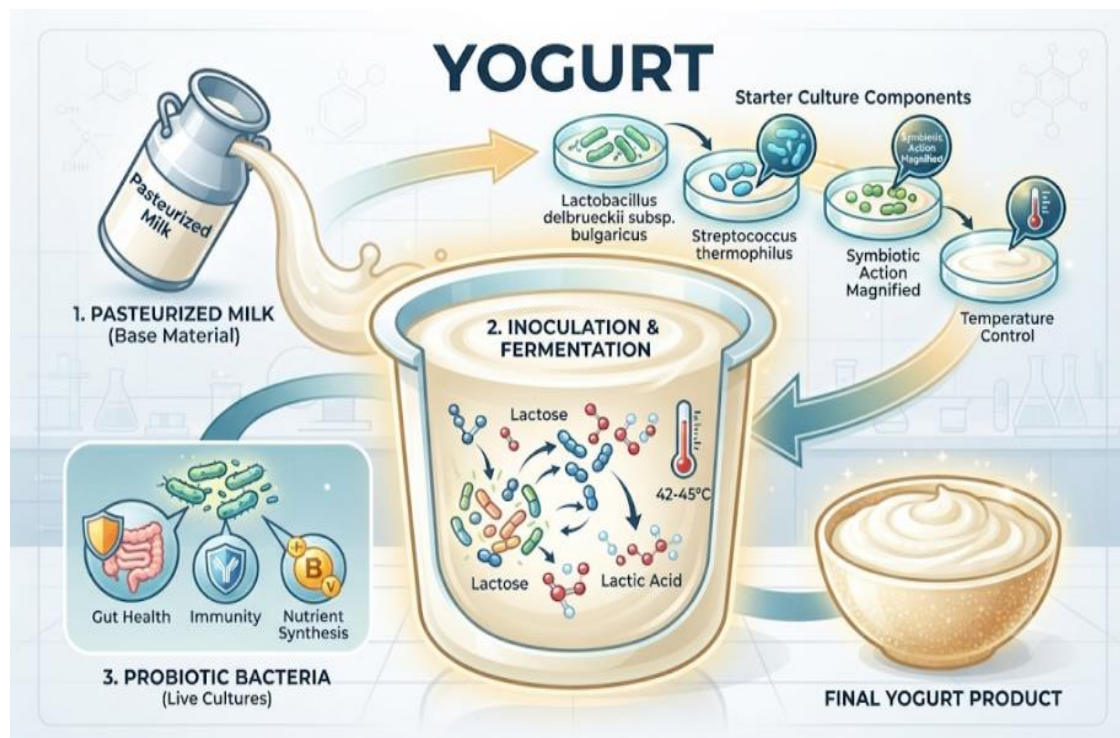
1. Digestion in the gastrointestinal tract

Digestive enzymes such as pepsin and pancreatic proteases break proteins into smaller peptides. Some of these peptides may survive digestion and exert biological effects.



2. Fermentation

Fermentation is an important natural method for generating bioactive peptides. Microorganisms such as *Lactobacillus* and other lactic acid bacteria produce proteolytic enzymes that break down food proteins. This is particularly relevant to dairy products such as yogurt, dahi and fermented milk.



3. Enzymatic hydrolysis

Food proteins can also be treated with selected enzymes under controlled conditions to release specific peptides. This approach is widely studied for developing functional foods and nutraceutical ingredients.

4. Food processing

Processes such as heating, fermentation, and maturation can modify proteins and influence the release or availability of bioactive peptides.

Major health-promoting roles of bioactive peptides

Researchers are investigating bioactive peptides for a wide range of physiological effects. Their potential roles include the following.

1. Supporting healthy blood pressure

One of the best-studied activities of food-derived peptides is angiotensin-converting enzyme (ACE) inhibition. ACE plays an important role in the renin-angiotensin system, which regulates blood pressure. Certain peptides can inhibit ACE activity and may therefore help maintain healthy blood pressure. Several peptides derived from milk proteins, particularly caseins and whey proteins, have

demonstrated ACE-inhibitory activity. However, it is important to distinguish between a peptide showing ACE inhibition in a laboratory study and a food product being proven to treat hypertension in humans.

2. Antioxidant protection

Our bodies naturally produce reactive oxygen species during normal metabolism. Excessive oxidative stress can damage cellular components. Some bioactive peptides can act as antioxidants or support antioxidant defenses by scavenging reactive species or influencing antioxidant mechanisms. Peptides containing amino acids such as tyrosine, tryptophan, methionine, cysteine, and histidine may contribute to antioxidant activity. This has generated considerable interest in using food proteins as sources of naturally occurring antioxidant peptides.

3. Antimicrobial activity

Some bioactive peptides can interact with microbial cell membranes and interfere with microbial growth. These antimicrobial peptides have attracted attention because of the growing global concern surrounding antimicrobial resistance. Milk is particularly interesting in this context. Certain milk-associated proteins and peptides, including lactoferrin-derived peptides, have shown antimicrobial properties. Researchers are investigating these peptides for applications in food preservation, animal health, and human health.

4. Immune-modulating effects

The immune system is a highly complex network involving cells, proteins and signaling molecules. Some food-derived peptides have demonstrated immunomodulatory properties in experimental studies. They may influence immune-cell activity or inflammatory signaling pathways. Milk proteins are again of particular interest because digestion and fermentation can generate peptides with potential immunomodulatory functions.

5. Possible role in metabolic health

Researchers are also studying bioactive peptides for their potential influence on glucose metabolism, insulin response, and lipid metabolism. Certain peptides may interact with enzymes involved in carbohydrate digestion or glucose regulation. Others are being investigated for their potential effects on fat metabolism. This area is promising, but much more human research is needed before making specific health claims.

6. Bone and mineral health

Some milk-derived peptides may help improve the availability or utilization of minerals such as calcium. Certain casein-derived peptides, commonly referred to as casein phosphopeptides (CPPs), can bind minerals and may help maintain calcium in a soluble form. This has led to interest in their possible applications in foods designed to support bone and mineral nutrition.

7. Potential effects on brain and nervous-system health

An emerging area of research is how food-derived peptides interact with the nervous system. Some peptides have been investigated for potential neuroprotective, cognitive, or stress-related effects.

Researchers are examining whether particular food peptides can influence neurotransmitter systems or other biological pathways. This field is still evolving, and stronger clinical evidence is needed.

Milk: A treasure house of bioactive peptides

For dairy scientists and dairy industries, bioactive peptides are particularly exciting because milk is naturally rich in proteins that can serve as precursors for many functional peptides. The major milk proteins—caseins and whey proteins—contain sequences that can potentially be released during digestion or fermentation.

For example:

- Caseins can generate ACE-inhibitory, mineral-binding, and other functional peptides.
- β -Lactoglobulin and α -lactalbumin can release peptides with antioxidant and other biological activities.
- Lactoferrin can generate peptides with antimicrobial and other potentially beneficial activities.
- Fermentation of milk by selected microorganisms can increase the release of certain bioactive peptides.

Therefore, traditional fermented dairy products such as curd, dahi and yogurt may be more than sources of protein and calcium—they can also serve as vehicles for potentially beneficial peptide components.

Bioactive peptides and functional foods

The growing interest in bioactive peptides is closely connected with the concept of functional foods. A functional food provides nutritional value while potentially offering additional physiological benefits. This opens interesting possibilities for the dairy sector. Researchers are exploring products such as:

- Peptide-enriched fermented milk
- Functional yogurt and dahi
- Whey-protein hydrolysates
- Fermented dairy beverages
- Specialized nutritional products
- Dairy-based nutraceutical ingredients

The challenge is to develop products that contain effective peptide sequences in sufficient amounts while maintaining good taste, stability, safety, and consumer acceptance.

CONCLUSION

Bioactive peptides may be tiny molecules, but their potential impact is enormous. Derived from proteins in everyday foods, these small peptide fragments are being investigated for roles in blood pressure regulation, antioxidant defense, antimicrobial activity, immune modulation, metabolic

health, and mineral utilization. Milk and dairy proteins are particularly promising sources, making bioactive peptides an exciting area for future dairy research and product development.

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