ISOLATION, CHARACTERIZATION, AND THERAPEUTIC USE OF MILK BIOACTIVE PEPTIDES

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ABSTRACT

Milk bioactive peptides are short chains of amino acids derived from milk proteins, exhibiting a range of biological activities. These peptides have garnered significant interest due to their potential therapeutic benefits. They can be naturally released during digestion or produced through enzymatic hydrolysis, fermentation, or recombinant technologies. Various methods, including chromatography, electrophoresis, and mass spectrometry, are employed to isolate and characterize these peptides. These bioactive peptides have demonstrated numerous health benefits, including antioxidant, anti-inflammatory, antimicrobial, antihypertensive, immunomodulatory, antithrombotic, and neuroprotective effects. Their ability to enhance mineral bioavailability, support gut health, and exhibit anti-cancer and hypocholesterolemic properties further highlights their therapeutic potential. The integration of milk-derived peptides into functional foods, nutraceuticals, and pharmaceutical formulations offers promising avenues for disease prevention and management. Ongoing research focuses on optimizing their bioavailability, stability, and delivery systems to maximize their efficacy. This review provides an overview of the extraction techniques, biological activities, and potential applications of milk bioactive peptides in human health.

INTRODUCTION

Milk is a rich source of bioactive compounds, including proteins, peptides, and lipids. Among these, milk-derived bioactive peptides have gained notable attention for their therapeutic potential. These peptides are primarily derived from proteins such as casein and whey and have demonstrated various biological effects.

ISOLATION OF MILK BIOACTIVE PEPTIDES

The process of isolating milk bioactive peptides typically involves:

1. **Protein Extraction**: Techniques such as centrifugation, filtration, and precipitation are employed to extract proteins from milk.
2. **Enzymatic Hydrolysis**: The extracted proteins are hydrolyzed into peptides using enzymes like trypsin, chymotrypsin, and pepsin.
3. **Peptide Separation**: Methods such as chromatography, electrophoresis, and ultrafiltration are utilized to separate the resulting peptides.

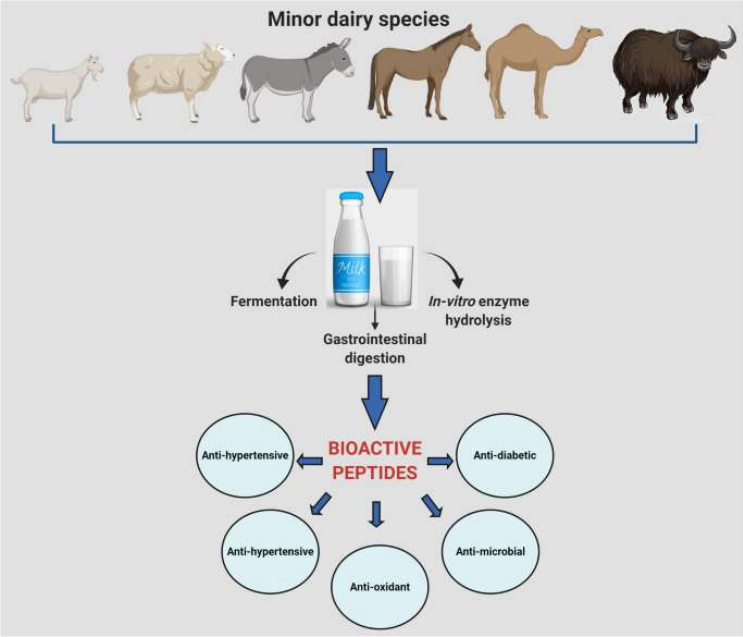
CHARACTERIZATION OF MILK BIOACTIVE PEPTIDES

Characterizing these peptides involves several methods:

1. **Amino Acid Sequencing**: Techniques such as Edman degradation and mass spectrometry are used to determine peptide sequences.
2. **Molecular Weight Determination**: Methods like gel permeation chromatography and mass

spectrometry help ascertain the molecular weight of peptides.

3. **Structural Analysis**: Nuclear magnetic resonance (NMR) spectroscopy and X-ray crystallography are employed to study peptide structures.



THERAPEUTIC APPLICATIONS OF MILK BIOACTIVE PEPTIDES

1. Antioxidant Properties

Milk-derived bioactive peptides help combat oxidative stress by scavenging free radicals and reducing oxidative damage. These peptides can enhance the body's natural antioxidant defense mechanisms, including the up regulation of enzymes like superoxide dismutase (SOD) and glutathione peroxidase. By preventing lipid peroxidation and oxidative DNA damage, they contribute to cellular health and may reduce the risk of chronic diseases like cardiovascular diseases, neurodegenerative disorders, and cancer.

2. Anti-inflammatory Effects

Certain milk peptides exhibit potent anti-inflammatory activity by inhibiting pro-inflammatory cytokines (e.g., IL-6, TNF-α) and down regulating inflammatory pathways. These peptides can suppress the activation of NF-κB, a key regulator of inflammation, thereby reducing tissue damage and chronic inflammatory conditions. They may help in conditions like arthritis, inflammatory bowel disease (IBD), and metabolic syndromes.

3. Antimicrobial Effects

Milk-derived peptides, such as lactoferrin and casein-derived peptides, possess antimicrobial properties against bacteria, viruses, and fungi. These peptides work by disrupting microbial cell membranes, inhibiting bacterial adhesion, or modulating the host immune response. Their broad-spectrum antimicrobial activity makes them potential alternatives to conventional antibiotics and useful in preventing infections and promoting gut health.

4. Antihypertensive Effects

Some milk peptides, particularly those derived from casein and whey proteins, have been shown to inhibit angiotensin-converting enzyme (ACE), which plays a role in blood pressure regulation. By blocking ACE activity, these peptides help lower blood pressure and reduce the risk of hypertension. Regular

consumption of milk peptides has been linked to improved endothelial function and overall cardiovascular health.

5. Immunomodulatory Effects

Bioactive peptides in milk can modulate immune responses by stimulating immune cells, enhancing the production of immunoglobulins, and regulating cytokine levels. These effects contribute to better immunity against infections and may also help manage autoimmune conditions. Lactoferrin, for example, has been extensively studied for its ability to enhance both innate and adaptive immune responses.

6. Opioid-like Activity

Certain milk peptides, known as casomorphins, bind to opioid receptors in the brain and gastrointestinal tract. These peptides can have calming effects, reducing stress and anxiety, and improving mood. Additionally, they influence gut motility and digestion, potentially providing relief from gastrointestinal disorders such as irritable bowel syndrome (IBS).

7. Antithrombotic Properties

Some milk peptides act as natural anticoagulants by inhibiting platelet aggregation and fibrin clot formation. This can help reduce the risk of thrombosis and related cardiovascular complications such as stroke and heart attacks. These peptides work by modulating enzymes involved in blood clotting cascades.

8. Anti-cancer Properties

Certain milk-derived peptides have demonstrated anticancer activity by inhibiting cancer cell growth, promoting apoptosis (programmed cell death), and preventing tumor angiogenesis. Lactoferrin-derived peptides, for instance, have been shown to suppress tumor growth in various types of cancers, including breast, colon, and prostate cancer. These peptides work by modulating immune responses and interfering with cancer cell signaling pathways.

09. Hypocholesterolemic Effects

Some milk peptides contribute to cholesterol reduction by inhibiting the absorption of dietary cholesterol and regulating lipid metabolism. Peptides derived from whey protein, for instance, have been shown to reduce LDL (bad) cholesterol levels while increasing HDL (good) cholesterol. This lipid-lowering effect plays a crucial role in cardiovascular disease prevention.

10. Neuroprotective Benefits

Milk-derived peptides exhibit neuroprotective properties by reducing neuroinflammation, improving synaptic function, and protecting neurons from oxidative damage. These peptides may help prevent or manage neurodegenerative diseases such as Alzheimer's and Parkinson's disease. They also influence cognitive function, potentially improving memory and learning abilities.

FUTURE DIRECTIONS

Further research is necessary to:

1. **Enhance Isolation and Characterization Techniques**: Improve the efficiency of methods used to isolate and characterize milk bioactive peptides.
2. **Explore Therapeutic Potential**: Investigate the potential uses of these peptides in treating a wider range of diseases.
3. **Develop Novel Delivery Methods**: Create advanced delivery systems for administering milk bioactive peptides, such as oral and injectable forms.

CONCLUSION

Milk bioactive peptides represent a promising area of research with potential therapeutic applications across various health conditions. The processes of isolating, characterizing, and utilizing these peptides are fundamental for developing new treatment options.

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