Probiotics as a Good Companion for a Healthy life

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Abstract

The age-old wisdom of Hippocrates, "Let food be the medicine and medicine be the food," certainly applies to probiotics. Probiotics are live microbial components of food that offer health advantages by boosting immune system. They belong to the category of functional foods that can beneficially influence biological and physiological processes in human nutrition. Probiotics have been utilized in food and alcoholic fermentation for millennia, and in the past century, scientists have discovered their ability to prevent and treat various human diseases. Probiotics can come in various forms, including powder, liquid, gel, paste, granules, and capsules or sachets. They may consist of bacteria, molds, or yeast. Among the various bacterial genera suggested as probiotic cultures, Lactobacillus and Bifidobacterium are the most widely utilized. Choosing an effective probiotic strain involves a complex selection process. The beneficial properties of probiotics can be categorized into four main areas: antimicrobial, biochemical, physiological, and immunological effects.

Introduction

Probiotics are products containing live microorganisms engineered to support or increase beneficial bacteria in the body, while prebiotics are foods, usually high fiber content, that serve as nutrition for the body's own microflora. Probiotics, whether in supplements or food forms, have become a principal ingredient in the realm of functional foods. They have always been crucial and targeted commercially for their potential health benefits. The term "probiotic" was coined by Werner Kollath in 1953, derived from the Latin "pro" and the Greek "βιο" meaning "for life." Kollath defined probiotics as active organisms with essential roles in promoting various aspects of health. According to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), probiotics are live microbes that, when consumed in adequate amounts, confer health benefits on their host organisms. Several bacterial species from genera such as *Pediococcus, Lactococcus, Enterococcus, Streptococcus, Propionibacterium, and Bacillus* are considered possible contender for probiotic status.

Criteria that Define Bacteria as Probiotics

Based on three criteria, bacteria are classified as probiotics: They must be safe to consume, meeting the standards of Generally Recognized As Safe (GRAS) regulations, scientific evidence must demonstrate specific bacteria produce measurable health benefits and the bacteria must remain alive and be administered in sufficient quantities from manufacturing through consumption to reach the human gut (Tuohy *et al.*, 2003).

Promising Health Benefits of Probiotics

Lifestyle choices and dietary habits significantly influence each person's overall health. In ancient times, humans likely consumed food abundant in live bacteria. As hygiene practices advanced, our diets shifted towards cleaner food with fewer live bacteria. The diet in Western countries has been linked to the onset of diseases like heart disease and cancer, attributed to high levels of saturated fats and sugars, insufficient intake of vegetables and fruits, and a lower presence of beneficial omega-3 fatty acids. The reduction in fermented foods in the Western diet coincides with an increase in inflammatory conditions, allergies, obesity, heart disease, and cancers, which correlates with decreased probiotic intake. Probiotics offer numerous nutritional and therapeutic benefits to the host. They can act beneficially by mechanisms such as antimicrobial activity and modulation of indigenous microbes. Probiotics are widely believed to help restore intestinal flora balance, offering protection against infections and enhancing metabolism. However, guaranteeing the survival and effectiveness of orally taken microorganisms in the challenging conditions of the human digestive system continues to be a significant challenge.

Probiotic Impact on Gut Wellness

The gastrointestinal tract is crucial for nutrient digestion and absorption, as well as maintaining the integrity of the mucosal barrier. Within the human GI tract, a diverse community of commensal bacteria actively impacts physiological processes. Alterations in intestinal microflora can be achieved through antibiotics, probiotics, prebiotics, and fecal transplantation. The metabolic activity of the gut microbiome significantly affects the overall health of the host, influencing both positive and negative outcomes. Disruption of the delicate balance in microflora (known as eubiosis) can lead to acute and chronic clinical conditions such as antibiotic-associated diarrhea (AAD), ulcers, inflammatory bowel disease (IBD), and irritable bowel syndrome (IBS). Furthermore, research indicates that microbial dysbiosis may contribute to the development of certain gastrointestinal cancers. Restoring a healthy gut microbiota is a practical approach for managing intestinal diseases. Probiotics have been shown to enhance microbial richness and diversity, increase the production of enzymes like lactase, improve the immune micro-environment, and enhance intestinal barrier function. These mechanisms contribute to the alleviation of intestinal diseases. Various studies have explored the efficacy of probiotics in treating intestinal disorders.

How Probiotics Work

Significant progress has been achieved in the field of probiotics, yet a definitive breakthrough in understanding their mechanism of action remains elusive. Probiotics potentially benefit the human body through several primary mechanisms: competitive exclusion of pathogens, enhancement of intestinal barrier functions, modulation of the immune system, and production of neurotransmitters (Tuohy *et al.*, 2003). Probiotics compete with pathogens for nutrients and receptor sites in the gut, hindering their survival. They also function as antimicrobial agents by generating substances such as short-chain fatty acids (SCFA), organic acids, hydrogen peroxide, and bacteriocins, which reduce pathogenic bacteria in the gut. Furthermore, probiotics enhance intestinal barrier function by promoting mucin protein production, regulating the expression of tight junction proteins like occludin and claudin 1, and influencing immune responses within the gut. Probiotics additionally modulate both innate and adaptive immune responses by interacting with dendritic cells, macrophages, and B and T lymphocytes. They promote the production of anti-inflammatory cytokines while engaging with intestinal epithelial cells and attracting macrophages and mononuclear cells. Moreover, probiotics have the capability to synthesize neurotransmitters in the gut via the gut-brain axis. Certain probiotic strains can alter serotonin, gamma-aminobutyric acid (GABA), and dopamine levels, influencing mood, behavior, gut motility, and stress-related pathways.

Utilization of Probiotics in Food Sector

The decline in fermented foods in Western diets has paralleled an increase in inflammatory conditions, allergies, obesity, heart disease, and cancers, likely due to reduced intake of probiotics. Probiotics provide numerous nutritional and therapeutic benefits to the host, functioning through mechanisms such as antimicrobial activity and modulation of indigenous microbes (Suvorov, 2013). They are widely believed to contribute to restoring intestinal flora balance, thereby safeguarding against infections and improving metabolism. However, ensuring the survival and effectiveness of orally ingested microorganisms in the harsh digestive tract environment remains a significant challenge. The market for probiotics-based products is projected to reach $75 billion by 2025. This substantial growth in sales has spurred considerable interest among food producers in developing new probiotic-enhanced products. Probiotics are commonly incorporated into dairy, beverage, baking, and edible film industries.

Probiotic Products

Probiotic products intended for human consumption are categorized into three main types: infant foods, cultured milk products, and pharmaceutical preparations (Butel, 2014). There has been significant commercial interest in incorporating Bifidobacteria into baby foods and developing "bifidus milk" enriched with growth-promoting bifidogenic factors like lactulose and fructo-oligosaccharides. Examples of such products include Lactana-B and Femilact. Numerous dairy-derived products containing probiotic bacteria are available on the market, such as sour cream, ice cream, buttermilk, yogurt, powdered milk, and frozen desserts. Probiotic cultures can be added during fermentation alongside traditional yogurt starters, added to the final

fermented products, or introduced to fresh products before distribution. For instance, "Cultura," produced in Denmark, involves fermenting protein-enriched whole milk with *B. bifidum and L. acidophilus*, offering a shelf life of at least 20 days post-production. Another example is "Biograde," produced by over 45 dairies in Germany, made by fermenting milk with *S. thermophilus, B. bifidum, and L. acidophilus*, all of which are clinically proven to confer health benefits.

Challenges

Upon ingestion, probiotics must withstand the conditions of the stomach and intestines while maintaining their cellular integrity and functional properties. Among probiotic cells, lactic acid bacteria are particularly susceptible to inhibition by bile juices. S. thermophilus, in particular, is highly sensitive to bile. Compared to other probiotics, lactic acid bacteria exhibit lower hydrophobicity, affecting their ability to adhere to hydrocarbons. The lack of robust scientific evidence supporting the benefits of probiotics, alongside concerns about potential adverse effects, limits their application in product formulations. Products must demonstrate minimal harmful effects to gain market acceptance and regulatory approval. Approval from relevant authorities, such as FSSAI (Food Safety and Standards Authority of India) in the case of food products in India, is crucial to ensure legal compliance and consumer confidence in product quality. Consumer awareness plays a central role in promoting the benefits and uses of probiotic products, influencing consumer purchasing decisions. The quality and safety of products ultimately determine their market demand, and consistent improvement in product quality is essential for sustaining company growth. The role of culture media is vital in biomass production for probiotics. These specialized media provide essential nutrients like carbon sources, nitrogen, minerals, vitamins, and growth factors necessary for microbial growth. Optimized culture media are critical for achieving high biomass yields under optimal cultural and physical conditions, which are periodically maintained to support probiotic cell growth effectively.

Future prospects

Probiotics are microorganisms known for their health benefits and are typically consumed as dietary supplements rather than medicines. Because probiotics mainly consist of unicellular bacteria, they can be easily cultivated under controlled conditions such as optimal temperature, pH levels, and sufficient nutrients and minerals in a suitable medium. Production of probiotics on a large scale to meet demand for functional foods is achievable without substantial investment, often utilizing large tanks known as bioreactors in industrial settings. Different types of cells require specific bioreactor designs tailored to their nutritional needs. The effectiveness of probiotics is enhanced when they proliferate within their cultivation medium, which necessitates continuous maintenance of optimal growth conditions. Despite their numerous health benefits, probiotics have been associated with uncertainties. For instance, in young children with compromised immune systems or severe illnesses, probiotic cells can enter the bloodstream, a condition known as bacteremia, which may lead to sepsis. This can trigger a significant immune response, potentially exacerbating the severity of the illness and complicating recovery.

Conclusion

Probiotics have established physiological effects with clear mechanisms, yet further research is necessary to fully understand how they enhance health and prevent various diseases. Clinical trials have shown promising evidence that probiotics can potentially alleviate gastrointestinal and other disorders. However, despite some understanding of the molecular mechanisms involved in their benefits, clinical efficacy remains uncertain for many autoimmune and inflammatory conditions. Additionally, much of the research has been conducted in animal models, highlighting the need to translate these findings to humans. Currently, genetically modified lactic acid bacteria are being explored to deliver specialized health-promoting compounds, although most research involving recombinant bacteria focuses on vaccines. Nevertheless, genetically modified bacteria offer opportunities for innovative strategies in delivering bioactive molecules to mucosal tissues. More rigorous and reproducible clinical trials are essential to ascertain the efficacy, limitations, and safety of probiotics, particularly their effects on the immune system. In conclusion, integrating probiotics into novel functional foods holds potential for promoting human health, with ongoing advancements in

methodology and research contributing to their application by food producers.

References

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Table 1 List of probiotic microbes and the food it is found

Brand/ trade name	**Food type**	**Sources/strains**
Aciforce	Freeze-dried product	*Lactococcus lactis, Lactobacillus acidophilus, Enterococcus faecium, Bifidobacterium bifidum*
Actimel	Probiotic yoghurt drink	*Lactobacillus casei Immunitas*
Activia	Creamy yoghurt	*Bifidus Actiregularis*
Bactisubtil	Freeze-dried product	*Bacillus* sp. strain IP5832
Hellus	Dairy product	*Lactobacillus fermentum* ME-3
Proflora	Freeze-dried product	*Lactobacillus acidophilus, Lactobacillus delbrueckii* subsp. *bulgaricus, Streptococcus thermophilus, Bifidobacterium*
Provie	Fruit drink	*Lactobacillus plantarum*
ProViva	Natural fruit drink and yoghurt	*Lactobacillus plantarum*
Rela	Yoghurt, cultured milk and juice	*Lactobacillus reuteri*
Yakult	Milk drink	*Lactobacillus casei* Shirota
Yosa	Yoghurt-like oat product	*Lactobacillus acidophilus, Bifidobacterium lactis*
Vifit	Yoghurt drink	*Lactobacillus* strain
Vitamel	Dairy products	*Lactobacillus casei GG, Bifidobacterium bifidum, Lactobacillus acidophilus*

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