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Functional and Probiotic Assessment of Lactic Acid Bacteria Derived from Commercial Milk Products

Swati Sharma[1], **Jayanand**[2*]

[1,2*]Department of Biological Engineering & Life Sciences, Shobhit Institute of Engineering & Technology (Deemed-to-be-University), Modipuram, Meerut, Uttar Pradesh

Corresponding author: **Jayanand**

E-mail address: jayanand@shobhituniversity.ac.in

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ABSTRACT
LAB is a large category of advantageous microorganisms that is broadly found in fermented dairy items, and has been studied extensively because of its probiotic and functional characteristics. The commercial products of milk (yogurt, cheese, kefir, and fermented milk drinks) are valuable sources of technologically valuable and health-promoting LAB strains. Over the last few decades, the growing consumer awareness concerning functional foods has led to greater research in the isolation and characterization of probiotic LAB obtained as commercial dairy matrices. The current review critically explores the diversity, isolation methods, functional aspects, probiotic assessment criteria, safety issues, molecular characterization methods, and applicability of technology of LAB obtained using commercial milk products. It focuses on gastrointestinal tolerance, antimicrobial action, adhesion, immunomodulatory, cholesterol-lowering, and antioxidant effects. In addition, the development of genomics and other technologies based on the omics is presented to show the new horizons in the validation of probiotics. The review offers a combined perception of the practical use of dairy-based LAB and their future prospects as therapeutic and nutraceutical agents.

INTRODUCTION

Lactic acid bacteria are Gram-positive and non-sporing, catalase-negative microorganisms that ferment carbohydrates to lactic acid as the final product(Parmar et al., 2024a). They are phylogenetically heterogenous, and they usually pertain to genera of *Lactobacillus, Lactococcus, Streptococcus, Bifidobacterium, or Leuconostoc*. These microorganisms are inherently linked to nutrient-dense foodstuffs such as milk and milk products and these microorganisms are important in fermentation, food preservation, flavor formation, and texture adjustment(Parmar, Patel, et al., 2025). In addition to technological significance, LAB have extensive scientific interest because they have potential to be used as probiotics and have been reported to have health promotion.

The term probiotics is used to refer to live microorganisms that when taken in sufficient doses, have health benefits on the host. Dairy products of commercial use are one of the most typical and dependable means of probiotics delivery, due to their positive buffering capacity, the composition of nutrients, and the acceptance by consumers(Parmar, Arya, et al., 2025). The pressure of the growing demand of functional foods has encouraged the research works in terms of the systematic isolation and testing of LAB of commercial milk products with the aim of identifying strains with improved probiotic properties and therapeutic capabilities(R. K. Arya et al., 2020).

Commercial Milk Products Diversity of LAB

Milk products sold commercially offer an intricate ecological niche, which sustains an enormous number of LAB species. Starter cultures used in yogurt include Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus which are synergistic in their fermentation. The strains of Lactobacillus acidophilus and the representatives of the genus Bifidobacterium can be used as probiotics variants(Kumar et al., 2020). Both starter and non-starter LAB are found in cheese varieties and help in the process of ripening and formation of the flavors. Kefir is a traditional fermented milk drink, which has a symbiotic consortium of LAB, yeasts, and acetic acid bacteria entrenched in the grains of kefir(Shishir et al., 2026).

The microbial diversity found in commercial milk products is also contingent upon a number of factors, such as the quality of raw milks, composition of starter cultures, conditions of fermentation, as well as storage methods. The contemporary molecular methods have demonstrated that even the commercially standardized products can have various native LAB strains, some of which have been found to have promising probiotic properties. This variety has led to the possibility of screening of new strains with distinct functional attributes(Aschemann-Witzel et al., 2020).

Dairy-Derived LAB Functional Characterization

An important procedure of making decisions about the probiotic appropriateness of LAB strains is functional assessment. The possibility of living under severe gastrointestinal conditions is one of the major requirements. Acid tolerance tests reflect the gastric pH (2.0 to 3.0) whereas the bile tolerance tests test the ability to survive with physiological concentration of bile. Strains that are able to survive in this condition are regarded as being strong probiotic candidates(R. Arya, 2020).

Other important functional properties are antimicrobial activity. LAB generate organic acids, hydrogen peroxide and bacteriocins that prevent pathogenic microorganisms. As an example, the Nisin that is secreted by some strains of Lactococcus lactis is

highly active against Gram-positive pathogens. Lab-derived LAB have been shown to inhibit other pathogens like Escherichia coli and Salmonella enterica indicating that they may be used in gastrointestinal protection(Alonso-Vargas et al., 2025).
Colonization and contact with the host immune system require sticking to the intestinal epithelial cells. The determination of adhesion capacity is usually achieved using in vitro studies and the use of Caco-2 and HT-29 cell lines. Other functional features are autoaggregation, coaggregation with pathogens and biofilm formation which help them to exclude their competitors and reinforce their guts barrier. Enzymatic activities like the production of août-galactosidase are another enzyme that increases the lactose digestion and improves the tolerance of lactose-intolerant subjects(R. Arya et al., 2021).

Health-Promoting Effects

LAB that are sourced in dairy products have a variety of health-promoting effects that can be justified by in vitro, animal, and clinical research. The mechanism of immunomodulatory activity is the balance of cytokine production and macrophage stimulation in addition to increasing the secretory IgA level. Some of the strains have been shown to balance both pro and anti-inflammatory reactions thus leading to immune homeostasis(Liu et al., 2024).
The ability of cholesterol to lower the cholesterol level is ascribed to the following mechanisms: cholesterol assimilation, bile salt hydrolase activity and co-precipitation with deconjugated bile salts. Also, antioxidant activity, determined with the help of such assays as DPPH and ABTS radical scavenging tests, implies the ability of LAB to counteract free radicals and mitigate oxidative stress. There is also emerging evidence on the possibility of anticancer effect by altering the composition of intestinal microbiota, short-chain fatty acid production, and causing apoptosis in cancer cell lines(Sar et al., 2025).
The capacity of LAB to reestablish gut microbial homeostasis is especially topical when it comes to antibiotic-associated dysbiosis and GI infections. Probiotic LAB help in keeping the intestinal integrity and microbial balance by synthesizing antimicrobial compounds and preventing adhesion sites.

Safety Assessment and Regulatory Assessment

A condition of probiotic commercialization is safety evaluation. Profiling on antibiotic susceptibility also ensures that the candidates are not carrying any transferable resistance genes. The test of hemolytic activity on blood agar will confirm the lack of any pathogenic character. Further validation of safety is done through molecular screening of virulence gene and plasmid-based resistance determinants(Parmar et al., 2024b).
Regulatory systems across the world differ, however, most LAB species that are utilized in dairy products are covered under Generally Recognized as Safe (GRAS) or Qualified Presumption of safety (QPS). However, safety evaluation should be done at strain levels, since effects of probiotics and safety profiles are not species-specific, but strain-specific(Maftei et al., 2024).

Technological and Industrial Relevance

In addition to health advantages, LAB has to bear technological properties that can be applied in the industries. The speedy acidification, exopolysaccharide formation and synthesis of flavor compounds adds to desirable product characteristics. Processing and storage viability is of critical importance, since the efficacy of probiotics relies on the provision of sufficient viable cells at the point of consumption. Protective delivery systems and microencapsulation have been created to improve gastrointestinal passage survival. The functional and technological characteristics must be incorporated in making the next generation probiotic dairy products. The developments of fermentation technology, strain enhancement, and formulation planning persist in increasing the dairy-derived LAB in food and nutraceuticals(Abedin et al., 2024).

Future Perspectives

The latest advancements made in genomics, transcriptomics, proteomics, and metabolomics have transformed the knowledge on probiotic mechanisms. Whole-genome sequencing makes possible the determination of genetic determinants to stress resistance, adhesion, and metabolite production. Systems biology methodologies have been used to map host-microbe interactions. Moreover, there are emerging areas in the personalized nutrition and precision probiotics that seek to customize the probiotic interventions based on the personal microbiome profiles. Clinical validation of health claims still requires continued clinical validation by well-designed randomized controlled trials. Joint work between microbiologists, food technologists, clinicians and regulatory bodies will fasten the application of laboratory results to evidence-based functional dairy products(Al-Kharousi, 2025).

Conclusion

Lactic acid-based bacteria, which are based on commercial milk products, are a potential source of probiotic strains which are functionally active and clinically relevant. They have to be comprehensively evaluated (isolation, molecular identification, functional characterization, safety assessment, and technological validation) to determine their probiotic efficacy. Dairy-derived LAB have a great possibility to contribute to the creation of new functional foods that can help promote human health and prevent illnesses with the help of incorporating advanced omics technologies and clinical research.

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