REVIEW ON IMPORTANCE OF LACTIC ACID BACTERIA IN MILK PROCESSING INDUSTRY

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SUMMARY: Species of lactic acid bacteria (LAB) represent as potential microorganisms and have been widely applied in food fermentation worldwide. Milk fermentation process has been relied on the activity of LAB, where transformation of milk to good quality of fermented milk products made possible. The presence of LAB in milk fermentation can be either as spontaneous or inoculated starter cultures. Both of them are promising cultures to be explored in fermented milk manufacture. LAB have a role in milk fermentation to produce acid which is important as preservative agents and generating flavour of the products. They also produce exopoly saccharides which are essential as texture formation. Considering the existing reports on several health-promoting properties as well as their generally recognized as safe (GRAS) status of LAB, they can be widely used in the developing of new fermented milk products.

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INTRODUCTION

Lactic Acid Bacteria (LAB) play a crucial role in the milk industry, significantly impacting various aspects of dairy production and quality Lactic acid bacteria represent as the most extensively studied microorganisms for milk fermentation (Ghosh *et al*., 2019). The presence of LAB in milk fermentation can be either as spontaneous or inoculated starter cultures. Milk itself is known as one of the natural habitats of LAB (Gemechu, 2015). Although under spontaneous fermentations the growth of LAB cannot be predicted or controlled, but this procedure has been practiced and carried out traditionally for years. A procedure called as back slopping is often used. In general, the technology of milk fermentation is relatively simple and cost-effective. On the other hand, standardized fermented milk products are produced and manufactured in large-scale production under controlled conditions and become an important industrial application of LAB as starter cultures. There are some important features of LAB starters in fermented milk products. A single potential starter culture will dominate and reduce the diversity of microorganisms in fermented milk products compare to that of products under natural fermentation. In this review we focus on the potential role of LAB in milk fermentation based on their properties that support the development of fermented milk products (García *et al.,* 2020).

1. IMPORTANCE OF LACTIC ACID BACTERIA

Milk fermentation process has been relied on the activity of LAB, which play a crucial role in converting milk as raw material to fermented milk products. In milk fermentation industry, various industrial strains of LAB are used as starter cultures. Starter cultures of LAB were obtained from sequence activities and passed a process of isolation, selection and confirmation. Several behaviors as the characteristics of each individual selected strains of LAB has been established and used in the production of fermented milk products industrially. The most important properties of LAB are their ability to acidify milk and to generate flavour and texture, by converting milk protein due to their proteolytic activities (Kieliszek *et al.,* 2021). The mild acid taste and pleasant fresh are characteristics of fermented milk products such as yoghurt and cheese (Ranadheera *et al.,* 2021).

2.1. Preservative Property of Lactic Acid Bacteria

Milk and fermented milk products are favorable substrates for the growth of microorganisms that may bring to spoilage condition. The most well known characteristics of LAB related to preservative property is their ability to produce acid, which in turn exhibit antimicrobial activity. Acidification of the milk protects the milk against spoilage microorganisms and proliferation of pathogens. LAB also releases antimicrobial metabolites so called

bacteriocins (Zacharof and Lovitt, 2012). Both acids and bacteriocins are great potential to be used in food preservation, which are considered as safe natural preservatives (Ahmad *et al.,* 2021).

2.1.1. *Acid Production*

Organic acids is the end product of carbohydrate metabolism produced by BAL. Homo fermentative species of LAB convert sugars in milk mostly into lactic acid, whereas the hetero fermentative species convert lactose into lactic acid, acetic acid, ethanol and CO_2. Production of lactic acid by LAB is strain depended. The newly identified Lactobacillus paracasei subsp. paracasei CHB2121 was reported to produce high concentrations of L (+)-lactic acid efficiently. It produced 192 g/L lactic acid from medium containing 200 g/L of glucose, with 3.99 g/(Lh) productivity, and 0.96 g/g yield. In addition, the optical purity of the produced lactic acid was estimated to be 96.6% L(+)-lactic acid. This strain may be suitable for use in the industrial production of lactic acid (Moon *et al.,* 2012).

A study using 10 strains of Lactobacillus showed that organic acid production was considerably influenced by media used. Three different media including skimmed milk, de Mann Rogosa Sharpe (MRS) broth and Jerusalem artichoke were used. The highest acidity was obtained in MRS broth and the weakest acidification was found in skimmed milk. Lactobacillus casei Shirota produced the highest and Lactobacillus rhamnosus VT1 the lowest amount of substances being estimated as titratable acidity. The study pointed at the dissimilarity of organic acid production of Lactobacillus strains (Zalán *et al.,* 2010). Two Lactococcus lactis strains were studied for their ability to repress the growth of bacterial pathogens. The study showed that L. lactis subsp. lactis biovar. diacetylactis strongly inhibits the pathogenic E. coli and Salmonella enteritidis strains tested. The main inhibitory effect seemed to be associated with fast acid production which resulted in rapid pH reduction. Given these good attributes of L.lactis subsp. lactis biovar. diacetylactis, it can be recommended for use as a starter culture, preferably as a freeze-dried culture, to prepare cultured milk similar to naturally fermented milk (Samelis *et al.,* 2023).

In a yoghurt preservation period experiment and mould-proof accelerated testing at 4˚C, addition of 2% (v/v) Lactobacillus casei AST18 in yogurt completely inhibited the growth of Penicillium sp., which was used as indicator fungi. L. casei AST18 produced lactic acid and cyclo-(Leu-Pro) as antifungal compounds. The addition of L. casei AST18 improved the quantity of Lactobacillus, but the number of Streptococcus lactis in 2% AST18-added yoghurt decreased by 1.0 Log (cfu/mL) compared with that in the blank group. Direct use of antifungal strains as protective cultures presents important application value to the food industry (Zhang *et al.,* 2013).

LAB from raw milk of cow, goat and ewe are detected to have antifungal activity against 4 spoilage fungi, Penicillium expansum, Mucor plumbeus, Kluyveromyces lactis and Pichia anomala. Raw milk of cow and goat can be considered as reservoir of antifungal LAB. The most active colonies with antifungal activity belonged to Lactobacillus spp. It is suggested that their apparent specialization may be linked to organic acids and/or ethanol produced, and the tested fungi are sensitive to those molecules. Acetic acid produced by heterofermentative Lactobacilli certainly played a role in antifungal activity (Fidan *et al.,* 2022).

2.1.2. Bacteriocins Production

Bacteriocins are substances of protein structure, either proteins or polypeptides, that possessing antimicrobial activities and produced during the primary phase of bacterial growth. Generally bacteriocins only active against closely related bacterial species. Milk fermented with L. lactis W8 can be used as a rich source of nisin for commercial purposes (Murat, 2021). Pediocin PA-1 produced by Pediococcus acidilactici is an equally promising bio preservative in foods as nisin. However, its industrial scale production has not been taken up yet due to lack of a comparable scale of production. To improve pediocin production heterologous systems have been studied which have used a variety of promoters for enhanced expression, secretory proteins for fusion and peptide tags to facilitate purification. Pediocin is also an attractive antimicrobial agent against many pathogenic bacteria and hence has pharmaceutics application (Porto *et al.,* 2017).

2.2. Flavor Formation

There are varieties of fermented milk products available in the market from different parts of the world. Variation may due to the different technology applied and strains of LAB used. Cheese is among fermented milk products with high variety and may be classified based on different criteria that include the contribution of LAB strains in the ripening process. Starter cultures of LAB are responsible for the formation of cheese flavor. Several LAB are widely used and their role can be divided into starters, and non-starters, including adjunct, cultures. Main role of starter cultures is to produce acid during manufacture and also contribute to the ripening process. Non-starter cultures do not responsible to the production of acid, but they contribute more during ripening process. Flavor formation and the characteristics flavor of individual cheese varieties are develop during ripening process by both starter and non-starter LAB. All LAB are active synergistically to produce specific flavor of the cheese products. Several steps in cheese flavor development by LAB including metabolism of lactose, lactate and citrate; lipolysis that liberate free

fatty acids and proteolysis where degradation of casein followed by amino acid catabolism occurred (Mazhar *et al.*, 2020).

Effort to improve the quality of cheese by producing cheese with specific flavor has been of increasing interest and researches focusing on the use of potential starters derived new and powerful technology have been widely carried out (Centeno *et al.*, 2023).

The most common LAB cultures used in yoghurt manufacture is Streptococcus thermophiles and Lactobacillus bulgaricus. They, in association and synergistically, produce volatile metabolites that determine the flavour of yoghurt. The mutual benefit between them occurred by releasing the amino acids from the milk as well as organic acids and therefore they produced more lactic acid and aromatic compounds (Canon *et al.*, 2020).

2.2.1. *Starter Cultures of Lactic Acid Bacteria for Cheese Production*

Starter cultures of LAB can be either mesophilic from the genera of Lactococcus and Leuconostoc or thermophilic from the genera of Streptococcus and Lactobacillus. Among species, Lactococcus lactis Streptococcus thermophilus and Lactobacillus helveticus are intensively studied. L. helveticus is specialized of milk species and belong to the member of dairy niche species (Alexandraki *et al.*, 2019). Several cheese products are based on L. helveticus as starter. It is also known that L.helveticus have significant role in production of specific flavor compounds in Italian cheese types and de bittering of cheese (Chelladhurai *et al.*, 2023).

2.2.2. Non Starter Cultures of Lactic Acid Bacteria

Nonstarter LAB play important role in cheese ripening. Nonstarter LAB released enzymes that participate in the basic role of the transformation of curd in cheese. Since the population of nonstarter LAB is uncontrolled, it is suggested that selection of strains to be developed to maintain a certain cheese flavor (Carafa *et al.*, 2019).

2.3. Texture Development

Yoghurt is special fermented milk product which has a texture of soft and thicker compare to that of its raw material, the milk. The mild acid with pleasant fresh taste supported characteristics of yoghurt as an extraordinary fermented milk product. The texture of yoghurt is supported by production of exopolysaccharides (EPS), as viscosifying agent, produced by LAB. It is also suggested that is contributed by coagulation, as a result of neutralization of the negative charges on the milk proteins, as another effect of acid produced by LAB. EPS is produced by some of AB, depending on the strain (Yang *et al.*, 2014).

2.4. Nutritional-benefits of Lactic Acid Bacteria

Lactic Acid Bacteria (LAB) offer several nutritional benefits in the milk industry, contributing to both the quality and health aspects of dairy products. Here are some key benefits: LAB help break down lactose into lactic acid, making dairy products easier to digest, especially for individuals with lactose intolerance. Certain LAB strains act as probiotics, promoting a healthy gut micro biome. They can improve digestion, boost immune function, and may reduce the risk of gastrointestinal disorders (Samelis *et al.*,2023). LAB can synthesize essential vitamins, particularly B vitamins (like B12, riboflavin, and folate), which enhance the nutritional profile of fermented dairy products. Fermentation by LAB can increase the bioavailability of nutrients, making them more accessible for absorption by the body. This includes minerals like calcium and magnesium. LAB strains produce compounds with antioxidant properties, which can help combat oxidative stress and may contribute to overall health (Canon *et al.*,2020).

LAB can influence the fatty acid composition of dairy products, potentially increasing beneficial fatty acids like conjugated linoleic acid (CLA), which is associated with various health benefits. Fermented dairy products often have a lower glycemic index, which can be beneficial for blood sugar management. LAB can produce bioactive peptides during fermentation that may have health-promoting properties, such as antihypertensive and immunomodulatory effects. LAB contributes significantly to the nutritional benefits of dairy products, enhancing their digestibility, nutritional value, and health-promoting properties, making them an essential component of the milk industry (Murat, 2021).

2.5. Health-promoting Property of Lactic Acid Bacteria

Lactic Acid Bacteria (LAB) play a crucial role in the milk industry, particularly in the fermentation of dairy products. Here are some of the key health benefits associated with LAB in this context: Many LAB strains, such as Lactobacillus and Bifidobacterium, are considered probiotics. They help maintain a healthy gut microbiome, improving digestion and enhancing immune function. LAB convert lactose into lactic acid, which can make fermented dairy products easier to digest for individuals with lactose intolerance, reducing symptoms like bloating and discomfort. Fermentation by LAB can enhance the bioavailability of nutrients, such as calcium and magnesium, making them easier for the body to absorb. During fermentation, LAB produces bioactive peptides that may have various health benefits, including antihypertensive and immunomodulatory effects (Alexandraki *et al.,* 2019).
LAB strains produce compounds that exhibit antioxidant properties, helping to combat oxidative stress and potentially reducing the risk of chronic diseases. LAB can help restore balance to the gut microbiota, which can be beneficial after antibiotic use or gastrointestinal disturbances. This balance supports overall digestive health. Some studies suggest that probiotics from LAB may help regulate metabolism and fat storage, potentially assisting in weight management. LAB can inhibit the growth of pathogenic bacteria in the gut, reducing the risk of infections and gastrointestinal diseases. Regular consumption of LAB-rich dairy products may boost the immune system's response to infections and inflammation. Certain LAB strains have been associated with reductions in cholesterol levels, contributing to cardiovascular health. LAB in the milk industry not only enhance the flavor and texture of dairy products but also offer a range of health benefits that support digestive health, nutrient absorption, immune function, and overall well-being (Mazhar *et al.,* 2020).
The high demand of fermented milk products is due to the health property generating from consumption of fermented milk products. Bioactive peptides produced from hydrolysis of casein in milk generated by L. helveticus have been reviewed and showed effect of antihypertensive, immunomodulatory activity, anti-cancer and calcium binding ability. L. helveticus is known as one of LAB which has efficient photolytic system. Fermented milk products are reported to contribute to human health through several mechanisms (Chen *et al.,*2023). LAB is in the first rank of listed organisms as species used in probiotic preparation. LAB, in general, showed to possess most of the requirements for strains to be called as probiotics (Bubnov *et al.,* 2018).

3. CONCLUSION AND RECOMMENDATIONS

Lactic Acid Bacteria (LAB) play a crucial role in the milk industry, significantly impacting various aspects of dairy production and quality. Here are some key conclusions regarding their importance:-LAB are essential for the fermentation process in products like yogurt, cheese, and kefir. They convert lactose into lactic acid, which not only preserves the milk but also enhances flavor and texture. The production of lactic acid lowers the pH of dairy products, creating an environment that inhibits the growth of spoilage organisms and pathogenic bacteria. This contributes to food safety and extends the shelf life of dairy products. LAB can enhance the nutritional profile of dairy products by increasing the bioavailability of nutrients, producing vitamins (such as B vitamins), and improving digestibility, particularly for lactose-intolerant individuals. LAB contributes to the functional properties of dairy products, such as texture, viscosity, and creaminess. These characteristics are vital for consumer acceptance and marketability. Certain strains of LAB are recognized as probiotics, offering health benefits beyond basic nutrition. They can support gut health, boost the immune system, and may even have positive effects on mental health. LAB are pivotal in the development of new dairy products and flavors, catering to evolving consumer preferences for health-oriented and specialty items. LAB are indispensable in the milk industry, enhancing product safety, quality, nutritional value, and consumer appeal. Their multifunctional roles underscore the importance of ongoing research and innovation in harnessing their potential for future dairy applications.

Lactic Acid Bacteria (LAB) are crucial in the milk industry for various reasons**.** Based on these conclusions, the following recommendations are proposed:

- Incorporate specific probiotic LAB strains into dairy products to promote gut health and improve consumer health benefits.
- Implement rigorous quality control measures to monitor LAB populations in production to ensure product safety and consistency.
- Educate consumers about the benefits of LAB in dairy products through labeling, marketing campaigns, and informational resources.

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