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Research progress on probiotic properties of probiotics in fermented dair

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ABSTRACT
With the continuous development of social economy, people's cognitive level and economic level continue to improve, and people's pursuit of quality in food is getting higher and higher. In recent years, yogurt, as one of the most popular probiotic fermented dairy products, has often appeared in the popular choice of post-meal snacks, and the probiotics among them are one of the important raw materials for fermented dairy products. Probiotics are a type of active microorganisms that can regulate the host mucosa and system immune function or regulate the balance of bacterial flora in the intestinal tract by colonizing in the human body, thereby helping the body's intestinal nutrition ab sorption and health. Probiotic yogurt is usually fermented by adding probiotics to milk. During the fermentation process, these probiotics multiply and produce beneficial substances, eventually making yogurt products containing active probiotics. By studying the nutritional value relationship between fermented dairy products and probiotics, it can provide consumers with healthier food choices and can also promote the healthy development of my country's dairy industry to a certain extent. Based on this, this study review s the probiotic properties of probiotics and provides theoretical support for future basic research on probiotics.

KEYWORDS
fermented dairy products; probiotics; probiotic properties

1 Introduction

In China, the research and application of probiotics started late, but it has received great attention in recent years. Domestic research mainly focuses on food research on probiotics, application of probiotics and identification. In addition, in the Chinese market, well-known brands such as Mengniu and Yili are rushing to launch new dairy product s with probiotics as their selling points. During the research and development of these products, research results from modern food science and microbiology are comprehensively used to ensure the activity and stability of probiotics in dairy products. Product anal ysis results show that different brands of dairy products have different emphasis on pro biotic types, content and product formulas, providing consumers with rich choices. Despite this, the research and development and application of probiotic products still face certain technical barriers and market challenges, such as the maintenance of beneficial bacteria activity and product functional labeling specifications, which need further in-depth discussion among domestic researchers. Because probiotics developed early abroad, their characteristics research shows a trend of parallel expansion of depth and breadth. Many well-known research institutions and leading companies, such as Danone and Yakult, have made rich achievements in the research and application development of probiotics. Through cooperation with academic institutions, these companies have further promoted the scientific research and productization of probiotics. Based on this, this stud y will explore the application of probiotics in fermented dairy products based on an international perspective, and provide reference and reference for the development of my country ’ s probiotic industry.

2 Related study on the properties of probiotics

2.1 Types of probiotics

Probiotics originally refer to a class of substances that can regulate the microbial ecology in the host's intestine, but now this concept has been expanded to "a living microbiota that can have a positive impact on the host's health when consumed in moderation" (Liu et al. 2018)[1] . Most of these microorganisms are derived from our natural gut microbiota, which cover the inhibition of pathogenic bacterial settlement, regulating host immune system responses, and maintaining the stable state of the gut microbiota (Mols ka and Reguła 2019) [2]. Among the many probiotics, lactic acid bacteria (LAB) is the most common category, covering multiple genera such as Lactobacillus, Sertodiana, Lactococcus, Carnivorous, Enterococcus, Pilococci, Streptococcus, Quadcoccus, Roaming Cyperus, Rheumatoidea, Vessella and Bifidobacteria (Jing et al. 2015) [3]. In addition to these, there are other genera such as yeast and Bacillus. Among these probiotics, Bifido bacterium and Lactobacillus are the most widely used, and they are often added to a variety of functional foods and nutritional supplements (Plaza-Diaz et al. 2019) [4] .

As the public's pursuit of a healthy lifestyle is increasing, the market demand for probiotics has also risen. In the fields of medicines and food, the use of commercial probiotics is also increasing. At present, among the products sold on the market, common probiotic species include Crhamnosus GG, Lactobacillus mucinus DSM 17938, Bifidob acter long subspecies BB536, and Bifidobacter long infant subspecies R0033. In my country, there are more than 40 species of bacteria approved for food, of which the number of species suitable for infant and young children has expanded to 14.

2.2 Probiotic screening criteria

Probiotic products must strictly abide by high standards, covering various requirements such as safety, efficacy and quality. To ensure the quality and efficacy of probiotics in functional foods, we will conduct a series of performance evaluations on the isolated strains, covering tolerance, adhesion, safety and functional characteristics. In particular, the ability of the strain to adhere to the gastrointestinal tract and its resistance to g astrointestinal substances such as gastric acid and bile salts are key factors in the selection of probiotics (Kanimozhi and Sukumar 2024)[5] . After being challenged by gastric acid and bile salts, probiotics must have the ability to survive and regenerate in the intestines to play their health-promoting role. Therefore, it is indispensable to evaluate the ac id resistance and bile salt tolerance of the strain.

Furthermore, we have to pay attention to the safety assessment link. At this stage, when evaluating the safety of probiotic strains, my country usually focuses on four key areas: strain identification, animal infection experiments, toxin generation experiments, and drug resistance detection. Among the numerous evaluation criteria, consideration of strain sensitivity to antibiotics is particularly critical. Once the strain becomes resistant to antibiotics, it may fail in the treatment or prevention of intestinal diseases. Also, this resistance may also have a negative impact on human health, and resistance genes may be transferred from strains to human pathogens (Katiku et al. 2022) [6]. Therefore, the evaluation of strain resistance is particularly important.

In the selection process of probiotics, the evaluation of their adhesion ability also plays a decisive role. Probiotics rely on adhesion to settle on the host's intestinal mucosal cells, thereby building biofilms and secreting a variety of metabolites, thus forming a natural defense line and producing a series of physiological benefits to the host. For exogenous probiotic products, their adhesion and settlement ability in the intestine are one of the key indicators to measure their effectiveness (Xiong Shijin et al., 2019) [7] . Evaluating the adhesion of probiotics usually involves measurements of hydrophobicity, self-cohesion and cocohesion on the surface of strains, as well as the detection of their ability to adhere to human intestinal cells. Hydrocarbon adhesion tests are a comm on method for evaluating the surface hydrophobicity of strains. Although protein com pounds on the surface of the strain increase hydrophobicity, favoring the contact between microorganisms and host cells, which is regarded as an important marker of adhesion, studies have also shown that it is not always directly related to adhesion rates in human cell experiments (Margalho et al. 2021) [8] . Therefore, this indicator alone is not enough. It is also necessary to combine other indicators (such as self-cohesion and cocohesion) and in vitro cell experiments to explore the adhesion of microorganisms in depth. After the strain's tolerance, safety and adhesion is evaluated, its function can be e valuated, its probiotic potential can be explored, and new probiotic resources can be developed.

2.3 Functionality of probiotics

Moderate intake of probiotics can bring many health benefits to the host. Among them, its most well-known utility is to maintain the balance and stability of the microbiome in the intestine, thereby promoting digestive system function, and alleviating symptoms such as irritable bowel syndrome, diarrhea and constipation. The main ways i n which probiotics have a positive impact on the host include the release of antibacterial substances, occupying adhesion points and nutrient resources, strengthening intestinal defense barriers, and regulating immune responses (see Figure 1-1).

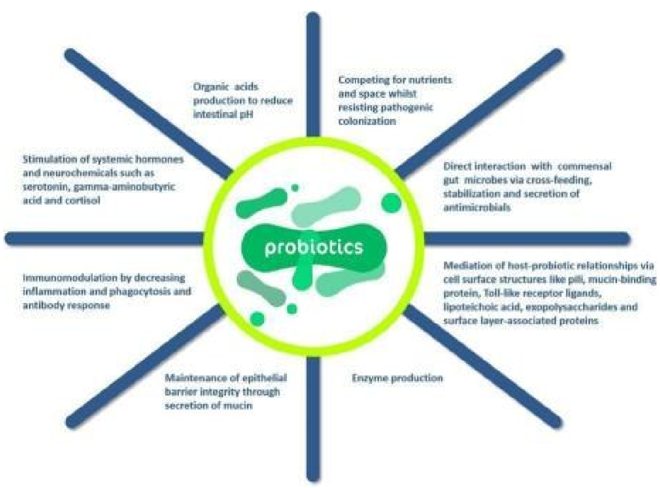

Figure 1-1 The mechanism of action of probiotics (Ashaolu 2020)

Recent studies have shown that probiotics have many benefits, including reducing lactose intolerance, reducing blood cholesterol, fighting cancer, preventing and treating allergic reactions (Sivamaruthi et al. 2020)[9] . Lei et al. (2021) [10] found that Lactobacillus sake CJLS03 can help obese patients reduce body fat without causing serious adverse reactions; at the same time, studies have confirmed that probiotics can effectively alleviate non-alcoholic fatty liver. Its mechanism of action may be related to regulating lipid metabolism, reducing liver fat accumulation, restoring intestinal flora balance, repairing intestinal barriers, and reducing inflammatory responses. In addition, Zeng et al. (2019) [11] induces type 2 diabetes in rats through a high-fat diet and low-dose streptozotocin. The results showed that the NL41 strain of paracetaccacia can reduce insulin resistance and oxidative stress in rats and prevent diabetes by protecting β cellular function. L ee et al. (2018) [12] found that Veszius sinus effusion JW15 enhances the immune system by increasing NK cell (natural killer cell) activity. Probiotics also produce a variety of nutrients during culture, among which short-chain fatty acids may be key regulators in promoting the growth of intestinal epithelial cells. Studies have also shown that certain probiotic strains can reduce the incidence of Helicobacter pylori by 5-10% and effectively alleviate the resulting conditions (Alvi et al. 2016) [13]. Meanwhile, the latest research points out that probiotic treatment alone or in combination can significantly improve memory disorders caused by Helicobacter pylori (Seddighi et al. 2024)[14].

Furthermore, the application of probiotics in food can not only improve the shelf life, taste and texture of food, but also have many benefits. Among the many probiotics, lactic acid bacteria occupy the mainstream, such as Bifidobacterium and Lactobacillus. These lactic acid bacteria can produce a variety of beneficial metabolites, such as bactericin, rocetin and hydrogen peroxide.

These are low molecular weight compounds that can inhibit harmful microorganisms. Adding probiotics to edible films can effectively inhibit the growth of spoiled bacteria and can also improve the nutrition and taste of fruits and vegetables during storage. Mo re importantly, these probiotics produce active substances that are safe and natural and harmless to the human body, so they become healthier and more environmentally friendly options than traditional preservatives and antibiotics.

3 Study on the probiotic properties of probiotics in fermented dairy products

3.1 Fermented milk

At a time when the quality of life is increasing, people's dietary requirements have long exceeded the simple fullness, and they value food safety, health, environmental protection and nutrition more. Therefore, the dairy market urgently needs to launch products with special effects. Fermented milk is one of them. It forms a curd-like product through the lactic acid fermentation process by ingesting lactic acid bacteria, such as L. delbrueckii subsp. bulgaricus and S. salivarius subsp. thermophilus in the milk. In this process, microbial strains that can produce lactic acid must be introduced, such as lactic acid bacteria. They consume lactose in milk and convert it into lactic acid, thereby reducing the pH of the milk and increasing its acidity. (Guo et al. 2020) [15]. L. delbrueckii subsp. bulgaric us and S. salivarius subsp. thermophilus are commonly used fermented bacterial species in the production of fermented milk. The metabolites produced by these two types of bacteria during fermentation can promote each other's growth, and at the same time help to form the flavor components of fermented milk. Among fermented milk, the most common lactic acid bacteria categories include Lactobacillus, Streptococcus, Enterococcus, Lactococcus, and Beaded Bacteria (Galli et al. 2021)[16].

The taste and aroma of dairy products mainly comes from a series of complex biochemical processes, which can be divided into two levels: first, the basic reaction, including the decomposition of sugar, the hydrolysis of proteins, and the degradation of fats; second, further metabolic activities, involving changes in amino acids and fatty acids. During the fermentation process, the sugars, lipids and proteins in the milk are broken down and transformed by fermented microorganisms and their secreted enzymes. For example, certain enzymes convert lactose into lactic acid while simultaneously producing galactose, as well as a range of flavor compounds such as oligosaccharides, polysaccha rides, acetaldehyde, butanone and acetone. The role of lipase is to catalyze the decomposition of triglycerides and produce short-chain free fatty acids with unique odors. Hydrolysis of proteins helps release lipid compounds in milk and supplies free amino acids, which are the basis for the formation of various aromatic compounds and have a direct impact on the flavor of fermented milk. It can be seen that fermented microorganisms pl ay a crucial role in the manufacturing of fermented dairy products (Yu et al., 2024) [17] .

3.2 Probiotic properties of probiotics in fermented dairy products

Research in the field of probiotics has gradually deepened, coupled with the continuous optimization Dairy products are gradually becoming functional dairy products. In this regard, people have conducted a more in-depth exploration of the active effects of probiotics in this type of fermented dairy products. According to Wang et al. (2023) [18], buckwheat milk was fermented using probiotics and gavage experiments in mice. The results showed that buck wheat fermented milk had significant effects in controlling mouse body weight growth.

At the same time, the intestinal flora diversity and short-chain fatty acid production of m ice edible buckwheat fermented milk were improved. Another study pointed out that daily intake of fermented milk containing C. rhamnosus SD11 and maltitol can reduce the production of Streptococcus mutans in the oral cavity, thereby enhancing oral health and re ducing the risk of tooth decay (Rungsri et al., 2017)[19]. Fermenting cow's milk with Lactobacillus brevis DL1-11 can result in a high content of γ-aminobutyric acid (GABA), a neurotransmitter that helps relieve anxiety and improve sleep. Its role may be related to regulating intestinal flora and increasing the levels of short-chain fatty acids such as butyr ic acid (Yu et al., 2020). Cheng et al. (2023) [20] found that probiotic dairy products fermented by C. paracetamol JY062 and Lactobacillus Grignard JM1 can relieve constipation by improving gastrointestinal motility and intestinal flora. In addition, Jitpakdee et al. (2021) [21] isolated two lactic acid bacteria strains of P. pentosaccharide ENM104 and P. lactobacterium lactobacterium SPS109 from fermented foods. Compared with dairy product s fermented by a single strain, the cholesterol content of mixed fermented dairy products has a lower cholesterol content, a higher GABA content, and a stronger antioxidant activity. Probiotic fermented milk composed of three probiotic strains, Lactobacillus acidophilus CL1285, C. C. casei LBC80R and C. rhamnosus CLR2, can reduce the total number of abnormal crypt foci (ACF) in rats, thereby preventing colon cancer (Preston, 2018)[22].

Although numerous studies have revealed the multiple health benefits of probiotic fermented milk, such as reducing cholesterol in the blood, optimizing intestinal function, preventing multiple cancers, enhancing immunity, and reducing symptoms of Alzheimer's disease, however, when converting this discovery into actual products and putting it to the market, due to in-depth research on safety and applicable populations, commercial promotion cases are rare. In addition, when selecting bacterial strains, we must not only consider their safety, but also pay attention to their actual application effects. According to research, strains such as Lactobacillus plantarum DP3, C. C. C. C. C. DP21, C. C. C. DP25, Lactobacillus brevis DP30 and Lactobacillus brevis DP31 showed excellent functional properties and no adverse effects were found, so they were considered potential probiotic candidates. In particular, the probiotic effects of Lactobacillus lactobacillus DP3 and C. coix DP21 are more prominent (Bakhshayesh, 2018)[23]. If these strains are used as fermentation agents, they can not only improve the quality and health function of dairy products, but also effectively reduce the cholesterol content in fermen ted products. Although the safety assessment of these strains has been completed, their practical application in dairy fermentation process still needs to be verified.

4 Conclusion

At present, the development trend and prospects of probiotic fermented dairy pro ducts in the market are broad, and more and more people are aware of a healthy diet. Therefore, the purchase of probiotic fermented dairy products represented by yogurt has steadily increased. However, the quality and cost of probiotic fermented dairy products on the market are not stable enough, and there is a lack of a large number of review articles to provide reference for the fermented dairy industry. Although there are many clinical studies on the characteristics of probiotics in fermented dairy products, there is relatively lack of summary and summary of the characteristics of probiotics. Therefore, this article summarizes its characteristics and has certain theoretical support and practical reference value for future product research and development and further rese arch and expansion in this field.

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