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Effects of Lactic Acid Bacteria on The Quality of Steamed Bread and Its Process Transformation

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Abstract. The starter culture of traditional steamed buns is composed of a variety of microorganisms, among which lactic acid bacteria are the main source of fermentation. The quality of the product is directly affected by the diversity and abundance of lactic acid bacteria. As a probiotic that plays an important role in many fields, lactic acid bacteria have an important impact on the quality of steamed buns. These effects include enhanced nutritional value, improved flavor, altered texture, extended shelf life, production of antioxidants, etc. The dough fermentation method in which lactic acid bacteria play a major role is called sourdough. It has better technological value than ordinary dough and is one of the research focuses of the food industry. This study explores the natural link between lactic acid bacteria and the flavor, texture, antioxidant activity, and nutritional value of steamed bun dough. At the same time, the effects of process improvement and the addition of new raw materials on the quality and nutritional properties of steamed buns fermented by lactic acid bacteria were explored.

Keywords: lactic acid bacteria; the flavor; antioxidant activity; nutritional value; Steamed Bread.

1. Introduction

Fermentation processes play a crucial role in various fields, including food and beverage production, biotechnology, and waste treatment, making them a valuable and versatile tool in many industries. Fermentation technologies are extremely important to the food business because they make it possible to preserve food goods, increase their shelf life, and still give them the desired sensory qualities. Additionally, they benefit food's ability to promote health since they include probiotics, nutrients and enhancing the product's microflora. They can also improve microbiological safety [1]. Fermentation processes are biological processes in which sugars are converted into other compounds, such as alcohol or organic acids, by microorganisms. These processes typically occur in the absence of oxygen and involve the action of enzymes produced by the microorganisms. One common example of fermentation is alcoholic fermentation, where yeast converts sugars into ethanol and carbon dioxide. This process is used in the production of alcoholic beverages such as beer and wine. Another example is lactic acid fermentation, which is carried out by certain bacteria. In this process, sugars are converted into lactic acid, which is used in the production of fermented foods like yogurt and sauerkraut.

Lactic acid bacteria (LAB), including Lactobacillus, Bifidobacterium, and Lactococcus, are a group of Gram-positive bacteria that play important roles in the food industry as well as in the gastrointestinal tracts of humans and animals. LAB are essential probiotic microorganisms with diverse beneficial functions and widespread applications in the food industry and health-related fields. In the food industry, LAB are widely used for fermentation and extending the shelf life of food products. The production of lactic acid by LAB inhibits the growth of spoilage and pathogenic bacteria, prolonging the storage time of food. Additionally, LAB impart unique flavors and textures to food products. Among other things, lactic fermentation is used to acidify milk, which results in the creation of fermented dairy goods including yogurts, cheese, butter, sour cream, etc. [2]. Additionally, the procedure is utilized to mature cold cuts and is responsible for the production and stabilization of vegetable silage and sourdough.

Apart from their applications in the food industry, LAB are extensively studied for their potential in improving human and animal health. LAB have various probiotic functions, including antimicrobial activity, regulation of gut microbiota balance, enhancement of immune response, and promotion of nutrient absorption. They inhibit the growth of harmful bacteria and improve the intestinal environment by producing lactic acid and other beneficial substances. Furthermore, LAB can improve the integrity of the intestinal mucosal barrier, reducing the permeation of harmful substances. Probiotic formulations often contain LAB to improve gut microbiota, enhance immune response, and prevent or treat certain gastrointestinal conditions. The probiotic effects of LAB have attracted increasing attention from scientists and researchers.

Chinese steamed bread (CSB) is a form of fermented and steamed wheat dish with unique cultural characteristics. It is also known as steamed bun or mantou. Over the past two thousand years, it has been a staple diet in various regions of China, and its ubiquity is growing. Due to the lack of harmful Maillard reaction products as acrylamide and furan, as well as potential low oil and sodium concentrations, it is regarded as a nutritious and healthy diet. In comparison to baked bread, the comparatively moderate steaming temperature (100 °C) during manufacture may result in better retention of a variety of endogenous and added nutrients [3]. Due to its importance, CSB-related research is a major focus of the Chinese food industry. Based on the role of LAB in fermentation, sourdough technology was developed and applied to the production of CSB. This article will discuss the impact of the application of LAB on CSB.

2. Sourdough

The importance of sourdough has increased along with consumer consumption trends, drawing attention on a global scale. Traditional biotechnology known as sour dough fermentation plays a significant role in fermented pasta, enhances bread's texture and flavor, delays bread aging, and prevents fungal and bacterial decay, among other things. As a result, it has significant potential for use in the human diet.

The traditional starter for many breads is sourdough, which is fermented by yeast and LAB. Traditional biotechnology known as sour dough fermentation plays a significant role in fermented pasta, enhances bread's texture and flavor, delays bread aging, and prevents fungal and bacterial decay, among other things. As a result, it has significant potential for use in the human diet. Through the separation of sourdough sponges, the effects of LAB and yeasts were discovered to interact. More than 20 different yeast species, including the most prevalent Saccharomyces cerevisiae, are present in the sour dough, along with more than 50 different Lactobacillus species, the majority of which are Lactobacillus sanfranciscensis, Lactobacillus brevis, Lactobacillus plantarum, and Lactobacillus fermentum [4, 5]. The importance of sourdough has increased along with consumer consumption trends, drawing attention on a global scale. Sourdough is also used to bake CSB.

3. Effects of LAB fermentation on the quality of steamed bread

3.1. Nutrition

In addition to improving the concentrations of various bioactive substances and mineral bioavailability during sourdough fermentation, LAB also reduces levels of harmful substances and starch bioavailability (applicable to products with low GI values), enhances the texture, flavor, and mouthfeel of whole grains, high-fiber grains, and gluten-free grains, and the fermentation of wheat bran sourdough can promote the hydrolysis of HPA effectively and increase absorption [6, 7].

Phytic acid reduces the bioavailability of minerals in grains. Although phytase exists in grains, yeasts and LAB, endogenous phytase is the most important enzyme in grains [8]. During the fermentation of sour dough, the heterogenous LAB acidified and the disulfide bond of gluten decreased, the activity of endogenous phytase and the substrate accessibility were improved, however, Lactobacillus strain-specific intracellular peptidases destroy the structure of gluten, leading to protein degradation and the production of amino acids [9]. The results showed that different LAB produced different organic acids and amino acids. For example, LAB type I fermentation produces more lactic acid and sweet amino acids than obligate LAB type II fermentation. The results showed that different LAB produced different organic acids and amino acids. For example, LAB type I fermentation produces more lactic acid and sweet amino acids than obligate LAB type II fermentation [10]. Exopolysaccharides produced by sour dough the fermentation process may enhance the structure of the gluten network, shrink dough strength and elasticity, mask the impact of organic acids, and produce oligosaccharides, which improve the nutritional value of gluten-free foods. The improvement effect was correlated with EPS yield, properties, and metabolites including organic acids during fermentation [6, 11, 12].

3.2. Flavor

The flavor of medium sourdough is mostly influenced by microbial and enzyme processes during fermentation. Microbiological fermentation results in the production of acid, alcohol, aldehydes, ketone, ester, and lactone [13]. Through their different metabolic pathways, Lactobacillus and yeasts create unique taste compounds that contribute to the flavor of sour dough. The development of the sour dough flavor was influenced in certain ways by the LAB's metabolism and its enzyme system. Half of the sugars in the glucose 6-phosphate pathway are converted to lactic acid, while the remaining sugar sources were converted into volatile flavor compounds like ethanol, acetic acid, and CO_2. Lactic acid is the end product of the glycolytic process in the two major metabolic pathways of LAB with less flavor. Because LAB fermentation sourdough will produce acid, pH reduction, so that the activity of protease and amylase in the dough to accelerate protein hydrolysis, protein hydrolysis can produce volatile flavor precursors and amino acid substrates that can be transformed into volatile flavor precursors by microorganisms, giving flour products richer flavor. LAB can also use their own enzyme system for amino acid metabolism [14]. Another important factor in the development of the sour dough flavor is the production of alcohols, aldehydes, and esters by yeast fermentation. Amino acids are also metabolized through the Ehrlich pathway to produce flavor compounds such aliphatic or aromatic fuel oils and fusel acids. Exopolysaccharides, which can be further subdivided into isopolysaccharides and Sy exopolysaccharides, are bacterial polysaccharides created and secreted into the environment by LAB. In order to manufacture exopolysaccharides and glycosyltransferase, sucrose is used as a sugar-based donor and result in a flavor change. Isopolysaccharides are mostly employed to enhance the qualities of baked goods, although their current applications are confined to enhancing the texture of yoghurt and other milk products [15].

3.3. Texture characteristics

Steamed bread's texture may be enhanced by fermentation with LAB. The steamed bread fermented by Lactobacillus plantarum had higher elasticity, less reversion, chewiness, cohesion, and hardness compared to the steamed bread fermented by yeast and yeast. The textural properties of the steamed bread made by LAB were hardness 9136.218, elasticity 0.90, cohesiveness 0.47, chewiness 3833.72, and reversibility 0.139, respectively [16]. It has been demonstrated that when yeast powder and LAB powder are combined to ferment steamed bread, the amount of LAB in the mixture must be greater than 0.3%. This ends up resulting in a smaller specific volume of fermented bread, increased hardness, increased acid production, and raised sour flavor. If the acidity of the dough is too high, the gluten network structure is destroyed, and the sensory quality of the fermented bread is reduced [17].

3.4. Preservation performance

The predominant bacteriocin-producing strain is Lactobacillus. In addition to being the subject of study on the preservation and preservation of microbial preparations, some bacteriocins have the potential to be used as food additives and can hinder the development and reproduction of harmful microorganisms and putrefaction bacteria. Our nation's traditional staple meal is steamed bread, however owing to its high-water content and nutritional value, it is prone to bacterial and mold growth and can degrade in as little as 16 hours, especially in environments with high temperatures and humidity [18]. The findings demonstrated that as the temperature rose, so did the rate of microbial development in the package-steamed bread. The shelf life is quite short and the crucial temperature range determining the rate of microbial growth was 20 to 30°C. It was noted that bacteria multiplied most quickly in the sealed steamed bread at room temperature (25°C), where the total number of colonies reached 10^6 CFU/G after 36 hours. Mold and yeast growth rates were also noted to be slow. The product also contained heat-resistant bacteria, which multiplied quickly during storage to become the dominant bacteria. By spraying a twice-concentrated solution of LAB fermentation supernatant on the surface of steamed bread, the quantity of bacteria and mold on the surface could be reduced by 17.6% and 9.5%, respectively, and the shelf life was increased by 2d. The outcomes demonstrated that preservation of steamed bread was somewhat influenced by LAB fermentation supernatant [19].

3.5. Antioxidant activity

When LAB ferment the dough, they produce various organic acids, such as lactic acid, acetic acid, and other metabolites. These organic acids can act as antioxidants, providing protection against oxidative damage caused by reactive oxygen species (ROS). ROS are highly reactive molecules that are generated during the dough fermentation process. They can damage lipids, proteins, and DNA, leading to the deterioration of the dough and the formation of off-flavors.

The antioxidant properties of LAB help to neutralize and scavenge these ROS, effectively reducing oxidative stress. This leads to improved dough quality, extended shelf life, and enhanced flavor profiles. Furthermore, LAB also enhance the production of natural antioxidants, such as phenolic compounds and vitamins, during the fermentation process. These antioxidants further contribute to the overall antioxidant capacity of the sour dough. The presence of LAB in sourdough not only improves its nutritional value but also enhances its resistance to oxidative damage, ultimately resulting in a healthier and more flavourful final product.

LAB in the sourdough can hydrolyze the protein in the grain to release the active peptides with antioxidant properties, the antioxidant properties of the products have been significantly improved [20]. The antioxidation property of steamed bread was increased, and the quality deterioration of steamed bread was obviously improved [21]. However, wheat flour has very little antioxidant content, and while fermentation can increase the biological activity of the grain, steaming will have a bigger influence on the grain's antioxidant qualities [22, 23]. This may be connected to the fact that most antioxidants are thermally unstable [24].

4. Process transformation of steamed bread

One of the main bacteria in the conventional starting culture for steaming bread is LAB. In the classic starter culture, there are certain types of yeast and acetic acid bacteria. These bacteria co-ferment to generate several compounds, including ethanol, carbon dioxide, lactic acid, and taste components. While the product fermented by a typical starter was unstable and easily contaminated by mixed bacteria, the steamed bread fermented by a single microbial population had a mediocre taste.

Research was done on the process and characteristics of steaming bread fermented by plant LAB. In specific volume and sensory evaluation, the steamed bread made with 0.7% high active dry yeast, 0.3% Lactobacillus plantarum, and 25 minutes of fermentation performed better than both common steamed bread and yeast steamed bread [16]. However, it is smaller than fermented steamed bread, and the steamed bread fermented by Lactobacillus plantarum has greater elasticity, less resilience, chewiness, cohesion and hardness. New research highlights the positive effects of yeast, LAB, and composite koji fermentation on the quality of wheat bran mantou. The study suggests that the amount of bran added is the primary factor affecting the quality of bran mantou, followed by the amount of LAB powder. The optimal conditions for the addition of LAB powder, bran, and koji are 0.150%, 6.0%, and 1.75%, respectively. Under these conditions, the resulting bran mantou has a light brown color, even and fine pores, a smooth surface, and a good sensory score [25].

In order to increase the nutritional value of steamed bread, more and more varieties of steamed bread products are being sold on the market. These products often have additional ingredients added to enhance nutrition and improve flavor. Therefore, they contain increased levels of dietary fiber, protein, and amino acids [26]. Soy milk, a common breakfast for Chinese people, is considered can be added to the ingredients of steamed breads.

Soybean milk is used as the primary raw material for fermented soybean milk, which is a type of fermented soybean product [22]. Some studies have done on how fermented soybean milk affects the quality of steamed bread and how different bean flours and bean by-products can alter the quality and flavor of flour products. After being ground, soybean fat is oxidized by lipoxygenase to form alcohols, spermidines, and aldehydes. Because soybean contains a lot of anti-nutritional components, it interferes with in vivo nutrient metabolism. In addition to promoting the breakdown of macromolecular components in soy milk and enhancing protein digestion and absorption, LAB fermentation can also reduce the odor of soy milk [27]. Other benefits of LAB fermentation include the degradation of antinutritional components in soybean and an improvement in the digestibility of oligosaccharides. In contrast to LAB directly fermented dough, the addition of fermented soya-bean milk made up for the lack of lysine content in common steamed bread and added new flavor and taste to it. Fermented soya-bean milk also prevents the formation of gluten networks in the dough. Fermented soymilk is a novel and versatile bean ingredient as a result.

5. Conclusion

Traditional steamed bread starters are complex microbial communities that can be easily contaminated by unrelated germs during manufacturing, are challenging to manage, and are challenging to industrialize. Although the flavor of the single strain steamed bread leaven is subpar, it is often stable. One of the microbial groups in the traditional steamed bread starter, LAB, produce a variety of nutrients, flavors, and active ingredients in the fermentation of CSB. LAB also aid in the fermentation of other microbial groups in the starter. As a result, LAB are crucial to the fermentation of CSB.

Traditional staple foods are given greater quality by using sour dough to ferment wheat flour to make steamed bread. This also improves the current scenario of traditional staple foods with single flavor and opens up a new prospect for traditional staple foods. Because the fermentation of sour dough is not a single process and is frequently influenced by numerous factors, including fermentation bacteria, fermentation environment, and processing conditions, etc., the quality of the final fermented product is unstable, making it difficult to produce on an industrial scale and requiring the use of sourdough in steamed bread. But as modern science and technology have advanced, the food industry has begun studying the mechanism of sour dough fermentation in-depth and testing different strains to determined which has a better effect on fermentation. There are still many uses for sour dough that can be discovered, including the use of native fermentation strains and the creation of novel bioactive compounds. To meet consumer demands, it is anticipated that the application potential of mixed fermentation, particularly LAB, will be fully realized in China's traditional staple cuisine including steamed bread.

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