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Microbial Fermentation and Its Application in Fermented Foods

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ABSTRACT

Fermented food is an important component of people's daily diet. The rich microbial community in fermented foods and the various biochemical reactions generated during the food fermentation process played an important role in enriching the production and processing technology of fermented foods, enhancing nutritional value, improving sensory quality, and forming unique flavors. This article provided a review of microbial fermentation and its application in fermented foods, aiming to provide theoretical basis for better leveraging the role of microbial fermentation technology in fermented foods, enriching the production and processing technology of fermented foods, and enhancing the nutritional value of fermented foods.

KEYWORDS

Microorganism; Fermentation; Fermented food

1. INTRODUCTION

Microbial fermentation is a process in which microorganisms produce a series of effects on substances, thereby completing material processing and treatment. It has shown good performance in the food industry. In recent years, there have been more and more applications of microbial fermentation technology, and the fermented food industry, as the most commonly used field of microbial fermentation, is also constantly developing in terms of specific application situations. Microbial fermentation is applied in the field of fermented food, which can not only process and treat food, but also improve and adjust food quality according to the characteristics of microbial fermentation technology. While successfully completing food processing, it also optimizes the quality of fermented food [1]. Through fermentation, food changes its original characteristics, allowing beneficial microorganisms to proliferate in large numbers under specific conditions, reducing the content of harmful microorganisms, and transforming the existing large molecular substances in food into small molecular substances, which is more conducive to human digestion and absorption. Fermented foods have become a focus of attention due to their unique sensory and nutritional characteristics, especially in recent years when scientific research has shown that their microorganisms can promote health [2]. This article provides a review of microbial fermentation and its application in fermented foods, aiming to provide theoretical basis for better leveraging the role of microbial fermentation technology in fermented foods, enriching the production and processing technology of fermented foods, and enhancing the nutritional value of fermented foods.

2. MICROORGANISMS IN FERMENTED FOODS

Traditional fermented foods were often made by mixing and fermenting complex microbial communities, and the formation of their unique flavors was closely related to the complex metabolic processes of microbial communities using raw materials. During the fermentation process, certain microbial groups can temporarily dominate due to factors such as food substrate, process operations, and interactions between microorganisms. In the process of microbial succession, different microbial groups successively exert their functions, ultimately forming fermented foods with unique quality [3]. For traditional fermented foods that undergo natural fermentation, they typically contain many strains of bacteria, yeast, and mold simultaneously [4].

2.1. Bacteria

Bacteria are involved in almost all traditional fermented foods, with the most prominent group being lactic acid bacteria. Lactic acid bacteria contain approximately 380 species of bacteria from 40 genera, and their main metabolic function is to convert sugars in the food matrix into lactic acid, reduce the pH of the environment, and thus achieve the purpose of preserving and preserving food [5]. In addition, lactic acid bacteria can also metabolize and produce other types of compounds that help improve food flavor, enhance food nutrition, and safety. Some fermented foods also contain many other types of bacteria, such as Bacillus in fermented soy products in Asia. Its main function is to produce proteases, which hydrolyze proteins in soy products into functional small molecule peptides and amino acids that are easier to digest and absorb [6]; During the fermentation process of fruit vinegar and kimchi, there were acetobacter species that can convert ethanol produced by other microorganisms into acetic acid.

2.2. Yeast

According to reports, there were approximately 21 genera of yeast present in different fermented alcoholic beverages and foods, mainly including Brettanomyces, Cryptococcus, Debaryomyces, Galactomyces, Geotrichum, Hansenula and Hanseniaspora [7]. Among them, Saccharomyces cerevisiae was most widely used in fermented foods such as bread and alcoholic beverages. During the fermentation process, it mainly converts small molecule sugars into ethanol and carbon dioxide and can also metabolize to produce small amounts of other flavor compounds.

2.3. Mold

Mold is also one of the main microorganisms in the koji making process of many fermented foods in Asia and the maturation process of cheese and sausages in Western countries. The main genus includes Amylomyces, Aspergillus, Monascus, Mucor, Neurospora, Penicillium, Rhizopus, and Ustilago [8]. The main function of these molds in fermented foods was to produce various hydrolytic enzymes, which convert large molecules in the food matrix into easily absorbable small molecules. At the same time, these small molecules also contributed to the growth and metabolism of bacteria and yeast.

3. COMMON FERMENTED FOODS

The latest authoritative definition of fermented foods comes from the "Consensus on Fermented Foods" released by the International Association of Probiotics and Prebiotics Science in 2021 [9], which defines fermented foods and beverages as foods made through expected microbial growth and enzymatic conversion of food ingredients. This definition further clarifies the category of fermented foods: firstly, there was a fermentation process involved in the production process; Secondly, there may be no live microorganisms present during consumption; Thirdly, beverages are also fermented foods. According to the above definition, it can be seen that although microbial inactivation or removal is not common in all fermentation processes, food that has undergone microbial inactivation or removal still meets the definition of fermented food and belongs to the category of fermented food.

3.1. Fermented Soy Products

Fermented soy products are the most common application of microbial fermentation in the food industry. Soybean is one of the foods that most often use microbial fermentation technology in food production and processing. Through microbial fermentation technology, ordinary soybean raw materials can be made into tofu, dried tofu and other products, and then the subsequent food processing process can be completed. The microbial fermentation technology used in soy products mainly involves the process of protein hydrolysis by proteases, which reduces the hardness of soybeans through microbial fermentation technology, promotes changes in their protein structure, and achieves the purpose of processing. The process of most fermented soy products is quite similar. Taking soybean paste as an example, the main processes include soaking, steaming, draining, koji making, adding salt water, and fermentation [10]. In the traditional natural koji making process, various molds grow on the surface of the substrate and secrete many hydrolytic enzymes to hydrolyze large organic compounds into small molecules. Combined with subsequent fermentation by bacteria and yeast, a delicious and sauce flavored soybean paste is obtained. This fermented yellow brown semi-solid sauce mash, filtered to obtain a sauce, can be used as a daily seasoning, namely soy sauce [11].

3.2. Fermented Dairy Products

Fermented dairy products are relatively common in microbial fermentation technology, mostly fermented products based on milk as the raw material. Microbial fermentation technology can ferment milk to obtain a series of dairy products, among which yogurt is a common fermented dairy product. Yogurt is usually made from cultures containing strains of Streptococcus thermophilus and Lactobacillus bulgaricus. However, many commercial products have added probiotics, especially Bifidobacterium and Lactobacillus strains [12], to obtain additional health benefits. Yogurt, as the most representative dairy product, not only has a good taste, but also incorporates probiotics to improve gastrointestinal function and promote nutrient absorption. At the same time, fermentation greatly extends the storage time of dairy products, which can avoid the problem of spoilage caused by increased storage time and has good application value.

3.3. Fermented Tea Products

Fermented tea products also occupy an important position in the food industry. As the origin of various types of tea, China has a long history of using microbial fermentation technology to ferment tea and produce different types of tea products. Half fermented tea and fully fermented tea are two commonly used types of tea products in microbial technology. Specifically, oolong tea, white tea, black tea, and other types of tea have applied certain microbial fermentation techniques, and their flavors have undergone significant changes compared to unfermented green tea. The production of new compounds in fermented tea can consolidate beneficial components in tea, prevent cardiovascular and cerebrovascular diseases, and facilitate the elimination of edema, improving the nutritional and health value of tea, which is widely welcomed by the consumer market [13].

4. THE ROLE OF MICROBIAL FERMENTATION IN FERMENTED FOODS

4.1. extend the Shelf Life

The original purpose of fermented foods was to preserve food and extend its shelf life [14]. The principle of fermented food preservation is that carbohydrates and their derivatives are oxidized into primary or secondary metabolites of fermentation such as organic acids, alcohols, and carbon dioxide, which can inhibit the growth of spoilage microorganisms; And the oxidation of these substances is only partial oxidation, so food still retains sufficient nutrients [15]. Many fermented foods contain lactic acid bacteria, and research on the function of microorganisms in extending the shelf life of fermented foods has mainly focused on the lactic acid bacteria group. Studies have shown that some strains in the lactic acid bacteria group have good inhibitory effects on food spoilage and pathogenic bacteria [16]. They first produce antibacterial effects in fermented foods by producing acidic substances that lower the pH of the substrate. The main mechanism is that organic acids such as acetic acid, lactic acid, and propionic acid can interfere with the maintenance of bacterial cell membrane potential and inhibit the active transport of the membrane [17]. They had inhibitory effects on Gram positive bacteria, Gram negative bacteria, yeast, and mold.

4.2. Improve Nutritional Value

During the fermentation process, microorganisms can produce various hydrolytic enzymes, which degrade large molecules such as sugars, proteins, and lipids into more easily absorbable functional small molecule active substances, thereby increasing the bioavailability of food and producing functional nutrients [18]. The degraded small molecule substances can provide the necessary material basis for subsequent microbial fermentation, ensuring the smooth progress of the fermentation process. In China and other parts of Asia, in the process of making Baijiu and soy sauce, a large number of microorganisms are enriched from the environment through koji making to induce the production of carbohydrate hydrolase, protease and lipase. These enzymes degrade large molecular substances in grain raw materials into small molecular substances, which can be absorbed and utilized by microorganisms such as brewing yeast and lactic acid bacteria that cannot utilize large molecules during subsequent fermentation processes [14]; Secondly, during the hydrolysis of large molecules, many functional small molecules such as bioactive peptides and nattokinase can be produced [19], which have certain effects on human immune regulation; In addition to large molecules of sugars, proteins, and fats, plant-based materials used for fermented foods also contain a large amount of polyphenolic compounds. After fermentation treatment, their nutritional value can be significantly improved [20].

4.3. Improve Gut Microbiota

Probiotics refer to a group of microorganisms that are beneficial to the health of the host and have vitality when consumed in appropriate doses. Probiotics in food not only have the effect of improving the shelf life and nutritional value of food, but also have a significant positive impact on the intestinal health of the host. Probiotics must have the ability to resist gastric juice and bile, and be able to proliferate and colonize in the digestive tract. The most significant benefit of probiotics to the host is their ability to resist intestinal pathogens. Common probiotics include Lactobacillus, Enterococcus and Bifidobacterium [21]; In recent years, yeast and other microorganisms had also been developed as potential probiotics [22]; In addition, many probiotics can also be isolated from fermented foods such as kimchi, sausages, and red wine [23, 24]. Therefore, consuming fermented foods rich in probiotics has many benefits for physical health.

4.4. Enhance the Sensory Quality of Food

Microbial fermentation can enhance the sensory quality of food from four characteristics: color, aroma, taste, and texture. The flavor in food includes the taste in the human mouth, smell in the nasal cavity, and sensation in the trigeminal nerve [25]. The flavor compounds of fermented foods can be divided into volatile components and non-volatile components. The aroma components of fermented foods are composed of volatile flavor compounds, which are perceived through human smell. The pleasant aroma can increase people's appetite and enhance their digestive function; Nonvolatile flavor compounds are perceived through taste and trigeminal nerve sensation [26]. The formation of flavor compounds in fermented foods mainly includes hydrolysis reactions of raw material matrices, synthesis reactions of microbial metabolites, or biochemical reactions catalyzed by enzymes.

5. SUMMARY

Various fermentation microorganisms in fermented foods participate in the fermentation process through a series of biochemical reactions, which not only enriches the types of fermented foods, enhances their nutritional value and sensory quality, prolongs their shelf life, but also improves the gut microbiota of the human body to a certain extent after ingestion.

At present, although fermented foods have a large market share, many well-known fermented foods such as yellow wine, vinegar, fermented black beans, ham, cured meat, sausage, shrimp sauce, etc. are common ingredients in daily life. However, due to the lack of systematic scientific research, people's understanding of the microorganisms in these fermented foods is still insufficient, which will become the direction of future research. With the industrialization of production, the processing technology of some fermented foods will undergo certain changes. When innovating in technology, attention should be paid to not losing the traditional flavor of fermented foods through changes in fermentation technology. The problem of harmful substances to the human body caused by the mixing of miscellaneous bacteria due to the selection of raw materials, insufficient processing technology, or other factors cannot be ignored. It is necessary to further clarify the types and contents of microorganisms in fermented foods to ensure the safety of commercially available fermented foods.

Although fermented foods are very common in daily diet, the public's awareness of fermented foods is not high at present. China has a long history of consuming fermented foods and has a wide variety of traditional fermented foods. It is necessary to improve our understanding of fermented foods, further explore the relationship between fermented microorganisms and fermented foods, and clarify their various mechanisms of action, which will promote the future development of Chinese fermented food industry.

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