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Microorganisms in Fermented Foods and Their Effects on the Human Body

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Abstract:

In recent years, microorganisms in fermented foods have shown an important role in regulating human health. Studies have shown that probiotics have significant health benefits in fermented foods, such as improving gut health, stimulating immune function, and promoting metabolism, and mental health. Specifically, lactic acid bacteria in yogurt can increase the number of beneficial bacteria in the intestines and reduce the growth of pathogenic bacteria, and yeasts such as Saccharomyces cerevae have multiple health effects on intestinal microbiota protection and anti-inflammation. In addition, various enzymes and metabolites produced by Aspergillus during fermentation process can improve the nutritional value of food. However, although lots of research has been done, the understanding of the microbial mechanism under different fermentation conditions is still insufficient. In this article, the types and influencing factors of microorganisms in yogurt, wine and seasoner were reviewed. The effects of temperature, pH value, fermentation time and other conditions on microbial activity and product quality were analyzed. The results showed that suitable fermentation conditions could significantly increase microbial activity, improve product flavor and health function, and provide a theoretical basis for optimizing the production process of fermented food. The article provides a theoretical basis for improving the fermented food production process, thus helping to improve product quality and market competitiveness. However, this article has some limitations like the lack of understanding of interactions between different microorganisms. Future research should focus on examining the collaborative relationship between these microbes to improve the health benefits and production efficiency of fermented foods.

Keywords: Probiotics; microbiota; fermentation; nutrition.

1. Introduction

Fermented foods play an important role in human dietary culture and its history can date back to thousand years ago [1]. As far back as ancient Egypt and China, people began to use natural fermentation to preserve food and make drinks. Not only fermented foods are advantageous in the preservation aspect, but they also are loved due to their unique flavor and nutritional value. During fermentation process, microorganisms like lactic acid bacteria, yeasts, and molds breed in the food. By breaking down complex organic matter, these microorganisms will produce products such as lactic acid, ethanol, and carbon dioxide and give unique taste and flavor for fermented foods.

Recent studies have shown that probiotics contained in fermented foods can improve intestinal health and stimulate immune function, which will have a positive effect on metabolism and mental health. For example, lactate bacteria in yogurt can increase useful bacteria quantities in the intestine and reduce the growth of pathogenic bacteria [1]. Yeast bacteria like S. cerevisiae have various health effects such as protection of intestinal flora and anti-inflammation [2]. Molds like A. oryzae can produce various enzymes and metabolites during the fermentation process, which can increase the nutritional value of food. Although there have been various researches proving that fermented foods are beneficial in health, there also exist unknown questions. The type and quantity of microorganisms in fermented foods will be influenced by many factors including raw materials, environmental conditions and fermentation technology. Understanding these factors is very important to optimize the production of fermented foods and enhance health benefits.

The review aims to learn the effect of microorganisms in fermented foods on human health. It will analyze the main microorganisms in various types of fermented foods and their physiological functions. At the same time, the article will consider the factors affecting the type and quantity of microorganisms in fermented foods to support theoretical aspects for the optimization of microbial supplements in

the fermented food industry. By summarizing and analyzing the extant research results can reveal the specific mechanism of the effect of microorganisms on human health in fermented food and show the direction of future research.

2. Types of Microorganisms in Fermented Food and Their Influencing Factors

2.1 Yogurt

Most yogurt is produced by the fermentation of genera Lactobacillus and Bifidobacterium of lactic acid bacteria [1]. These bacteria break down into lactic acid during fermentation, lowering the pH and giving the yogurt its distinctive taste and texture. The temperature during fermentation, acidity and time are vital factors that affect the growth of lactic acid bacteria. The right fermentation temperature (37~45°C) can provide for the development and metabolism of lactic acid bacteria. [1] For example, one study has found that yogurt has the best texture and flavor at a fermentation temperature about 42°C. This study tested the effects of different fermentation temperatures on yogurt precisely, and the results showed that yogurt which fermented at 42°C had higher lactic acid bacteria activity and better taste. Moreover, the initial pH and fermentation time play a significant role in the final quality of yogurt. Longer fermentation time can increase the amount of lactic acid and then enhance the flavor and texture of yogurt [3]. Another study showed that extending the fermentation time from 4 hours to 6 hours could significantly increase the lactobacillus content and sour taste in yogurt [4]. In the production of yogurt, temperature is very important because excessive temperature would kill lactic acid bacteria, while extremely low temperature would prolong the fermentation time [1]. In addition, lactic acid bacteria produce lactic acid in the fermentation process and then restrain the growth of other harmful microorganisms. This significantly improves the safety and health benefits of yogurt [5].

2.2 Wine

The main microorganism in wine fermentation is yeast, especially S. cerevisiae. This yeast produces alcohol by turning glucose into ethanol and carbon dioxide by the glycolysis pathway [6]. Factors that affect yeast fermentation include sugar concentration, fermentation temperature, and oxygen supplementation. High sugar concentrations, while increasing alcohol production, may also inhibit yeast activity [7]. For example, one study has found that yeast growth and fermentation rates would be significantly reduced when sugar concentrations were too high. This study specifically discussed the effects of different sugar concentrations on yeast fermentation, and found that too high sugar concentration would lead to the decline of yeast activity and affect the quality of wine [8]. A suitable fermentation temperature (usually 20-30°C) facilitates yeast reproduction and metabolism [6]. In addition, as oxygen promotes the growth and reproduction of yeast, it is necessary in the very early stage of fermentation. However, in the later stage of fermentation, the oxygen exposure needs to be minimized to inhibit the oxidation of ethanol to acetic acid, which would harm the quality of the wine [7]. By precisely controlling these factors, producers can improve fermentation efficiency and alcohol yield, ensuring product quality [7].

2.3 Seasoner

The fermentation process of seasonings such as soy sauce and miso usually involves the interplay of molds like Aspergillus, lactic acid bacteria, and yeast [8]. Aspergillus molds decompose starches and proteins in raw materials into sugars and amino acids by secreting amylase and protease, providing necessary nutrients for lactic acid bacteria and yeast in the subsequent fermentation stage. For example, one study showed that enzymes which produced during fermentation can greatly improve the taste and quality of soy sauce [9]. Under different fermentation conditions, the impact on the quality of soy sauce has been discussed: under the right temperature and humidity conditions, Aspergillus molds contain a large number of violent substances and have been found to degrade, improving the taste and texture of soy sauce. The selection of raw ingredients, the temperature and humidity of fermentation environment, and the length of fermentation time can significantly affect the flavor and quality of fermentation seasoning. For example, higher temperatures and proper humidity help mold reproduction and enzyme activity, while longer fermentation times can make the flavor of the seasoning more intense and complex. By optimizing these factors, producers can improve the quality of fermentation seasonings to meet market demand.

3. The Influence of Microorganisms in Fermented Food on the Human Body

3.1 Intestinal Flora

Probiotics in fermented foods promote gut health by improving the gut environment and inhibiting harmful bacteria. Regularly consuming fermented foods which are rich in probiotics can increase the diversity of intestinal flora, improve nutrient absorption capacity and digestive function as well as reduce inflammation. These probiotics inhibit the growth of pathogenic bacteria by producing acid

and implementing a competitive inhibition mechanism. At the same time, they enhance the useful bacteria reproduction in the intestine. This helps maintain the balance of intestinal flora. Lactobacillus and Bifidobacterium that belong to probiotics could produce short-chain fatty acids and regulate the immune response of host cells to reduce intestinal inflammation. This promotes a healthy balance of intestinal bacteria [10]. Research has shown that regularly consuming probiotics could reduce the incidence of gastrointestinal diseases and improve intestinal function to increase overall health. [10]

3.2 Immune System

Probiotics family have a positive impact on the immune system. They regulate the balance of gut microbiota and enhance mucosal immune responses to improve the body resistance to infections. For example, lactic acid bacteria could stimulate the secretion of immunoglobulin A (IgA) by intestinal epithelial cells, thereby enhancing the intestine barrier function [11]. IgA plays a crucial role in mucosal immunity and can neutralize pathogens and prevent them from passing through the intestinal barrier into the bloodstream [12]. Additionally, probiotics can enhance the activity of immune cells such as macrophages, dendritic cells, and T cells by interplay with gut-associated lymphoid tissue (GALT). This interaction helps enhance the body's resistance to infections. Studies have shown that regular consumption of fermented foods containing probiotics can significantly improve the body's resistance to pathogens and help alleviate symptoms of allergies and autoimmune diseases.

3.3 Metabolic Health

Microbes in fermented products have a significant impact on the health of metabolism. Recent studies have shown that the use of fermented products such as yogurt and beans can improve labeling associated with metabolic disorders such as insulin sensitivity, lipid levels and weight control. The study showed that frequently used yogurt containing dairy bacteria reduces the body mass index (BMI) and the body size of overweight people. In addition, probiotics could reduce fat absorption in the intestine by regulating the composition of intestinal bacteria, thereby improving blood lipid levels. For example, Bifidobacterium and Lactobacillus strains can produce short fat chains (SCFAs), such as butyric acid and propionic acid. These products contribute to fat distribution and energy absorption. Another study has found that lactic acid bacteria present in fermented beans could significantly reduce blood glucose levels and glycosylated hemoglobin (HbA1c) in people with type 2 diabetes [13]. These results show that fermented food plays an important role in preventing and treating metabolic diseases.

3.4 Mental Health

In recent years, more and more research has focused on the mental health effects of fermented foods. For example, probiotics could influence brain function and mood regulation through the gut-brain axis [14]. Consuming fermented foods rich in probiotics can improve symptoms in people with depression and anxiety. One study has shown that regularly consuming fermented dairy products containing Lactobacillus and Bifidobacterium strains could greatly relieve symptoms in people with anxiety. Other studies have found that probiotics can reduce intestinal inflammation by regulating the balance of intestinal flora, thereby indirectly improving brain function and emotional state [14]. For example, the Lactobacillus rhamnosus strain can ease anxiety symptoms by increasing the production of gamma-aminobutyric acid (GABA) [15]. In addition, a clinical trial showed that consuming fermented foods containing probiotics could significantly reduce patients' depression scores and improve the quality of life of patients with depression [16]. These findings suggest that fermented foods have important application prospects in improving mental health.

4. Optimization of Microbial Addition in Fermented Food Industry

4.1 Optimize the Selection of Microbial Strains

The selection of suitable microbial strains is the key to fermented food production. Recent studies have shown that different strains exhibit different metabolic characteristics and products during fermentation. One study found that the use of multi-strain co-fermentation can significantly improve the flavor and texture of fermented foods [17]. For example, fermentation using a combination of Lactobacillus plantarum and Saccharomyces cerevisiae could improve the antioxidant activity and nutritional value of yogurt. Lactobacillus plantarum has acid and salt tolerance and can maintain high activity during fermentation, while Saccharomyces cerevisiae can produce rich aromatic substances that enhance the flavor and taste of the product. The selection of a suitable strain combination can not only optimize the fermentation effect but also improve the function and market competitiveness of the product. In addition, modifying microbial strains by genetic engineering means to make them have higher metabolic efficiency and product specificity is also an important direction of future research. The optimization of strain selection should not only consider its influence on the yield and quality of target products but also take into account production cost

and environmental adaptability [18].

4.2 Optimization of the Fermentation Process

Optimizing the fermentation process is very important to promote the quality and safety of fermented food. By controlling key factors such as temperature, pH and time, microbial activity and product quality could be maximized. One study has shown that controlling the fermentation temperature between 37-42°C could significantly promote lactic acid production of lactic acid bacteria. In addition, by optimizing the fermentation time, production efficiency can be improved on the premise of ensuring product flavor and texture. For example, shortening the fermentation time can reduce the over-acid and bitter taste of the product and improve consumer acceptance. [19] Specifically, in the early stage of the fermentation process, controlling the temperature and pH precisely could rapidly start the growth and metabolism of microorganisms. In the middle stage of the fermentation process, the high activity and high yield of microorganisms could be maintained by adjusting the oxygen supply and nutrient concentration. At the end of the fermentation process, by gradually lowering the temperature and controlling the pH, harmful microorganisms can be inhibited to ensure the quality and safety of the product [19]. These results provide a specific operation plan for the optimization of the fermentation process and also provide a reference for the production of different types of fermented food. These results provide a specific operation scheme for the optimization of the fermentation process.

4.3 Quality Control and Safety

Quality control and safety are important links in the production of fermented food. By monitoring the growth and metabolic processes of microorganisms, problems in production can be discovered and solved in time. One study noted that by using advanced detection techniques such as high-performance liquid chromatography (HPLC) and mass spectrometry (MS), metabolites and harmful substances produced during the fermentation process could be accurately monitored. In addition, the establishment of a strict quality control system can ensure the stability and consistency of products. [20] For example, regular testing of microbial content and toxin levels in products can effectively prevent food safety accidents. Specific quality control measures include real-time monitoring of critical control points in the production process to ensure that the parameters of each link are within the specified range. Use standardized operating processes and specifications to reduce human error and production fluctuations; The introduction of automation and intelligent equipment to improve production efficiency and detection accuracy; Conduct internal audits and external certification regularly to ensure the effective operation of the quality management system. These measures provide a guarantee for improving the quality and safety of fermented foods and also provide consumers with healthy and safe product choices.

5. Conclusion

This article summarizes the types of microorganisms in fermented foods, the influencing factors and their role in human health, and emphasizes the importance of optimizing the fermentation process and strain selection. The quality and safety of fermented foods could be promoted by controlling key parameters such as temperature, time and pH. The right temperature and fermentation time can promote the reproduction of lactic acid bacteria and improve the nutritional value and flavor of yogurt. Lactic acid bacteria could increase the beneficial bacteria strains and inhibit the growth of pathogenic bacteria. Additionally, yeasts like Saccharomyces cerevisiae have protective and anti-inflammatory effects on the intestinal bacteria, while enzymes and metabolites produced by Aspergillus could increase food nutrition. This paper also points out that the synergy between different microbial species and their impact on the quality of fermented products is a limitation, and the study focuses on yogurt, alcohol and some seasonings, and does not fully cover all fermented foods, limiting the applicability of the conclusions. Future research should focus on the synergy between different strains, optimize the combination of strains to improve the quality and health functions of fermented foods, and expand the scope of research to cover more fermented foods, to form a more comprehensive theoretical system. The production process of fermented foods can be improved by these efforts and then market competitiveness can be enhanced, and consumers can be provided with higher quality and healthier fermented foods.

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