

Progress in the Mechanism and Application of Microorganisms in Traditional Fermented Foods

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Abstract. Since a few centuries ago, fermentation has been used to preserve food and to enable the microbes in it to make the original food taste better, last longer and even become more nutritious. There's been a lot of research exploring the microbes in fermented foods and what parts of the microbes are good for people's bodies. These potentially beneficial parts of the body are called compounds, but the effects of their interactions and fermentation in different microorganisms have not been fully understood. This paper will explore the role of microorganisms in traditionally fermented foods, how lactic acid bacteria and yeasts can contribute to fermentation results, as well as the production of organic acids and the development of compounds. This paper also explores how to use starter cultures to produce the same results and examines the growth of dairy probiotics. However, there are still challenges in terms of microbial interactions and health effects on each other, and future research should focus on this area to improve knowledge as well as the application of food fermentation.

Keywords: Food fermentation; Lactic acid bacteria; bioactive compound.

1. Introduction

Fermentation is a process that can extend the shelf life of food, but also can make the taste richer, and the microorganisms are the main reason for these changes. Because of the principle of metabolism, microorganisms produce organic acids, alcohols and gasses and other compounds, extending the preservation time of the original food. Traditional fermented products, including kimchi, yogurt and sauerkraut, rely on microorganisms such as bacteria, yeast and mold to start their fermentation process

Among the microbes involved in fermentation are those called lactic acid bacteria. It is essential in the fermentation process of dairy products, vegetables and grains. It is mainly used to produce lactic acid, which lowers the pH index of food, so having an environment that inhibits the growth of spoilage organisms, and acidifying food helps with shelf life and taste. A lot of research has looked at the metabolic pathways of these microbes and how they make food more nutritious and even safer through fermentation [1].

There have been remarkable advances in molecular biology techniques that have allowed for more specific characterization of microbial communities through fermentation processes, particularly high-throughput sequencing, revealing more microbial communities with different metabolic capabilities than previously understood. The study shows that the microbes interact with each other to improve the nutrition and safety of food, and they can even identify probiotic strains and bioactive compounds that have certain health benefits, such as exopolysaccharides and peptides [2,3].

The starter culture that people use all the time is also an important aspect of the fermentation process today, and by using specific microbial strains, people can live to their desired fermented results of the food, which can also improve safety and consistency. Starter cultures are widely used in both conventional and industrial Settings, and new and different microorganisms can produce non-dairy probiotics during fermentation, which can help and attract a large number of consumers who are lactose intolerant or want plant-based alternatives. [1].

2. Genome Sequencing and Microbial Dynamics

This paper will analyze and synthesize the existing research on microorganisms in traditional fermented foods and their results. Emphasis is placed on the study of diverse microbial communities and their uniqueness, even their metabolic role in fermentation and the health of food. The goal is to combine the various studies to discuss their information rather than to conduct a primitive experiment.

The studies used in the analysis were sourced from research at Google Academics and the National Institutes of Health, which will focus on the microbial communities of fermented foods and their characteristics, fermentation biochemical processes, the role of probiotics, and metabolic pathways and the production of functional compounds. In this article, we will discuss microorganisms in traditional fermented foods such as kimchi, yogurt, sauerkraut, and kombucha. This topic was chosen because advanced technologies such as genome sequencing, which explore the details of microbial communities and their functions, will focus on the metabolic activity of microorganisms in fermentation and their interrelationships with health benefits. By combining these studies, this paper will explain the role of different microorganisms in the fermentation process, the details, and the impact of human consumption on this process.

3. Microbial Diversity and Role in Fermented Foods

Fermentation studies because different food types lead to different fermentation conditions and thus different microbial communities. In vegetable fermentation, such as sauerkraut, the microbial community will be in a dominant position. Lactic acid groups include *Lactobacillus plantarum*, *Lactobacillus brevis*, and *Bacillus mesentericus*, which are critical in the conversion of carbohydrates to lactic acid, as lactic acid helps in the long-term preservation and acidification of food [4].

Kimchi, a staple of Korean cuisine, provides research with a stark and clear example of how microbial communities change during fermentation. The study mentions that during the early fermentation period, non-lab species in kimchi dominate. As fermentation continues, its environment becomes acidic, and LAB performs better than other microorganisms (Lee et al. 2020). The acidic environment caused by lactic acid bacteria prevents the presence of spoilage bacteria, so kimchi has a long shelf life and does not need to be kept in low temperature.

The classic example of a fermented dairy food is yogurt. Yogurt contains Bulgarian bacteria and *Streptococcus thermophilus*, and these bacteria are the dominant strains. They convert the lactose in the food into lactic acid, which helps solidify the protein in the milk and give it the texture and taste of yogurt. Because of the presence of these bacteria, the taste and consistency of the yogurt will become the taste of the mouth, and the production of bioactive compounds for health.

Kombucha is a beverage, and what makes it different from ordinary drinks is that it needs to be fermented. Kombucha also contains many different microbial communities, such as yeast and acetic acid bacteria. Among the yeasts is *Saccharomyces cerevisiae*, which ferments by turning sugar into ethanol. Acetic acid bacteria are *Acetobacter* and *Staphylococcus*, which convert ethanol into acetic acid. The combination of these microbial communities contributes to the mild alcohol and sour taste in kombucha, especially because of its carbonation.

High-throughput genome sequencing has helped provide researchers with a useful tool for understanding the microbial communities of fermented foods. Traditional culture methods only allow us to detect microbial communities that grow well in laboratory environments and conditions, but genomic technologies such as 16S rRNA sequencing will allow us to identify a wider range of microbes, even those that may not grow well under typical culture environments and conditions.

The kimchi study, for example, used genome sequencing to map the succession of microbial communities during fermentation. In the beginning, non-lactic acid bacteria such as *Weissella* were abundant, but due to the development of fermentation and the decrease of pH index, Where *Lactobacillus plantarum* and *Lactobacillus brevis* predominate (Lee et al. 2020). Such a shift would result from the growth of tissue spoilage microorganisms that stabilize the food. In yogurt, such a similar genomic analysis demonstrates the advantages and advantages of *Lactobacillus Delbroueri*

and *Streptococcus thermophilus*, which are particularly important in the acidity and texture of the food produced by fermentation [5].

The use of genome sequencing can identify unusual species that are likely to play a role in fermentation. Genomic studies in kombucha have confirmed that various yeasts and acetic acid bacteria contribute to the unique fermentation process of kombucha. The action of these microorganisms is to produce ethanol, acetic acid, and carbon dioxide, which can all increase the taste, acidity, and carbonation of kombucha. [6]

The main metabolic pathways of microorganisms during fermentation were determined. During lactic acid fermentation, lactic acid bacteria convert sugars into lactic acid through lactic acid fermentation, which acidifies foods, rendering many pathogens unable to survive, and improving the flavor and texture of foods. At the same time, lactic acid is a natural preservative, which can extend the shelf life of food.

When kombucha or any other alcoholic beverage ferments, yeast, like *saccharomyces cerevisens*, metabolizes sugar and produces ethanol and carbon dioxide, but the ethanol is turned into acetic acid by acetic acid bacteria, which is why Kombucha acidifies. This two-step fermentation process is common in many fermented beverages, which helps preserve food and enhances its sensory properties [6].

In addition to lactic acid and acetic acid, other studies have shown that microorganisms produce other bioactive compounds during fermentation, such as EPS. Lactic acid bacteria produce EPS, which is used as a thickening agent to improve the texture of food. Other studies have suggested that EPS may also have antioxidant properties and may contribute to one of the health benefits of eating fermented foods [7].

4. Discussion

Various studies have shown that each different microbial community is very important in the fermentation process, especially as the process progresses and different microorganisms become dominant. In the fermentation of vegetables, lactic acid bacteria become particularly common at the later stage of fermentation, because they thrive in an acidic environment that is good for them. They lower the pH index because lactic acid bacteria produce lactic acid, which prevents the growth of spoilage organisms and allows food to be preserved for a long time. Changes in the microbial community are a normal part of fermentation and reflect how the environment inside the food has changed over time [8].

The fermentation process for dairy products follows the same pattern. The lactic acid bacteria in yogurt are in a dominant position, and these lactic acid bacteria will make the milk sour, so the proteins solidify and become like yogurt. This process explains how microbial activity is directly related to the final appearance of fermented foods [1].

In the fermentation process of kombucha, the role of yeast and bacteria has the contribution of each stage of fermentation. Yeast converts sugar to ethanol for fermentation, and acetic acid bacteria convert ethanol to acetic acid, which causes kombucha to sour and foam. Organic acids, such as lactic acid and acetic acid, are the result of microbial fermentation. Lactic acid bacteria are used in the production of lactic acid to preserve food and increase food flavor, which is also supported by research on vegetable and dairy fermentation. Lactic acid, found in foods such as pickles or yogurt, plays a role in lowering pH, reducing the risk of spoilage and extending shelf life [9].

In fermented drinks like kombucha, acetic acid produced by yeast and bacteria helps food taste and preserve. These metabolic processes are the result of mature fermentation, a process that allows microbes to convert sugars into alcohols and acids. Conversion of ethanol to acetic acid, showing alcohol fermentation, in which a secondary bacterial process alters the final food.

As highlighted by several studies, the exopolysaccharide produced by LAB strains is closely related to changes in food texture and viscosity. EPS not only has an important direct relationship to food texture, but also has other benefits, although more research is needed to investigate these

potential effects. Some studies have shown that the antioxidant properties of EPS require further research to reach a definitive conclusion [10].

Studies examining the health benefits of fermented foods often focus primarily on the probiotic powers of lactic acid bacteria. These microbes are known to survive stomach acid and may colonize the gut as they are associated with improved gut health. Studies of *Lactobacillus plantarum* and other lactic acid bacteria strains also support their role in maintaining a healthy balance of gut bacteria, but the extent of their role varies by food and by specific strain. However, it is of concern that all fermented foods preserve live lactic acid bacteria when eaten, especially pasteurized foods.

Bioactive peptides produced in dairy products, especially yogurt, can be identified as having health-related properties, such as antioxidant and anti-inflammatory effects. These peptides are produced when proteins are broken down during fermentation. While these findings point to potential health benefits, more research is needed to understand the effects of these compounds and how they work in people's bodies [1].

One of the challenges when fermenting food is getting the microbes to be consistent on a commercial scale. Traditional fermentation methods allow for a natural variation in the microbiome, but large-scale commercial production of these fermented foods will require much tighter and more careful control of environmental factors such as temperature and pH. These environmental variables can affect microbial dominance, which in turn affects the taste, texture, and shelf life of food. As the scale of making fermented foods has increased, it is also important to ensure the balance of microorganisms in the food, as the quality of the food needs to be maintained [7].

In addition to probiotics, people are curious about the health benefits of fermented foods. Studies of compounds such as polysaccharides and bioactive peptides produced in vitro have suggested that fermented foods may help with a number of human health benefits, such as supporting the immune system or providing antioxidants. However, this aspect needs to be supported by more clinical trials to ensure efficacy and safety for consumers.

5. Conclusion

This paper discusses the role of microorganisms in traditionally fermented foods, explaining how they contribute to the fermentation process, the by-products they produce, and the health benefits of consuming these foods. The transformation of key microorganisms into the original food plays an important role in the shelf life of food. The production of acids such as acetic acid and lactic acid is the main reason for maintaining food and changing the taste of food after fermentation. In addition, the researchers determined how to use starter cultures to determine the consistency of food. Interest in fermented foods has also grown because of the many health benefits of bioactive compounds such as exopolysaccharides and peptides.

The results of this paper summarize a clearer picture of how fermentation works at the microbial level and the functional compounds that emerge here. These understandings and insights could provide additional important information for future research or methods to improve fermented food production and point to the enormous potential of non-dairy probiotics.

At the same time, this paper is limited because it does not cover the detailed interactions of specific microbial strains with each other, nor does it delve into how environmental factors such as temperature or salinity affect the activity of microbial communities. In addition, whether regular use of fermented foods has long-term health effects has not been specifically explored, leaving room for further research.

Future research should focus on uncovering the complex interactions of microbial communities on each other and how they affect the final fermentation results. This requires more detailed and in-depth research into the nutrition and benefits of bioactive compounds found in fermented foods, and to assess actual and long-term effects on people's health through clinical studies.

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