Dietary Value and Health Impacts of Kimchi: A Comprehensive Analysis of its Nutritional Content and Effects

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Abstract. Kimchi, as a representative fermented food, holds a profound history and widespread popularity. Due to its unique fermentation process, changes in physicochemical characteristics, and microbial development, the nutritional content and dietary value of kimchi differ from other staple foods. Existing studies primarily focus on changes during the fermentation process, flavor control, and optimization of kimchi products, lacking a comprehensive summary of its dietary value and impact on human health. Therefore, this paper analyzes the vitamins, dietary fiber, minerals, probiotic types, and content in kimchi, summarizes the digestion and absorption processes of these nutrients in the human body, establishes and popularizes an overview of the dietary value of kimchi. Recommendations for kimchi consumption among different groups are provided based on the above analysis. This research aims to deepen people's understanding of kimchi in daily diet, laying the groundwork for future in-depth biological and nutritional studies on the interaction between kimchi and the human body. Due to the lack of specific organism experiments and long-term observations of changes in human health after consuming kimchi, the conclusions drawn in this paper may have individual variations and cannot provide long-term consumption recommendations. Future research should focus on individual differences and long-term consequences of kimchi consumption.

Keywords: Kimchi; fermentation; microorganisms; human health.

1. Introduction

Kimchi is a traditional Korean fermented food with a history of thousands of years. Due to the geographical constraints of the Korean Peninsula, after harvesting fish, meat, beans, and vegetables, a popular method to preserve food during times of scarcity is through fermentation using lactic acid bacteria. This has become a major characteristic of Korean cuisine, and among them, Kimchi stands out as the most iconic traditional dish on the Korean Peninsula [1]. Besides, China also has the similar fermented food that are called pickle, which has 3000 years of developing history, and have seperated into different kinds. The most famous types are Sichuan pickles, northeast sauerkraut and Fuling mustard and so on [2]. Kimchi and pickles have a wide audience and a huge market. In China, it is very commonly used as a condiment. In Korea, kimchi is an essential part of the Korean diet. And this condition makes its impact on human health a very important issue.

Today, there have been relatively numerous studies on the physicochemical characteristics of the fermentation process and changes in microbial communities during the fermentation of Kimchi. By simulating the processing and fermentation process of kimchi, the salt content, pH value, nitrite content and the microbial richness and content of Lactobacillus, Micrococcus, Leuconostoc, Lactococcus and Weisseria in different stages of kimchi were determined according to the measurement standard.

However, there is limited research on the chemical composition of Kimchi and the impact of microbial communities on human health. This article aims to fill this research gap. By analyzing the fermentation process and techniques of Kimchi, this study will summarize its nutritional components and further investigate the effects of these components and microorganisms on human health. The findings will provide valuable insights for determining the consumption of Kimchi and establishing food safety standards.

2. The Process of Making Kimchi

2.1. The Raw Materials of Kimchi

The process of making kimchi includes the pre-treatment, curing, fermentation and saving. Among them, the selection of raw materials plays an important role in the change of physical and chemical properties and the presentation of final flavor. The main ingredients include fresh cabbage or carrot, apple or pear, garlic, ginger, dried chili powder, sugar, pickled salt, white wine, mash juice, flour, fish sauce. Cabbage and carrot are the main parts of the kimchi, providing the taste. In order to increase the sweetness and fruity flavor of kimchi, apple or pear is added as auxiliary material, accounting for about 2.5% of the mass of cabbage [3].

2.2. The Process of Fermention

Due to the specificity of the microbial environment in the fermentation process, it is imperative to undertake pre-treatment of raw ingredients before initiating fermentation in the tank. Commence by selecting fresh, whole cabbage and carrots, ensuring a thorough washing of these ingredients. Subsequently, halve the washed cabbage and cut the carrots into strips. Proceed to incorporate 4% vegetable salt into the vegetables for pickling. After a 2-day marination period, remove and rinse the vegetables, allowing them to drain.

Finely chop the remaining seasonings, ensuring a thorough mix, and apply the mixture to both the interior and exterior surfaces of the cabbage. Carefully layer the cabbage compactly within the fermentation tank, covering it with plastic film and a cylinder head to establish an oxygen-free environment. The fermentation process should span a duration of 7-10 days. This meticulous procedure ensures optimal conditions for the fermentation of high-quality kimchi.

Most kimchi is made by natural fermentation. Generally, a large number of microorganisms are attached to the surface of fresh vegetables, mainly lactic acid bacteria, yeast, mold, enterobacteriaceae bacteria and pseudomonas bacteria. In a suitable environment, the use of lactic acid bacteria in the air, fresh vegetables as the substrate, to produce a unique flavor. In the environment with suitable oxygen content, water content, temperature, and concentration of salt for lactic acid bacteria, it become the dominant bacteria community. Lactic acid bacterias grow in number and acidize the vegetable matrix, resulting in the death of spoilage bacteria with poor acid resistance. However, because natural fermentation is an open production method, a mixed fermentation process including lactic acid bacteria was eventually formed. During the fermentation process, these microbial lines use the nutrients in the fermentation system to produce metabolites, such as organic acids, vitamins, amino acids, bacteriocins, etc [4].

During the fermention, the physicochemical characterastic in the kimchi changes. The salt content increases rapidly in first 4 hours, to 3%. Because of the lactic acid bacteria use carbohydrates to make lactic acid, the pH decreases rapidly in the first 16 hours, making the acid content remain 1% in the final products. In the process, the content of nitrite may rise above the food safety standard in the first few days, but eventually decrease after 10 days.

These physicochemical characterastic are mainly caused by the nunber of bacteria communities. At the very beginning, lactic acid bacteria become the dominant bacteria community. With the decreasing pH, the lactic acid bacteria and infectious microbe that dominate the fermentation are inhibited by the low pH, and the acid-resistant yeast continue to ferment until the sugar is exhausted [5]. That is the reason that pH and nitrite first go down and then go up.

2.3. The Storage Methods of Kimchi

As kimchi is a fermented food rich in microorganisms, improper preservation methods can easily lead to food safety problems such as contamination of bacteria and excessive nitrite. Home-made pickles should keep the jar sealed, reduce the time it takes to open the jar, and store in a cool, dry environment. This avoids the inoculation and growth of miscellaneous bacteria.

Adding preservatives and sterilization are the main preservation methods of industrial kimchi. However, after kimchi is pasteurized at high temperature, A large number of lactic acid bacteria are killed, and the content of nutritional elements such as protein and vitamin A and vitamin C is greatly lost. In order to avoid this situation, other non-heat treatment methods can be used, such as ultra-high pressure and irradiation. These two methods use high pressure and radiation sources to kill microorganisms and endogenous enzymes in kimchi, to achieve the purpose of sterilization and preservation [6].

3. Nutrient Content in Kimchi

3.1. Vitamins and Minerals Content in Kimchi

Kimchi is rich in calcium, iron, phosphorus and other trace elements. According to Su Jin, in the young Chinese cabbage commonly cultivated using nature friendly composts, there are 2.1mg/100g of Ca, 23.5mg/100g of Fe and 6.1mg/100g of P [7]. For Vitamins, Kimchi is rich in VitaminB1, B2, B3, B6, B9 and Vitamin C [7].

3.2. The Probiotics in Kimchi

Kimchi boasts a diverse array of probiotics, including lactic acid bacteria and yeast. Notably, lactic acid bacteria stand out as the most abundant and efficacious for the human body. Research indicates that lactic acid bacteria found in kimchi exhibit the ability to degrade cholesterol, resist both acid and alkali environments, thereby not only regulating cholesterol and nitrite levels in fermented food but also exerting inhibitory effects on the proliferation of miscellaneous bacteria [8]. Moreover, numerous studies have highlighted the positive impact of lactic acid bacteria in kimchi on the intestinal flora environment, demonstrating potential benefits in addressing conditions such as non-alcoholic fatty liver disease [9]. Lactic acid bacteria in kimchi have many health-promoting properties.

3.3. The Dietary Fiber in Kimchi

Dietary fiber is a general term for a class of compounds, including cellulose, hemicellulose, pectin and non-carbohydrate lignin in crop cell walls. Kimchi contains 36.7g fiber of 100g kimchi product [7] because most kimchis are made of China cabbage that rich in fibers. As a significant secondary food for both Chinese and Korean populations, kimchi, rich in dietary fiber, plays a crucial role in promoting intestinal peristalsis and preventing constipation. Dietary fiber functions by adsorbing excess proteins and moisture, effectively clearing waste from the intestinal tract. Additionally, as indigestible carbohydrates, dietary fiber helps regulate blood sugar levels by slowing down the absorption of carbohydrates, thus stabilizing blood glucose. These impacts show the importance of dietary fiber in kimchi as a valuable component contributing to gastrointestinal health and blood sugar management.

4. Consumption of Kimchi

All these factors have led to the globalization of kimchi, including a growing appetite for different cuisines, the growing influence of Korean pop culture, and awareness of its health benefits. Kimchi has a unique taste, with a spicy and umami flavor after fermentation, and is loved by all people around the world.

Kimchi has integrated into local foods and adapted well to many countries in recent years. Since this fermented food has many functions in cooking, such as taste improvement and serving as seasoning, it can be integrated into various cooking systems. For example, kimchi is used in tacos in the United States and burgers in Europe.

Korean restaurants were established in many countries, promoting the commercial sale of kimchi in supermarkets and contributing to its global influence. In addition, kimchi has benefited from the mainstream view that pays more attention to health, as it is rich in probiotics and dietary fiber.

4.1. The Impact of Kimchi Consumption on Human Health

Kimchi is rich in many vitamins and minerals, including vitamin A, vitamin C, vitamin K, calcium, iron, potassium and so on. These nutrient elements help to provide comprehensive nutritional support for human health. Vitamin C, as an antioxidant, plays a very important role in fighting free radicals and slowing down the aging process of cells, which has a positive impact on skin, eyes and human health.

The dietary fiber in kimchi is indigestible fiber, which can absorb water and protein in the digestive tract, promoting intestinal motility, and preventing constipation. In addition, dietary fiber can bind to cholesterol in the gut, impeding the absorption and increasing the excretion of bile acids. This help to lower cholesterol levels, especially low-density lipoprotein (LDL) cholesterol, helps maintain cardiovascular health.

In addition, dietary fiber helps to slow the absorption of carbohydrates, which in turn regulates blood sugar levels. This function is particularly beneficial for people with diabetes because it helps prevent sharp fluctuations in blood sugar.

In addition to these nutrients, kimchi also contains probiotics, such as Lactobacillus and Lactococcus, which are indispensable in the fermentation process. Probiotics in kimchi have a positive impact on gut and overall health by maintaining the balance of gut flora, enhancing immune system function, and potentially reducing gastrointestinal inflammation.

4.2. Suitable Consumer Groups and Consumption Recommendations for Kimchi

According to existing research, the properties of kimchi make it particularly beneficial to the health of some populations. It serves as a nutritious, delicious food that caters to different populations with different health concerns.

Probiotics in kimchi are great for people with digestive problems or constipation. First of all, the addition of probiotics in kimchi helps maintain a balanced intestinal flora and promotes the digestive function of the intestine. In addition, those with weakened immune systems, such as the elderly or those with chronic diseases, can get probiotics and vitamin C from kimchi, and their effects complement each other to enhance the elasticity of the immune system and increase the body's immunity.

Kimchi's rich dietary fiber is helpful for people who need to regulate their blood sugar. In addition to this, the presence of dietary fiber makes kimchi beneficial for those concerned about heart health. The potential cholesterol-lowering properties of dietary fiber help maintain the elasticity of blood vessels, thereby reducing the risk of cardiovascular disease.

In addition, kimchi appeals to individuals seeking dietary variety, not only does it provide essential nutrients, but its unique taste and flavor and diverse cooking methods give people a unique eating experience.

Although kimchi has a good effect on the health of most people, there are some special groups of people who are not suitable for kimchi. First, due to the higher salt content of kimchi, people with high blood pressure, kidney disease, or impaired kidney function need to consume it with caution, as a high-salt diet may have side effects on cardiovascular health and cause difficulties in sodium metabolism for people with impaired kidney function. Second, people suffering from stomach ulcers, excess stomach acid, or gastrointestinal sensitivities should consume kimchi with caution, as the elevated acidity in kimchi may irritate the stomach lining, thus exacerbating existing symptoms. Third, people who are allergic to chili peppers and other fermented foods should avoid pickle varieties that contain these ingredients, as some pickle recipes include chili peppers or chili products that pose a risk to sensitive people.

In conclusion, individuals with specific health conditions are advised to consult a healthcare professional or dietitian before choosing kimchi as a daily diet. This ensures that kimchi consumption is in line with individual health needs and maximizes the benefits of the kimchi diet.

5. Conclusion

In summary, based on the existing research, this paper summarized and analyzed the material of kimchi, the changes in physical and chemical properties and microbial development during fermentation, the main nutrients, and the effects of eating kimchi on human health. As a fermented food with special production process, kimchi contains rich vitamins and minerals, dietary fiber and a variety of probiotics. We can find that the choice of raw materials, fermentation environment and method, storage methods, will have different degrees of impact on the quality of the final pickle.

In recent years, most research has focused on the physicochemical aspects and microbial communities of pickle fermentation. This study revealed the chemical composition and potential biological significance of kimchi by analyzing its basic production process and physicochemical properties. However, the lack of biology-specific experiments and long-term observations on the health effects of kimchi consumption may lead to individual differences in the conclusions reached. Future research should focus on filling these gaps, taking into account individual differences and the long-term consequences of kimchi consumption. On this basis, future studies should also explore more complete and mature personalized kimchi consumption guidance based on individual health status.

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