Food Preservation Technology in Maintaining Food Texture and Taste

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Abstract. Currently, public attention to food safety continues to rise, and the demand for high-quality and delicious food is growing. Especially in long-distance transportation scenarios, how to maintain food taste and texture through preservation methods becomes a key issue. This paper focuses on food preservation methods as the core research topic, with a systematic analysis centered around various existing preservation technologies, particularly focusing on the application characteristics of three typical preservation methods: dehydration, refrigeration, and ozone. The study finds that when traditional preservation methods are combined with advanced materials, their preservation efficiency can be significantly optimized. At the same time, many improved preservation technologies are gradually developing towards convenience, promising to quickly integrate into daily life. However, it is also clear that each method has inherent limitations - they are prone to failure under specific conditions, leading to deterioration in food taste and texture, and even posing health risks. The significance of this research lies in comprehensively reviewing the advantages and disadvantages of multiple preservation technologies, providing a scientific basis for judging the adaptability of preservation methods in different application scenarios. Its core contribution is to help relevant practitioners and researchers more accurately choose reasonable food preservation strategies, effectively address food preservation challenges in scenarios such as long-distance transportation, and promote the development of the food preservation field towards efficiency and safety.

Keywords: Food preservation, preservation method, taste, texture.

1. Introduction

China has an old saying: food is the paramount necessity of the people. Nowadays, this sentence is no longer limited to the fact that enough food is required, but also related to how to preserve enough food. With the constant rise in living standards, the pursuit of healthy and nutritious products for people is increasing significantly. Therefore, researchers all over the world are dedicated to finding novel ways to make the shelf life of products longer and satisfy what customers and the market require. However, despite all the efforts made, the current situation isn't optimistic. The spoilage rate of food is still high, although many countries have taken steps to control it. For example, the spoilage rate of meat and aquatic products in China is 8% and 10% respectively [1]. This spoilage mainly influences products with a large water content. Previous studies have already demonstrated that corruption and deterioration of products (especially in meat) are likely to cause a decrease in water inside the tissue, leading to volume reduction and other phenomena. Eventually, this taste and texture may be totally ruined and the product may lose its edible value [2].

Therefore, the clock is ticking. The whole world is now thirsty for something novel to prevent the food. Instead of directly developing a new preservation method, researchers worldwide are dedicating themselves to optimizing traditional methods by applying sophisticated technology. And results showed that this step does improve the efficiency of food preservation. For instance, for normal chilling (such as 4.8 °C per hour), due to the influence of enzymes, plenty of ATP was generated and the glycolysis of meat is rapid, leading to the easier degeneration of meat. And this situation was only improved when the chilling rate was raised greatly [3]. However, it would be difficult for a normal family to gain such a rapid chilling equipment. In contrast, the method of freezing-thawing with MFC was once tested. This research is targeted at finding out the differences between directly chilling and chilling with auxiliary tools. The findings are rather positive, as freezing-thawing improved beef quality traits, especially from the aspect of color, water-holding capacity of holding water and tenderness. Compared to traditional chilling ways (including the method of raising chilling rate), tenderloin tended to become more stable during the whole process. So different MFC actually protects against excessive deterioration of meat taste and texture, which might serve as a promising option [4].

As a result, this paper was written to summarize as many practical methods as possible. These methods had to be convenient, accessible and applicable to daily life rather than purely scientific research. The content below was mainly divided into three sections: dehydration, chilling and ozone. The first two options were actually improvements on traditional methods. For ozone, this might be a new option for some people, but in fact, it has been developing rapidly in recent years. To sum up, these three options hold the greatest potential for introduction into daily life.

2. Three promising ways of preservation nowadays

When taking food preservation into account, there are plenty of ways of preservation nowadays. Dehydration, as one of the most common and traditional methods of preservation due to its stability of preservation and convenient process, has already been widely applied in the market. This aim was usually achieved by directly heating the product. This might work for dried vegetables. But when considering the meat products, the protein might be degraded, then the taste and texture could be dramatically ruined unless there was some special care.

In 2010, a new dehydration method - microwave vacuum drying (MVD) - was studied and shown to not only extend the life span of food products compared to those without this method, but also help improve their quality and hygiene as well. Besides, the quality and hygiene could be further optimized when MVD was added. In this typical method, by applying an electric field, the heat used to evaporate the water was generated by the frequent rotation of water molecules instead of directly heating the food product, and the drying time was significantly reduced when compared to other drying methods. Zhang also found out its outstanding ability in preserving the aquatic products. When carp slices endured the process of microwave-vacuum heating, the microwave power prevented the formation of burnt spots on the surface, thus improving the crispness of slices when consumed. In this way, the sensory quality of this typical fish product was guaranteed and the texture was at least not deteriorated. Also, this way could be optimized when other methods are integrated into [5].

Osmotic Dehydration (OD) technology can be used as an adjunct in conjunction with existing drying methods to preserve the texture and flavor of food products. To enhance preservation, the team summarized existing research on OD technology and noted that previous studies on OD have demonstrated its ability to preserve food texture [6]. For example, Enhanced Frequency Pulsing (EFP) as a pre-treatment step before dehydration, which is a type of osmotic dehydration technology, has been shown to improve food properties, such as not destroying the tenderness of raw materials during the dehydration process. What’s more, another sort of OD technology, ultrasonic-assisted treatment (US), whose feasibility had also been tested [7]. Litchi, which had an old saying as: color changes on the first day, fragrance loses on the second day and flavor alters on the third day, however, still had acceptable quality after being refrigerated at -18 degrees for 90 days with the help of US technology. That was because the pretreatment from the US enhanced the loss of water from Litchi [8]. In this way, Litchis were less likely to become rotten, thus the texture was assured to the maximum.

Because of the differences in customs and climate, the eating habits all over the world vary significantly. What remained unchanged was people’s eagerness for a better flavor of food. This wish can be reached by applying modern preservation methods. Apart from dehydration, there existed other methods of preservation. In daily life, refrigeration was taken into use for food preservation. That showed the key condition of preservation—chilling. A study had already been conducted on low-temperature preservation, aiming for the future. An article once summarized the existing low-temperature preservation aiming for food. It is proposed that low temperature serves as the most popular way to protect food nowadays. However, since each region (especially in Asia) has specific food targeting its particular geography, climate and culture, the traditional chilling way has its weakness for not effectively maintaining the original unique flavor, and the food becomes deteriorated in the end [9]. Therefore, the low-temperature method should be optimized to some extent or combined with other promising technologies (such as nonthermal sterilization) to ensure the freshness and tastiness, especially for preserving aquatic products.

Therefore, in the field of low-temperature preservation, metabolism techniques were once applied to investigate the circumstances of lamb enduring the process of very fast chilling (VFC). The results showed that the process of metabolism was dramatically altered during the typical way of preservation (lower than 0°C, coupled with 1.5 hours of slaughter). For instance, the concentration of both IMP and amino acid increased during this process, and IMP eventually became redundant. Instead of directly being degraded into inosine, the excessive IMP was speculated to combine with the myosin head (while this inference remained to be tested in future research), thus improving the texture of lamb by retaining its tender surface [10]. The VFC also had great potential. Despite the texture, this typical VFC method also showed its capability in preventing meat from aggressive microorganisms. One study investigated the effects of chilling rate. The experiment was conducted on a lamb as well. But what's different is that this study emphasized the chilling rate set at 14.52°C/h. By assessing the freshness and microbial community composition from three various chilling style, which were traditional chilling (1.76 °C/h), very fast chilling of type one (12.52 °C/h) and very fast chilling of type two (14.52°C/h) respectively, those outcomes demonstrated the fact that TVB-N (served as the indicator of freshness) of VFC (type two) treatment was significantly lower than that of other treatments. Therefore, microorganism that contributed to the formation of TVB-N from protein was restricted during this process [11]. The decline of microbial diversity was less likely to cause a lower deterioration.

One more detailed understanding of the tenderization mechanism was reached when applying the VFC to preserve beef muscle. In this experiment, apart from VFC, immediate chilling (IC) and delayed chilling (DC) served as the two main chilling treatments. In IC, striploins were immersed in a propylene glycol water bath at -20°C and gained at the temperature of -1.5°C in the end. By contrast, striploins in DC were gained from a water bath set at 15°C. When investigating pH differences, findings demonstrated that DC and IC resulted in different rates and extent of pH declines. From the aspect of light micrographs, the divides between fibers were likely to be larger in the case of IC samples. What's more, striploins after the process of IC held a lower peak force value, while this only took place during post-mortem. This finding demonstrated that hastened tenderization did occur due to early post-mortem of the VFC [12].

Besides the optimization of traditional preservation methods that had already been mentioned above. With the rapid research into the application of various materials, numerous sophisticated methods have emerged. Ozone, the substance that helps to protect us from ultraviolet radiation, was also considered to preserve the food effectively. Immersing vegetables in the ozone water served as a positive method to extend the expiration date. For example, the microorganism counts reduced significantly in nearly all subjects. That was due to the capability of ozone for destroying a great amount of microbiome by oxidizing some essential components of cells. This process won't dramatically influence the nutritional constituents and sensory quality of the original food. What's more, residue problems of ozone after preservation seldom exist, as this substance can degrade by itself and finally form oxygen, which is totally harmless when compared to chlorine [13]. A previous study was conducted on preserving orange juice. Before the ozone processing, the juice was subject to a plasma field at 70KV with a variety of times (15, 30, 45 and 60s, respectively). Firstly, the juice undergoing the process of ozone became lighter and more vivid; the hue angle increased by about 1.2 units when compared to the pasteurized orange juice, indicating that the ozone didn't affect the product color. When taking a look at the total phenolic content. Moderate phenolics can provide the juice with a rich and mellow taste. The study showed that without the process of ozone, the values declined from 2.52±0.20 to 1.93±0.12 grams per liter. However, when the juice was processed by ozone, the content dropped from 2.52±0.20 to 2.33 ± 0.07 grams per liter. In this way, the content of the content was higher when ozone was present. Last but not least, when considering the total antioxidant activity, which was detected by applying DPPH and ABTS free radical methods. When adding the least amount applied, which was 0.075mg O3/mL, the antioxidant activity of the juice didn't change significantly. However, when the amount added rose to 0.230mg O_3/mL, a great decline in the antioxidant capacity of the juice was detected. After quantization, the loss of the antioxidant capacity was about 18 percent. This amount was already enough when considering the sterilization [14]. Thus, the original taste of juice was less likely to be spoiled by the microbiome.

Besides, ozone also showed extremely strong compatibility. It was once integrated with UV to preserve the Pandalus borealis when travelling. Pandalus borealis, as a flavorful marine product, held strong market competitiveness. While the microbial spoilage during transportation could seriously impact its flavour. In this way, a UV-Ozone combined method was applied to preserve this product. Findings were also divided into several parts. Firstly, the colour was measured by sampling the second or third abdominal segment near the head. Findings showed that the group applied to this method was more likely to maintain the original coloration. That's because this treatment constrains the vigor of the enzyme responsible for discoloration and oxidative reactions. Next, it came to the texture, which served as the main part. The texture includes hardness, elasticity, chewability, and recovery. The texture characteristics were measured by a texture analyzer, and the parts taken were the same as those taken for the measurement of colour. To minimize the mistakes, three measurements were conducted for each sample, and the outcome was the average number. After 25 days, the results demonstrated that the treated group kept a slightly higher value than the control group. This result showed the ability of this system to slow the softening of tissue. This aim was achieved by the effect of this UV-ozone combined method, which restricted the microbiome that helped to degrade the muscle protein of shrimps. For other characteristics like elasticity and chewability, products from the treated group also deteriorated more slowly. The results demonstrated that the UV-Ozone method held the ability to powerfully reduce the microbial levels, thus extending the freshness period and without negatively affecting sensory properties(taste) and food safety [15]. This way offered a practical solution for improving the cold chain transportation of seafood and could have further industry applications.

Although the method of ozone had already been approved to be applied in food engineering in 2002, its limitations should be aware of and taken great care of before replacing the traditional method with this method. In the case of preserving onions, ozone was applied to diminish the Aspergillus niger, which may lead to black rot disease on the surface. This typical microorganism was cultivated on potato medium for 5 days at a temperature of 25°C to gain conidia. When they were subject to special treatments, germination of spores was observed under the microscope (Olympus BX50) every 6 hours and the total number of spores was counted. Results showed that nearly all spores in the suspension were treated with the ozone. However, some colonies failed to sporulate; moreover, the number of those that did not sporulate rose with the extension of ozone exposure time at a concentration of 4.80 mg/L. Besides, similar results applied to the ozone ineffectiveness at sucrose at 5 percent. In this way, the effectiveness of ozone in reducing spore germination was limited. The color change was witnessed (because of the black rot disease), and this not only led to the change in texture, but also raised great health concerns [16].

3. Conclusion

At present, with the variety of different ways in which foods can be preserved to keep their freshness and quality and make them last longer, dehydration and low-temperature preservation play important roles. These two methods were also proven to be available for daily usage. Like when considering the preservation of aquatic products, there existed a trend to improve the crispness in slices. Dehydration, served as a traditional and common method, had evolved when coupled with microwaves. Traditional direct heating risked damaging meat proteins and ruining texture, but Microwave Vacuum Drying (MVD) tackled this. It generates heat through water molecule rotation (not direct heating), which shortens drying time and preserves aquatic product quality. It also had the potential to be optimized by combining with other techniques. Apart from MVD, some Osmotic

Dehydration (OD) technologies like Enhanced Frequency Pulsing (EFP) and ultrasonic-assisted treatment (US) serve as effective alternatives. For instance, EFP maintains raw material tenderness during dehydration, while US extends litchi's acceptable quality to 90 days at -18°C by promoting water loss. Low-temperature preservation, especially refrigeration, was already widely used but had a weakness: traditional chilling failed to retain the unique flavor of region-specific foods, especially in Asia. Thus, optimization (VFC) or combination with sterilization was needed. VFC (which required 1.5h post-slaughter and the temperature below 0°C) changed lamb metabolism, increasing IMP and amino acid concentrations; excess IMP might combine with myosin heads(pending verification) to retain tenderness, and it also helped prevent meat issues in other fields. Ozone, one which showed obvious weakness, such as the color change, was witnessed during preservation, indicating its ineffectiveness. What's more, the process of reducing spore germination was not such satisfying as well. This was the most important weakness in showing the fact that the ozone method still contained health issues. However, when treated properly, the ozone method showed its ability in preserving the texture, which is consistent with the core of this essay. Last but not least, the key to future preservation methods might lie in the integration of various methods. Only when all advantages were gathered, the weakness of each method was minimized.

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