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*Original Paper*

# Application of Ultra-high Pressure Processing Technology

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***Abstract***

*High pressure processing is an innovation for the traditional food processing and preservation method. Since the method of ultra-high pressure processing (HPP) exerts a very little influence on the covalent bond of food, its influence on the nutrition, taste, and texture of food is minimized. However, HPP food is perishable in long distance transportation and sales process. Since food freshness directly affects the final demand in market, how to use the appropriate strategy to manage commodity stocks effectively during the long time and distance in food transportation and match the supply and demand of HPP food to improve the competitiveness of companies are the challenges faced by HPP food companies in upstream and downstream supply chain. This paper describes of the different features of HPP foods compared to that of traditional processed foods, and analyzes the collaboration of HPP foods supply chain members.*

***Keywords***

*HPP food, food freshness, cold chain*

## 1. Introduction

Ultra-high pressure processing technology refers to the process that sealing the food in containers, using water or oil as pressure transmitting medium, and carrying out 100-1000 MPa pressure treatment at normal temperature or slightly above normal temperature. It is an innovation of food processing and preservation methods that effectively kills microorganisms and maximizes the original quality of products.

Ultra-high pressure technology has made great contributions to China's food industry. Firstly, it can save production costs, reduce pollution and protect the ecological environment. Compared with traditional thermal processing, the ultra-high pressure processing can save energy by 85.5%. If the heating and pressurization energy loss are not counted, the volume utilization rate of the ultra-high pressure processing container is 60%. Secondly, China's total amount of agriculture is large, but the conversion rate of agricultural products is low; there are many agricultural products processing enterprises, but the proportion of deep processing enterprises is small. These are not conducive to improving the comprehensive competitiveness of China's agricultural products and expanding the income of farmers. From this perspective, traditional and primary agricultural production and management is a waste of agricultural resources. China's agriculture urgently needs to change its development mode, improve the breadth and depth of agricultural product processing, accelerate the process of agricultural industrialization, and extend the industrial chain to take the road of "intensive agriculture". As a new technology, ultra-high pressure production technology can promote agricultural industry upgrading. Thirdly, Good color, taste, texture, nutrition and safety are important features of high-quality food. With the improvement of residents' consumption power, consumers are increasingly demanding the high quality of processed agricultural products. Traditional thermal processing technology can no longer meet consumers' higher requirements for processed foods, so the improvement of product quality urgently requires a comprehensive upgrade of processing technology. Ultra-high pressure technology maintains food characteristics, avoids chemical residues and ensures food safety, it is an effective way to improve processing quality and solve food safety problems.

In recent years, there have been many foods processed by high-pressure technology in the world market, but the research level and direction of different countries are quite different. At present, China's production and processing of ultra-high pressure food is still in its infancy, and there is a big gap with developed countries. Currently, the production and transportation costs of ultra-high pressure foods are relatively high, and the prices of products are relatively high. For example, the high price of foreign equipment has greatly increased the cost of products, and it does not adapt to the current economic development of China, which seriously restricts the application of ultra-high pressure technology in China's food chemical industry. Additionally, constrained by the conditions of technology and logistics cold chain coordination, the range of foods currently used in ultra-high pressure technology is limited. At the same time, in the process of technology promotion and application, due to the lack of cold chain synergy scheme, the shelf life of ultra-high pressure food is short. All of these have limited the popularization of ultra-high pressure processing technology.

## 2. Practical Studies

According to the analysis of the effects of ultra-high pressure processing technology on food sensory quality (color, texture), nutritional components (protein, lipid, vitamin), physical and chemical quality (pH value, water holding capacity, volatile base nitrogen), ultra-high pressure processing can retain the original quality and flavor of food to the greatest extent. Therefore, as a new processing and storage technology, ultra-high pressure processing is an important development direction of food processing industry in the future. Taking cloudy ginger juice and fermented pomegranate juice as examples, this paper compares the changes of food indices under ultra-high pressure and thermal processing.

The effects of hydrostatic pressure treatment for 500 MPa, 10 min and super-high temperature treatment for 110 and 8.6 s on the quality of cloudy ginger juice were investigated during storage for 91 days at 4 and 25 degrees respectively. The microbial stability and other selected characteristics of ginger juice were studied, including pH, total soluble solids (TSS), edible acidity (TA), total phenols, ginger, antioxidant capacity, color and aroma.

The results showed that the microbial load was reduced by 3.0 logarithmic cycles under ultra-high pressure treatment, but the total phenol content increased by 5.31% without affecting pH, TSS, TA, antioxidant capacity and color (day 0), while the total phenol content decreased by 14.74% after ultra-high temperature treatment (day 0). The ginger increased by 14.43% and 14.18% respectively after ultra-high pressure and ultra-high temperature treatment (day 0). Monoterpenoids are the main volatile aroma components. After ultra-highpressure processing, there is no significant change, but after treated by ultra-high temperature (day 0), the content of monoterpenes decreased by 2.27%. During storage, the phenols, ginger and antioxidant capacity of cloudy ginger juice treated by ultra-high temperature were significantly lower than those treated by ultra-high pressure. The change of antioxidant capacity was positively correlated with total phenols and ginger. During storage, the color of cloudy ginger juice treated by ultra-high pressure and ultra-high temperature darkened and the aroma disappeared. The quality change of samples stored at 25 ℃ is more obvious than that of samples stored at 4 ℃.

The microbial quantity of fermented pomegranate juice after ultra-high pressure and heat treatment was in line with industry standards, and showed an upward trend during storage. At the end of storage, the total number of colonies in the ultra-high pressure and heat treatment groups was 55 CFU/mL and 80 CFU/mL, respectively, also in line with the industry standard requirements; pH, TA and TSS did not change significantly before and after treatment ($p > 0.05$); there was no significant change in pH and TSS during storage ($p > 0.05$), while TA decreased significantly ($p < 0.05$). The ultra-high pressure treated samples had higher total phenolics, anthocyanins, total flavonoids and antioxidant activities. During storage, total phenolics, anthocyanins, total flavonoids and antioxidant activities showed a downward trend. Compared with heat treatment, ultra-high pressure can better retain total phenol, anthocyanin content and antioxidant activity, while heat treatment can more effectively control the loss of total flavonoids during storage. The results of correlation analysis showed that the antioxidant activity of samples during storage was positively correlated with the contents of total phenols, anthocyanins and flavones ($p < 0.01$). Compared with the untreated group, the effects of ultra-high pressure and heat treatment on the color of fermented pomegranate juice were less ($E < 2$). The L* and a* values of the two treated groups during storage were less significant ($p < 0.01$). The change of b* value in heat treatment group was higher than that in HPP treatment group. In conclusion, compared with heat treatment, the total phenols, flavonoids, anthocyanins and antioxidant properties of fermented pomegranate juice treated by ultra-high pressure are better. Therefore, ultra-high pressure treatment or ultra-high pressure combined heat treatment can be used in the production and processing of pomegranate juice in order to achieve the purpose of sterilization and quality preservation.

## 3. The supply Chain Collaboration Process with HPP Foods

The food industry is a very important sector in the development of national economy, and various new methods of food processing and storage are researched and developed. Ultra-high pressure food processing technology has just met people's demands for high-quality and high-nutritional food, and sparked a new revolution of food industry. What happens with it is that the localization of equipment and design research of corresponding cold-chain logistics have become the bottleneck problems in the application of ultra-high pressure technique. These bottlenecks will increase the access threshold for food enterprises to develop ultra-high pressure food, thus, solving the bottleneck problems can help food enterprises to enhance their core competitiveness. Ultra-high pressure food supply chain is the industrial chain research of various concerted supply chains, such as technology equipment, food and packing material. Food cold chain covers the whole process of the perishable foods from origin acquisitions or fishing, to product processing, storage, transportation, distribution, retail, until transferred into consumers' hands. It is necessary to remain the low temperature environment in each link, to ensure the food quality and safety, reduce loss and prevent the contamination.

Color, taste and texture are not only the important quality characteristics of vegetables, fruit, seafood and meat, but also the main factors to affect the sensory quality as well as customer's acceptance of food. People apply various processing methods to increase the edibility and palatability of vegetable, fruit and meat besides extending their shelf life. Since the method of high pressure processing (HPP) exerts a very little influence on the covalent bond of food, its influence on the nutrition, taste, and texture of food is minimized. Therefore, HPP is an interesting choice for traditional food processing and fresh keeping. Specifically, HPP can promote the release of the protein in meat, eliminate part of the allergen and remove the pathogens. In the ultra-high pressure processing, different pressures and temperatures can be used to gain the desired effect of food color, taste and texture. However, when the endogenous enzymes or microorganisms are not completely inactive, because of the coexistence of chemical reactions (such as oxidations and biochemical reactions), the quality of fruits and vegetables processed by high pressure will change in the stockpile period. Therefore, the cold chain should be designed based on how to prevent the above-mentioned chemical reactions. Meanwhile, food and juice treated by ultra-high pressure have higher requirements for the cold chain. Therefore, only through rational optimal design of cold-chain logistics can cost be reduced and shelf life and taste of products be increased, thus achieving the mass consumption of food processed by high pressure. Otherwise, food processed by ultra-high pressure can only be so-called high-grade food, and the cold chain innovation will only become a high-cost technology application.

The main purpose of cooperative research on supply chains is to design a reasonable coordination and interest allocation mechanism, which is in order to improve the performance of the whole supply chains and make the decentralized decision-making reach the effects same with centralized decision-making. At the same time, the "win-win" situation can be created. Then, toward the relatively special food supply chain, what is the strategy for pursuing the maximum performance of the whole supply chain?

The case study shows that the traditional supply chain coordinating contracts (such as quantity discounts contract, buy-back contract, etc.) can also be applied to the field of ultra-high pressure and traditional food supply chain, however, the differentiation also exists. Therefore, the research is designed according to variable situations to improve the coordinated safeguard mechanism and benefit distribution mechanism for raw material, packing material suppliers, food manufacturers, cold-chain logistics service providers and retailers so as to provide decision-making guidance for the operation of super high-pressure food supply chain. The model of supply chain collaboration of high pressure processing food is constructed as follow. Products go through cold storage, distribution center and seller, finally achieving consumer with the reverse logistics and product packaging recovery after the point of seller returning back to the point of production recycling. The full range low temperature is controlled. Among the process from production to selling, enterprises would be collaborated, who follow the industry law and policy, formulate overall aims and implement them, share the benefits, profits and responsibilities, finally appraise the performance of supply chain coordination. With the supply chain synergy, personnel, foods and facilities are input. After the integration of supply chain cooperation of HPP foods, the customer satisfaction, food safety, management efficiency and profit would output. The optimization performance would be achieved with the coordinated supply chain.

## 4. Conclusion

Ultra-high pressure processing technology is an innovation of food processing and preservation methods that effectively kills microorganisms and maximizes the original quality of products. The biggest difference between the supply chain of ultra-high pressure food and the traditional high-temperature sterilization food supply chain lies in the cold chain control. Therefore, the coordination requirements are high, and the deep cooperation of the members of the supply chain is required to improve the competitiveness of the supply chain.

The future study is aim to the synergies and collaborations of supply chain members of HPP foods and beverages in the commercial production. With the research, we will focus on the production yielding rates of HPP technology application.

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