Comparative study of supercooling freezing with conventional freezing in different foods

［課程博士・論文博士共通］

博士学位論文内容要旨
Abstract

専　攻 Major	Applied Marine Bioscience	氏　名 Name	RAJIB LOCHAN POUDYAL
論文題目 Title	過冷却を利用した食品の高品質凍結 Comparative study of supercooling freezing with conventional freezing in different foods		

Freezing is one of the best methods of food preservation that can preserve the color, texture, taste, and nutritional quality in the foods for a long time, compared to other methods of preservations. During freezing, water changes into the ice; reduce the free water inside the food, which helps to inhibit the growth of the microorganism and reducing the enzymatic reaction. The formation of the ice crystals depends upon the various factors such as freezing temperature, sample sizes, water content, temperature fluctuations, etc. Freezing, in principle, can be realized by keeping food in the temperature below the freezing point. Nevertheless, if the temperature is not adequately low, slow freezing occurs and there is enough time for recrystallization, resulting in bad food quality after thawing. On the other hand, the ultra-low temperature rapidly makes the products frozen that enables small and uniform ice crystals. But, extreme rapid freezing increases the processing cost and may cause cracks on the microstructure, which further degrades the quality. To overcome such problems, various freezing methods have been attempted for about 10 years such as high-pressure freezing and the freezing assisted by ultrasound, microwave, radiofrequency-wave, electromagnetic field, combination of pulsed electric field (PEM) and oscillating magnetic field (OMF), etc. However, these freezing methods need an extra source of energy and cost during processing. Further, the utilization of high pressure and high voltage can be dangerous during handling.

High-pressure shift freezing is well known to enable small ice crystals and less microstructure damage. The phenomenon behind the high-pressure shift freezing is supercooling which is created by the high pressure. Since high pressure reduces the equilibrium freezing point, supercooling will occur just after releasing the high pressure applied to preliminarily cooled food. As a result, small and homogenous ice crystals are formed. Likewise, a combination of PEF and OMF is considered to help deeper supercooling. From these facts, supercooling before freezing is considered to have the potential to reduce the ice crystal size that leads to minimum freezing damage.

The main objective of this research was to investigate the freezing after supercooling enabled with slow and constant cooling on the atmospheric pressure; those did not employ special conditions such as high pressure or electromagnetic field. The effect of supercooling before the freezing was investigated in detail and the effect of different freezing rates after breaking supercooling was also investigated. Further, each and every food have own microstructure and the effect of supercooling can be different. So in this research, the effectiveness of the application of supercooling freezing was observed in three typical food products; protein coagulum, meat, and vegetable.

The specific objectives are; 1) To analyze the effect of supercooling freezing compared with conventional rapid and slow freezing. 2) To analyze the effect of freezing rate after breaking supercooling. 3) To analyze the effect

of supercooling freezing in drip loss, texture, and microstructure in the different food products. 4) To analyze the ice crystals morphology during supercooling freezing and conventional freezing methods. In order to achieve the above objectives, the strategic work plan has been done which are organized as following 6 chapters.

Chapter 1: The first chapter states the purpose of the study; firstly introduce the supercooling freezing followed by the past academic achievements, assessment of freezing damage and quality of the frozen foods which is already discussed above.

Chapter 2: This chapter contains materials and methods that are commonly used in all experiments in this thesis. Mostly the freezing methods, freezing rate as well as the quality parameter were discussed.

Chapter 3: This chapter first discussed the preparation methods of paneer, a soft cheese popularly consumed in Southern Asia. After that, the paneer frozen by supercooling freezing, conventional rapid and slow freezing were compared in terms of quality.

Chapter 4: This chapter especially focused on the influence of different freezing rates after releasing from the supercooling state on freezing of tofu. They were further compared with conventional freezing methods in terms of quality and sensory attributes.

Chapter 5: This chapter discussed the effect of supercooling freezing on the pork tenderloin. The supercooling had the ability to generate small ice crystals. However, in the case of pork tenderloin, the quality was not affected up to 3 month storage period.

Chapter 6: This chapter tried to investigate the different freezing methods on the blanched and non-blanched potatoes. No significant difference was observed between different freezing methods in the case of non-blanched potatoes.

In conclusion, it was found that the supercooling freezing generally had the potential to create small and homogenous ice crystals. Higher the freezing rate after breaking supercooling further reduced the ice crystal size and suppressed the recrystallization during preservation. The supercooling-rapid freezing was highly effective in tofu for improving the texture, lowering the drip loss and ice crystals sizes than conventional freeing. However, in the case of pork tender lion, ice crystal size was small as same as tofu, but quality indicators were not significantly different between supercooling freezing and conventional rapid freezing, while slow freezing only resulted in a little different trend. This would be because the cellular structure was strong in pork tenderloin. Similarly, in the case of non-blanched potato, supercooling freezing produced the small ice crystals but the quality indicators remained almost the same with conventional freezing, whereas the quality indicators were improved in case of blanched potatoes. The drip loss was reduced by supercooling freezing than conventional freezing except non-blanched potatoes and pork meat. Finally, the supercooling freezing had the potential to reduce the ice crystals which improved the quality in terms of texture, drip loss and microstructural damage in case of protein coagulum and blanched potatoes which indicated that, the quality parameters would not depend upon the ice crystal sizes in all food products.