The effect of processing conditions on quality changes of frozen surimi gels

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博士学位論文内容要旨
Abstract

専　攻 Major	応用生命科学	氏　名 Name	JIA RU
論文題目 Title	The effect of processing conditions on quality changes of frozen surimi gels （凍結すり身ゲルの品質変化に及ぼす処理条件の影響）		

Surimi-based products are processed fish products, including crab legs, kamaboko and fish sausage. The consumption of these products is constantly increasing in both developed and developing countries owing to their elastic properties and high nutritional values. Commercial surimi-based products are often stored in a frozen state before being sold in the market. For example, in Japan, surimi-based products play an important role and accounts for the major market share of processed fishery products, and they are frozen stored as it is required for scheduled production during high demand seasons such as the New Year. However, the quality of surimi-based products, especially traditional kamaboko, is easy to be damaged by frozen storage, and reduces the value of the products. Currently, the setup of freezing conditions depends on the manufacturer's experience. Essentially, the use of freezing technology for surimi-based products is not supported by a scientific basis. Therefore, the objectives of this study were 1) to investigate the influence of various conditions on quality changes of surimi gels after frozen storage, 2) to develop methods to reduce the quality changes of surimi gels after frozen storage.

In Chapter 1, literature review about surimi and surimi-based products, freezing of seafood products and starch in surimi-based products was carried out.

In Chapter 2, the physical properties and drip loss of five different types of commercial surimi-based products (*Itatsuki-kamaboko*, *Chikuwa*, *Satsuma-age*, *Datemaki*, and *Hanpen*) at different freezing conditions were evaluated. After frozen storage, the breaking strength and breaking strain of *Itatsuki-kamaboko*, which is a two-step–heated surimi gel without starch, decreased with frozen storage, while for the other products, which are direct-heated gels containing starch, the breaking strength and breaking strain increased. Drip loss increased after frozen storage, and the thawing drip was higher with *Itatsuki-kamaboko* than with other products. These changes were notable in samples subjected to slow freezing than subjected to quick freezing. Moreover, the results of physical properties and drip loss corresponded to the change in sensory characteristics. Thus, the quality change in frozen surimi-based products might be correlated to not only the freezing conditions but also the heating methods and ingredients used.

In Chapter 3, the effects of heating methods on the quality changes of surimi gels with different freezing conditions were evaluated. Heated surimi gels were frozen by quick or slow freezing and stored at -40 °C, -20 °C, or -10 °C for 12 weeks. Results showed that ice crystal size and structural damage increased after frozen storage, and it was greater in two-step heated gels than in direct heated gels. Drip loss increased after frozen storage, with higher drip loss in two-step heated gels. The disulfide bond content decreased after frozen storage, and these changes were more notable in two-step heated gels. In direct heated gels, the breaking strength increased with the frozen storage period, but in two-step heated gels, breaking strength decreased in the first two weeks and then increased. Moreover, the degree of quality deterioration increased with slower freezing rates, higher storage temperatures, and longer storage periods. From the above, it was concluded that

the quality of frozen surimi gels was affected by the heating methods, and the properties of gels could maintain to a major extent by quick freezing and low temperature storage.

In Chapter 4, the effects of small granule starches on the quality changes of heated surimi gels after freezing and thawing were evaluated by comparing four varieties of starch: native potato starch, native wheat starch, potato and wheat starches with small granules separated from native starches. Small granule starches absorbed less water and had a lower water-absorbing ability during the thermal processing, which caused the formation of smaller ice crystals, less structural damage, lower drip loss and less textural changes of surimi gels after freezing and thawing. In addition, due to the large granule size of two potato starches, large ice crystals and voids, more drip loss and structure changes were observed in surimi gels containing two potato starches than that containing two wheat starches. Results indicated that addition of small granule starch could reduce the quality changes of surimi gels after freezing and thawing.

In chapter 5, the effects of native sweet potato starch (NS) and native sweet potato starch with low pasting temperature and slow retrogradation tendency (NSL) on quality changes of heated surimi gels after freezing and thawing were evaluated and compared. Starch-surimi gels were frozen by quick or slow freezing and were stored at –20 °C for 4 weeks. Gelling quality was determined by microstructure, drip loss, and texture profile analysis. The results showed that ice crystal size after freezing and void size after thawing were larger in NS-surimi gels than in NSL-surimi gels, and NSL-surimi gels showed less structural damage after thawing. Higher drip loss was observed with NS-surimi gels after freezing, although the expressible drip before freezing was nearly the same in both types of surimi gels. As for the texture profile analysis, NSL-surimi gels showed no increase in hardness and a lower decrease in adhesiveness than NS-surimi gels. Moreover, freezing rate also affected changes in gelling quality. Compared with slow freezing, quick freezing led to the formation of smaller ice crystals, which allowed starch granules to maintain their original globular shape, resulting in a minor change in gelling quality. These results indicated that addition of NSL could improve the gelling quality of surimi gels after freezing.

In chapter 6, the quality changes in control gels and starch-surimi gels produced using SHF (setting-heating-freezing) and SFR (setting-freezing-reheating) were compared after freezing. Control gels showed larger ice crystals after freezing, larger void sizes after reheating, and higher drip loss in gels produced using SFR. In contrast, in the starch-surimi gels produced using SHF, the incorporated starch granules absorbed water and expanded before freezing, and were destroyed after freezing and thawing, resulting in a high drip loss and a large void size. In starch-surimi gels produced using SFR, un-gelatinized starch granules in setting gels were gelatinized after reheating, resulting in the absorption of the drip loss released after freezing and thawing, leading to lower drip loss and smaller void size than in those produced by SHF. Additionally, changes in the physical properties of gels were correlated with the changes in microstructure and starch granules. These results indicate that the SFR procedure can effectively reduce the quality changes in frozen starch-surimi gels. These findings may provide a new proposal to produce high quality surimi-based products by combining manufacturing and freezing procedures and may have important implications for the frozen food industry.

In conclusion, this study demonstrated the quality changes of frozen surimi gels were related to freezing conditions, thermal process of gelation, starch properties, as well as procedure of heating and freezing. Additionally, addition of micro granular starches and sweet potato starch with low pasting temperature, and the procedure of "setting-freezing-reheating" for starch-surimi gels could successfully reduce the quality changes of frozen surimi gels. The results obtained in this study provided important information about quality changes of frozen surimi gels. These findings, if generally applicable to frozen surimi-based products, may have important implications for the frozen food industry.