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Effect of starch grain size on changes in quality of heat-induced surimi gels upon freezing

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Introduction

Kamaboko is one of the most important surimi seafood products in Japan [1]. In the high-demand season, such as New Year, frozen storage is required for scheduled production. However, its quality may be damaged by freezing and frozen storage depending on various factors such as freezing conditions, components, etc.

Starch, a natural macropolymer of glucose synthesized by plants, is the most important ingredient in surimi seafoods [2], because of its high capacity to swell and retain water, which enhances gel strength, reduces the amount of surimi used, and it is said that starch ensures storage stability for frozen crab sticks [3]. Although many studies have reported the effects of starches on the gelation properties of surimi, the detailed effect of starches on the quality change of kamaboko has not been clarified yet. In our previous study, we found that both positive and negative effects by addition of various kinds of starch on quality changes of surimi gels upon freezing.

Thus, the objective of the present study is to determine the effect of different granule sizes of potato starch and wheat starch on the quality changes of surimi gels after freezing and thawing.

Materials and methods

Preparation of starches with different size

Potato starch (called minami tokachi) was obtained from Sunus Co., Ltd (Kagoshima, Japan). Wheat starch was obtained from Wako pure chemical industries (Osaka, Japan). Small-size starches were separated using the differential sedimentation method. A 20 g/L native starch suspension in distilled water was allowed to settle for 2h to obtain starch layers, and centrifuged the upper layer suspension at 800 × *g* for 10 min. The precipitate was collected and dried at 30°C until the moisture content below 15%.

Surimi gel preparation

Frozen surimi was thawed at -3°C overnight before being cut to 1 cm cubes. The surimi cubes were placed in a Stephan vacuum cutter (UMC-5, Stephan Machinery Corp., Columbus, OH) and chopped at 1,500 rpm for 1 min. Over the next 8 min, iced water (500 g/kg), salt (30 g/kg) and starch (50 g/kg) were sprinkled in, followed by chopping at 1,500 rpm. The paste was then stuffed into tubes and heated in a water bath at 90°C for 30 min. Cooked surimi gels were chilled quickly in iced water.

Freezing and thawing

The heated surimi gels were cut into cylindrical pieces (23 mm in diameter and 25 mm in length) and vacuum-packed in a plastic bag. Packed surimi gels were frozen with quick freezing and slow freezing and then stored at -20°C for 1 week. Before measuring the quality properties, frozen samples were thawed at 5°C overnight.

Microscopic observation

Surimi gels after freezing or thawing were cut to 2-3 mm thickness and fixed with a 10% formalin solution. The samples were embedded in paraffin using a rotary machine (RH-12DM, Sakura finetek Japan Co., Ltd., Tokyo, Japan) and cut to 5 μm slice. The paraffin sections were stained using Periodic Acid-Schiff (PAS) method [4,5] and observed by optical microscope (BZ-9000, Leica Microsystems Corp., Bensheim, Germany).

Water holding capacity

Water holding capacity (WHC) was measured by thawing drip and expressible drip. Thawing drip was determined by the drip loss which was released from the gels when sample was thawed. Expressible drip was determined by the drip loss which was released from the gels when 1 g of sample was compressed for 20 s [6].

Physical properties

A rheometer (RE-33005B, Yamaden Ltd., Tokyo, Japan) was used to evaluate the textural properties of thawed surimi gels. A spherical plunger was used for puncture test to determine breaking strength and breaking deformation from the surface of the gel to the breaking point. Textural profile analysis (TPA) of the thawed surimi gels were performed with a 20 kg load cell using a two-cycle compression. A two-cycle compression force versus time program was used to compress the samples till 30% of the original surimi gel thickness before returning to the original position and compressing again. A 30 mm diameter ebonite probe was used to compress, with test speed of 1 mm/s. Parameters recorded from the test curves were hardness and adhesiveness. All textural analyses were replicated six times and results were presented as mean values.

Statistical analysis

All tests were performed at least in triplicate. Analysis of variance was performed using the Tukey’s multiple-range test to compare treatment means. Significance was defined at $P<0.05$.

Results and discussion

In terms of WHC, there was no significant difference ($P>0.05$) between surimi gels with the two sizes of starch granules before freezing. After freezing, surimi gels with native starches showed a higher drip loss, especially in the case of slow freezing ($P<0.05$) (Fig. 1). Larger ice crystal size was found in the case of native starch-surimi gels, and the starch shape changed to be collapsed significantly after slow freezing and thawing. These microscopic observation results corresponded to those of WHC. It was indicated that surimi gels containing starches with a larger granule size were characterized by a higher drip loss after freezing. Regarding the breaking strength, there was no significant difference ($P>0.05$) between surimi gels containing the two types of potato starch. On the other hand, surimi gels containing wheat starch with a micro granule size showed a significantly lower ($P<0.05$) breaking strength than those with a normal granule size, both before and after freezing. The hardness, determined by texture profile analysis, showed the same tendency as the breaking strength by puncture test. It was considered that the physical changes were related to different retrogradation degrees of potato starch and wheat starch [7].

Fig. 1. Expressible drip measurement of thawed starch-surimi gels after 1-week frozen storage at -20°C.

Conclusions

Starch granule size significantly affected the quality changes of surimi gels after freezing and thawing. Ice crystal size of frozen surimi gels containing micro granule starches were smaller. And total drip loss of thawed surimi gels containing starch with micro granule starches was less than that with native size starch in both potato and wheat starch.

These findings, if generally applicable to frozen surimi based products, could have important quality and economic implications for the convenience of the food industry.

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