

Effect of the Heating Temperature on the Textural Properties of Sago Starch-Containing Gels Cooked from Walleye Pollack Frozen Surimi

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Abstract The effect of the heating temperature (80, 90°C) after preheating at 30°C for 30 min on the textural properties of walleye pollack frozen *surimi* gel with 4% sago and potato starch was investigated. The gel strength of the sago starch-added gel and the potato starch-added gel heated at 80°C was two times and three times higher than that of the control gel, respectively. On the other hand, heating at 90°C made the textural properties of all gels higher than heating at 80°C. These properties of the sago starch-added gel reached almost the same level as those of the potato starch-added gel. The L and b values (Hunter) of sago starch-added gel heated at 90°C were lower than those of the gel heated at 80°C and almost the same level as those of the potato starch-added gel. Using a natural scanning electron microscope, it was observed that the size of sago starch granules in the 90°C-heated gel was larger than that in the 80°C-heated gel, although the potato starch granules in the 90°C-heated gel were similar in size to those in the 80°C-heated gel. The above results showed that, when sago starch-added *surimi* is heated to 90°C rather than 80°C, the gel properties become almost the same as those of potato starch-added gel. This is probably because the sago starch granules swell more at 90°C than at 80°C

Key words: sago starch, potato starch, walleye pollack frozen *surimi*, textural properties, heating temperature

サゴヤシデンプンを添加したスケトウダラ冷凍すり身加熱ゲルの物性に及ぼす加熱温度の影響

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要約 前報において、すり身を80°Cで調製したゲル中では、直接加熱および二段加熱ともに、サゴヤシデンプンの粒子が馬鈴薯デンプンより小さかった。これはサゴヤシデンプン粒子の糊化温度が馬鈴薯デンプンよりも高いためと考え、本実験では、二段加熱を用いて更に高い90°Cで加熱ゲルを調製し、ゲル物性、色、微細構造等について80°C加熱の場合と比較・検討した。その結果、90°C加熱では、いずれのゲルの物性値も80°Cより大となり、サゴヤシデンプン添加ゲルと馬鈴薯デンプン添加ゲルとはほとんど同じ物性値を示した。また、90°Cで加熱した場合、サゴヤシデンプン添加ゲルは明るさ (L

値) 及び黄色味 (b 値) が 80°C で加熱したゲルより低くなり、馬鈴薯デンプン添加したゲルとほとんど同じレベルであった。低真空走査型電子顕微鏡により、90°C 加熱したゲル中のサゴヤシデンプンの粒子は 80°C で加熱したゲル中の場合よりも大きかった。しかし、馬鈴薯デンプン粒子は 90°C 及び 80°C で加熱したゲルの中でほとんど同じ大きさであった。

以上の結果から、二段加熱における最終温度を 80°C よりも 90°C にすることにより、サゴヤシデンプン添加すり身ゲルの物性は馬鈴薯デンプンを添加したゲルとほぼ同じになることが認められた。このことは、サゴヤシデンプン粒子が 80°C よりも 90°C で更に膨潤し、馬鈴薯デンプン粒子と同じレベルの大きさになったことによると判断した。

キーワード サゴヤシデンプン, 馬鈴薯デンプン, スケトウダラ冷凍すり身, ゲル物性, 加熱温度

Introduction

Previously, we reported on the effect of sago starch on the textural characteristics of walleye pollack frozen *surimi* gel heated at 80°C (Sompongse *et al.*, submitted). The sago starch increased the breaking strength, elongation, and gel strength of *surimi* gels less than potato starch did. In the *surimi* gels, the sago granules were not as swollen as the potato granules. Furthermore, the gel color of the sago starch-added gel was more opaque than that of the potato starch-added gel, that is, the gel with sago starch was slightly yellower than the gel with potato starch. In addition, the gelatinization temperature of the sago starch (74°C) is known to be higher than that of the potato starch (64°C) (Kobayashi, 1993). Using differential scanning calorimetry (DSC), it was confirmed that the gelatinization temperature of the sago starch used in our experiment were higher than that of the potato starch.

When the starch was mixed with *surimi*, it showed higher transition temperatures of DSC thermogram than when mixed with water (Wu *et al.*, 1985 a). Moreover, the presence of salt and sucrose caused starch gelatinization to shift to higher temperatures (Wu *et al.*, 1985 b).

The gel strength of *kamaboko* from walleye pollack that had been blended with 3% salt and 10% potato starch and heated at various temperatures was examined. Gelatinization did not take place under 65°C, and a clear taste of raw starch was noticeable. Complete gelatinization was observed at 80°C

(straight heating). This gelatinization of starch enhanced the formation of *kamaboko ashi* (Suzuki, 1981; Yamazawa, 1990).

The starch gelatinization in cooked fish-starch gels was studied by DSC. The effects of starches on the textural properties of cooked gels were dependent on their gelatinization characteristics, such as the gelatinization temperature, degree of swelling, and water uptake of the granules (Wu *et al.*, 1985 a).

It was reported that the gelatinization of wheat starch granules bound by walleye pollack frozen *surimi* proteins affected the elastic properties of the fish meat gels. It was subsequently hypothesized that the network structure of the *surimi* protein was compressed by the gelatinization of the starch granules (Kong *et al.*, 1999).

Therefore, it was suggested that a heating temperature higher than 80°C makes the sago starch granules swell more and, as a result, causes the gel strength of the sago starch-added *surimi* gel to increase. The objective of this study was to compare the effect of heating at 90°C on the gel properties of the sago starch-added *surimi* gel with that of heating at 80°C as a second heating. The two-step heating was applied, as this procedure is very popular for *kamaboko* processing to increase the gel-forming ability of fish meat. Subsequently, the effect of starch swelling on the textural properties of *surimi* gel was discussed.

Materials and Methods

Surimi and starch

Unsalted SS1 grade of walleye pollack frozen *surimi* (Maruha Co., Ltd., Japan) was used as the material. Potato starch was purchased from Tokai Dempun Co., Ltd., Japan. Sago starch was purchased from Mukah, Sarawak, Indonesia. These starches are the same ones as used in the previous paper (Sompongse *et al.*, submitted).

Preparation and properties of surimi gel

The *surimi* gels were prepared according to the method described in a previous paper (Sompongse *et al.*, submitted). The additional concentration of starch in this experiment was 4%, which is near the typical concentration in good-quality *kamaboko*. The gels were preheated at 30°C for 30 min and subsequently

at 80°C or 90°C for 20 min. A gel without starch was prepared as a control gel. The resulting gels were cooled and kept in the refrigerator (4°C) until the measurement. The gel properties were measured using a stretching test according to the method of Shimizu *et al.* (1981) as reported previously (Sompongse *et al.*, submitted). The gel color was assessed using a portable chromameter (Minolta CR-300). The microstructure of *kamaboko* gel was observed using a natural scanning electron microscope (Hitachi model S-2380N) at a magnification of 250.

Results and Discussion

Effect of the heating temperature on the textural properties

The textural properties of walleye pollack frozen *surimi* gel heated at 80°C and 90°C with and without

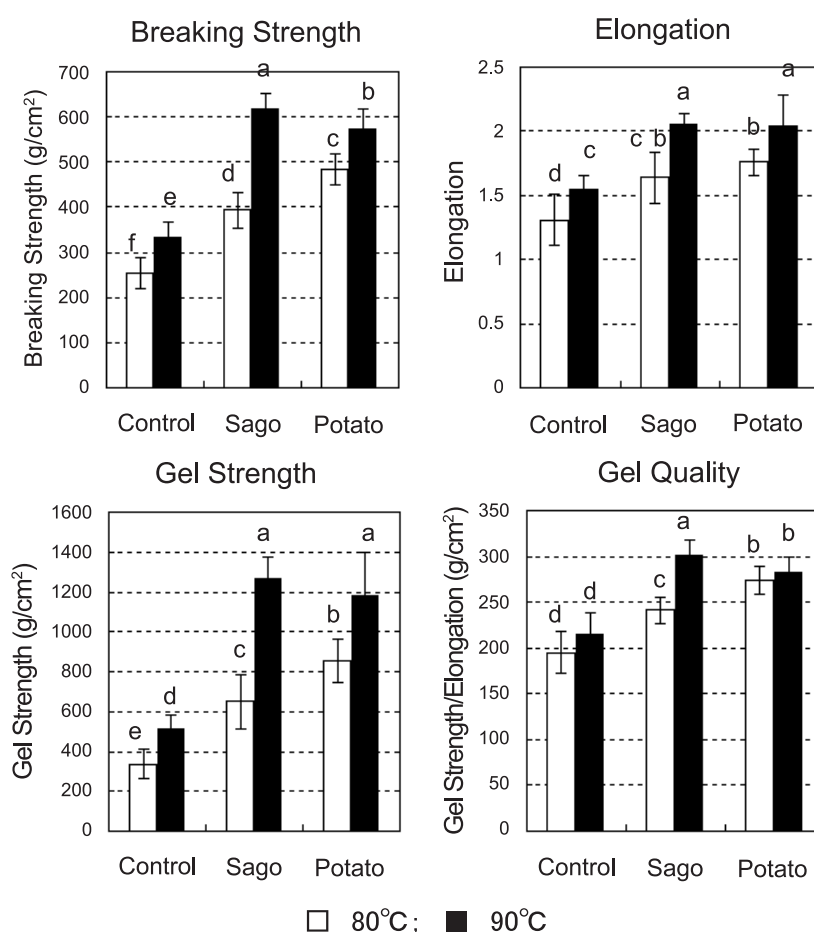


Fig. 1 Effect of the heating temperature on the textural properties of walleye pollack frozen *surimi* gels containing sago and potato starches. The vertical bars represent the standard deviation. Values with different alphabetical letters show significant differences.

4% starch are shown in Fig. 1. As shown in a previous report, *surimi* gels containing starch had a higher value of all textural properties examined (Sompongse *et al.* Submitted). In the case of heating at 80°C, the addition of potato starch increased the breaking strength to almost two times higher than that of the control gel. In addition, the gel strength of the sago starch-added *surimi* gel was two times higher, while that of the potato starch-added gel was three times higher than that of the control gel.

Heating at 90°C increased all of the textural properties more than heating at 80°C in all samples (Fig. 1). The gel strength of the sago starch-added gel was two times that of the gel heated at 80°C, while that of the potato starch-added gel was 1.5 times. In addition, the gel strength was similar in sago starch-added gel and potato starch-added gel at 90°C. The breaking strength and gel quality of sago starch-added gel were slightly higher than those of potato starch-added gel but different from those at 80°C. The gel properties of sago starch-added gel reached almost the same level as those of the potato starch-added gel through heating at 90°C rather than at 80°C.

Okada and Yamazaki (1957) reported that the gelatinization of starch is necessary to enhance the jelly strength of *kamaboko*. Wu *et al.* (1985 b) reported that the gelatinization of starch caused an increase in the rigidity of the system to a degree

depending on the starch type. Using a torsion test, they also reported sand trout *surimi* gels containing potato starch cooked at 70°C were much stronger than those cooked at 60°C. DSC analysis of fish gels containing starches showed that cooking at 70°C caused the complete disappearance of potato starch transition peaks (Wu *et al.*, 1985 a). Kong *et al.* (1999) reported that the modulus of the wheat starch in the walleye pollack frozen *surimi* gel increased continuously with the heating temperature.

Therefore, the higher increase in all of the textural parameters of gels containing starch heated at 90°C rather than at 80°C is supposed to be due to the fact that sago and potato starch granules swell more at 90°C than at 80°C. Moreover, heating at 90°C is supposed to cause the sago starch granules to swell as much as potato starch granules, although the gelatinization temperature of sago starch is higher than that of potato starch.

Effect of the heating temperature on color

The L, a, and b values (Hunter) (hereafter L value, a value, and b value, respectively) of gels heated at 80 and 90°C with or without starches were measured to evaluate their color properties. As shown in Fig. 2a, when the heating temperature was either 80 or 90°C, the L values of the gels were not significantly different, indicating that the heating temperature does

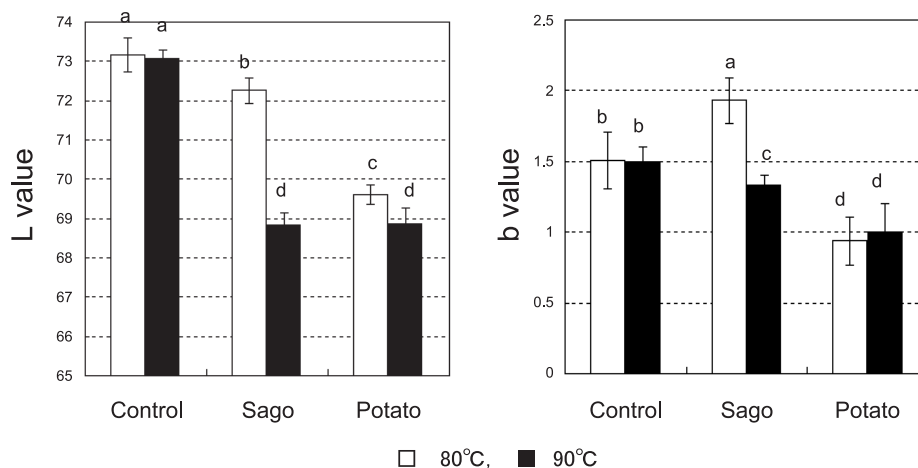


Fig. 2 Effect of the heating temperature on the color of walleye pollack frozen *surimi* gels containing sago and potato starches. The vertical bars represent the standard deviation. Values with different alphabetical letters show significant differences.

not affect the brightness of the control gel. In addition, the L values of the control gels were the highest value among all gel samples. The addition of starch decreased the L value. At 80°C, the decrease in the L value of sago starch-added gel was less than that of potato starch-added gel. The heating at 90°C resulted in a higher decrease in the L value in the sago starch-added gel than in the potato starch-added gel. Then, the L values of both gels containing sago and potato starch were almost the same level.

It was reported that fully swollen granules made the gel more translucent (lower in the L value) (Yang and Park, 1998). Therefore, the above results indicate that heating at 90°C caused the starch granules to swell more than heating at 80°C. Furthermore, the results suggest that the sago granules became as swollen as the potato starch at 90°C rather than at 80°C.

The b values of the control gel and the potato starch-added gel were not affected by the heating temperatures, although the b value of the potato starch-added gel was lower than that of the control gel (Fig. 2b). However, the b value of the sago starch-added gel heated at 80°C was higher than that of the control gel, and a remarkable decrease in the b value was observed after heating at 90°C. This means that

heating at 90°C caused the sago granules to swell more than heating at 80°C. The gels containing sago starch heated at 90°C had a slightly bluer color (less in b value) than those heated at 80°C.

Effect of the heating temperature on the microstructure

To confirm the swelling of starches in the gels, a natural scanning electron microscopic (N-SEM) observation was carried out. Starch granules were observed in the pores of the gels containing sago starch and potato starch. The granule size of sago in the gel heated at 90°C (40-71 μ m) was larger than that of sago in the gel heated at 80°C (35-53 μ m), indicating that a larger degree of swelling took place at 90°C than at 80°C (Fig. 3). It was difficult to differentiate the potato granule size among the gels heated at 80°C (43-70 μ m) and 90°C (the granule shape was slightly deformed). In addition, larger air spaces around the starch granules were observed at 90°C than at 80°C in the sago starch-added gel. In potato starch-added gels, the air spaces seemed to be similar in size when heating at 90°C and at 80°C. This enlarging of the air space might have induced the decrease in the L value, since the white area of the gel surface decreased and the surface lost its smoothness.

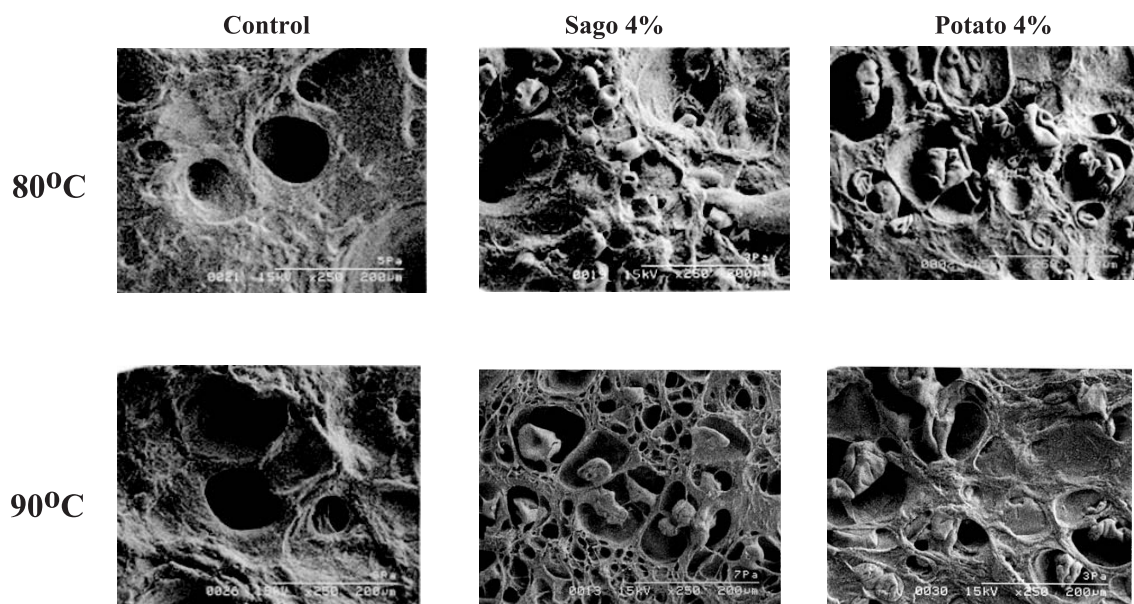


Fig. 3 Natural scanning electron microscopic observation of sago starch-added and potato starch-added gels of walleye pollack frozen *surimi* heated at 80°C and 90°C for 20 min after heating at 30°C for 30 min (two-step heating gel). Magnification = $\times 250$. Bar = 200 μ m.

The effect of starches on the development of rigidity in actomyosin-starch combinations during heating was previously indicated to relate to their granule swelling during gelatinization (Wu *et al.*, 1985 b). It was previously suggested that the swollen starch granules exert pressure on the protein gel matrix and cause the gel matrix to become more compact and firm (Kim and Lee, 1987).

Therefore, the higher gel-forming ability of sago starch-added gel at 90°C than at 80°C is probably due to the fact that sago starch swells more at 90°C than at 80°C.

Conclusion

All textural parameters of *surimi* gels containing sago starch heated at 90°C were higher than those of gels heated at 80°C as second heating temperature of two-step heating. Moreover, these parameters of the gels heated at 90°C were the same level as those of the potato starch-added *surimi* gels. Heating at 90°C caused the sago starch granules to swell more than heating at 80°C. Therefore, we concluded that heating the sago starch-added *surimi* gel at 90°C rather than at 80°C leads to improvements that are similar to those obtained by adding potato starch

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