Strengthening Effect of the Various Natural High Polymers on the Elasticity of the Kamaboko

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(Received August 6, 1987)

In order to compare the strengthening effect of various high polymers on the elasticity of the kamaboko from Alaska pollack frozen surimi, the textural parameters of the kamaboko added with each of them were measured. The high polymers examined were as follows: 1) agar powder, 2) k-carrageenan, 3) cellulose powder, 4) chitin from crab shells, 5) corn starch, 6) egg albumin, 7) gelatin powder, 8) lignin, 9) methyl cellulose, 10, 11) isolated soybean proteins A1 and A2, and 12) wheat gluten, where the soybean protein A2 was the heat-denatured product of the soybean protein A1. The textural parameters were determined by the dynamic visco-elasticity test, punctual test and expressible water test. The relatively effective high polymers were 1, 2, 5, 6, 10, 11 and 12.

The effect of gelling substances, such as starch, egg white and vegetable proteins, on the elasticity of kamaboko has been studied by many workers. However, there is scarce report of the comparative study of the effect of the various gelling substances on the different textural properties of the kamaboko, which is necessary for the elucidation of the mechanism of their gel-strengthening action. In this paper, we describe the effect of twelve sorts of hydrophilic high polymers on the textural parameters of the kamaboko, such as dynamic visco-elasticity, punctual property, and water holding capacity.

Materials and Methods

High polymers examined were as follows: agar powder (Wako Pure Chemicals, 1st grade), k-carrageenan (Ina Shokuhinkogyo), cellulose powder (Nakarai Chemicals, chemical grade), chitin powder from crab shells (Nakarai Chem., chemical grade), corn starch (Nihon Syokuhin-kako, Nisshyoku corn starch), egg albumin (Nakarai Chem., crude powder), gelatin powder (Wako Pure Chem.), lignin (Nakarai Chem., 1st grade), methyl cellulose (Nakarai Chem., chemical grade, 13-18 cps), isolated soybean proteins A1 and A2 (Ajinomoto, ISP-A1 and ISP-A2), vital wheat gluten (Glico Eiyo Shokuhin, A-glu F1). The isolated soybean protein A2 was the heat-denatured product of the soybean protein A1. Non-salted frozen surimi of Alaska pollack (Taiyo Fisheries, SA-grade) was used as a material of the kamaboko. The frozen surimi was thawed by leaving overnight in a refrigerator, minced and ground for 20 min with different amounts of the high polymer besides NaCl and water (3% and 30% to the surimi, respectively).

For the dynamic visco-elasticity measurement, the sample kamaboko was heat-shaped within a measuring cell (40 × 15 × 2 mm³). A sub-standard blade (25 × 3.5 × 0.5 mm³) was inserted in the center of the shio-surimi packed into the cell. The cell was fixed to a rheometer (Toyo seiki, Rheograph-sol No 653), and heated at 80°C for 30 min. The shear storage modulus and loss modulus of the resulting kamaboko were measured after cooled to 25°C. Both the moduli were read from a recording chart.

In the case of the other measurements, the sausage type of kamaboko was prepared. The shio-surimi was packed into a Saran casing (diameter: 3 cm, length: 10 cm), heated at 40°C for 30 min for setting and heated again at 80°C for 20 min. After preserved overnight in a refrigerator, the kamaboko was cut to 16 mm-high cylinders for the punctual test and 2.5 mm-thick disks for the expressible water measurement.

The compression puncture test was carried out as previously at a room temperature of 25°C (ball type plunger, diameter: 5 mm, speed: 6 cm/min). The breaking strength and breaking strain
were read from a recording chart.

The amount of expressible water of the kama-
boko was calculated by an equation, \(100 \times \frac{(W_0 - W)}{W_0}\), where \(W_0\) and \(W\) were the weight of sample piece before and after compression at 10 kg/cm\(^2\) for 20 sec, respectively.\(^7\)

Tests were repeated 6 times for each sample.

Results

Fig. 1 shows the effect of different high polymers on the storage and the loss moduli of the kamaboko. Both the moduli were remarkably increased by the addition of agar, \(k\)-carrageenan, corn starch, egg albumin, gelatin, soybean protein A1 and wheat gluten, somewhat increased by soybean protein A2, but reversely decreased by chitin, lignin and methyl cellulose.

![Fig. 1](image-url)

Fig. 1. Effect of natural high polymer on the storage and the loss moduli of kamaboko. --○---: storage modulus, --●--: loss modulus.

![Fig. 2](image-url)

Fig. 2. Effect of natural high polymer on the breaking strength and breaking strain of kamaboko. --○---: breaking strength, --●--: breaking strain. The vertical bar shows standard deviation.
Especially, in the case of \( k \)-carrageenan and gelatin, their coagulum was heterogeneously dispersed within the cooled kamaboko, when a large amount of them was added (above 8\%).

Fig. 2 shows the results of compression puncture test. The breadking strength of the kamaboko was increased by the addition of almost all the high polymers except for methyl cellulose. Agar and \( k \)-carrageenan were especially remarkable among them. The breaking strain was also increased by agar, corn starch and wheat gluten, but reversely decreased by cellulose, egg albumin, lignin and methyl cellulose.

Fig. 3 shows the effect of the added high polymers on the amount of the expressible water of the kamaboko. The amount was remarkably decreased by agar, \( k \)-carrageenan, corn starch, egg albumin, soybean proteins A1 and A2, but not decreased by cellulose, chitin, gelatin, lignin and methyl cellulose.

**Discussion**

For each gelling substance, there would be the peculiar condition, such as water content within the shio-surimi and heating temperature, under which the gelling substance brings about the highest gel-strengthening effect. In this experiment, however, the effect of every high polymer was compared under the same condition. Therefore, its relative effect can not be simply evaluated. Moreover, the same amount of water was uniformly added to the surimi (30\%) irrespective of the sort and amount of the added high polymer. The water content of the resulting kamaboko was increased with increasing in the amount of the added high polymers, as a result, the kamaboko may be strengthened. Nevertheless, as shown in Figs. 1–3, each high polymer showed characteristic gel-strengthening effect.

In the high polymers examined here, agar, \( k \)-carrageenan, cellulose, chitin, corn starch and methyl cellulose are the polysaccharides and the others except for lignin are the proteins, all of which are more or less hydrophilic. As well known, the sensory evaluation value of the kamaboko shows a positive correlation with the breaking strength, breaking strain and gel strength (the product of the breaking strength and breaking strain) but a negative correlation with the amount of expressible water.\(^\text{7-8}\) Furthermore, it has been found that a linear relationship exists between the gel strength and storage modulus.\(^\text{9}\) The loss modulus showing the viscosity of the sample is known to be higher for the elastic kamaboko.

Considering the above results and such the correlation between the textural parameter and sensory evaluation value, agar, \( k \)-carrageenan, corn starch, egg albumin, soybean proteins A1 and A2, and wheat gluten seem relatively profitable. Therefore, the gel-strengthening action may not be merely due to their water holding action, because hydrophilic cellulose, lignin and methyl
cellulose did not decrease the expressible water contrary to the expectation. On the other hand, the above profitable high polymers are classified to two different groups in the gel-forming ability, that is, the former three polysaccharides form a thermo-reversible gel on heating with water, while the latter three proteins form a thermocoagulating gel. Especially, as to the latter, it is considered that the heat-gelation of egg albumin\(^{10}\) and soybean protein\(^{11}\) is closely related to the hydrophobic interactions which have been proved to play an important role also in the gelation of the shio-surimi.\(^{12}\) Some mutual interaction may be induced between the fish muscular proteins and the above proteins on heating their mixture. Elucidation of this problem is now in progress with reference to the above results.

This study was partly supported by the grant in aid from Ajinomoto Co., Ltd.

References


