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Effects of starches on the textural, rheological, and color properties of surimi–beef gels with microbial tranglutaminase

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ABSTRACT

In order to evaluate effects of starches (corn starch, potato starch, and tapioca starch) on the characteristics of surimi–beef gels with microbial transglutaminase, the cooking loss, gel strength, color and rheological properties of samples were investigated. Results demonstrated that starches gave negative effects on the cooking loss of surimi–beef gels. The gel with corn starch had the highest cooking loss while that with tapioca starch showed the lowest value. The gel with potato starch obtained the highest gel strength. During the sol–gel transitions, surimi–beef complexes with 3% corn starch exhibited the highest storage modulus value, while that with 3% tapioca starch had the lowest one. The addition of starch caused the increase of L^* values of surimi–beef gels. Results showed that the excessive amount of starch resulted in the decrease in gel strength of surimi–beef gels.

1. Introduction

Surimi is a fish muscle protein concentrate, manufactured by washing and dehydrating fish mince. It is an intermediate product for fish products, such as fish balls, kamaboko, artificial crab sticks and other new products (Zhou, Zeng, Liu, & Sun, 2003). Fish muscle proteins have a unique capability to form a translucent and highly deformable gel. Fish muscles are often grounded with salt to form the viscous sol, which can turn into an elastic gel with heating. Both sol and gel are regarded as viscoelastic materials (Liu, Zhao, Xiong, Xie, & Liu, 2007), so the dynamic rheological measurement is usually used to monitor the sol–gel transition and characterize the viscoelastic properties of the gel matrix (Liu et al., 2007). Setting procedure is consequently used to keep surimi below 40 °C in order to enhance mechanical properties of the cooked products (An, Peters, & Seymour, 1996; Kamath, Lanier, Foegding, & Hamman, 1992).

An endogenous transglutaminase (TGase), an enzyme existing in some fish proteins, can catalyze the cross-linking between glutamine and lysine and eventually facilitate myofibrillar proteins aggregation at the setting temperature (Motoki & Seguro, 1998; Yokoyama, Nio, & Kikuchi, 2004). In recent years, microbial transglutaminase (MTG), derived from the microorganisms, has been applied in improving the mechanical properties of protein gels (Yokoyama et al., 2004), such as dairy, soybean, fish and meat products (Castro-Briones et al., 2009; Dickinson, 1997; Motoki & Seguro, 1998; Ramírez, Uresti, Téllez, & Vázquez, 2002; Yokoyama et al., 2004). Generally, beef protein is considered as a non-setting protein, while its gel can be formed by cooking directly due to the function of MTG (Castro-Briones et al., 2009). Beef gels with 0.3% MTG showed better mechanical properties compared to those without MTG when they both incubated at 50 °C (Castro-Briones et al., 2009).

Starch is one of the most widely used ingredients in food products, especially in surimi-based products (Couso, Alvarez, Solas, Barba, & Tejada, 1998; Kim & Lee, 1987; Yang & Park, 1998). The textural properties of products are modified because of the characteristics of starch granules in absorbing water and expanding themselves during heating (Kim & Lee, 1987). The content of amylose and amylopectin determines the swelling power of starch granule (Sasaki & Matsuki, 1998; Tester & Morrison, 1990). The swelling behavior mainly depends on the property of its amylopectin content (Tester & Morrison, 1990). Starch granules act as fillers in the gel matrix (Lee, Wu, & Okada, 1992). The granules produce reinforcement in the gel matrix after they absorb water and swell (Yang & Park, 1998).

In general, meats mixed with starch and other ingredients are manufactured into food products, such as sausage. It has been widely reported about effects of starch on textural properties and rheological properties of fish and meat proteins, respectively. There was no study

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on the gel properties of fish-meat starch mixtures. Therefore, the objective of this study was to evaluate the effects of starches on the textural, rheological, and color properties of surimi–beef gels with microbial transglutaminase.

2. Materials and methods

2.1. Materials

High-grade silver carp surimi was obtained from the Jinli Fishery Food Co., Ltd. (Honghu, Hubei, China), cut into about 500 g, sealed in the vacuum package, and then stored at −25 °C. Boneless beef (top round) was purchased from the local supermarket (Wuhan, Hubei, China), trimmed visible fat and connective tissue, and cut into about 1 cm×1 cm×1 cm pieces, sealed in the vacuum package and then stored at −25 °C. Potato starch (PS), corn starch (CS) and tapioca starch (TS) were purchased from the Kailong Starch Co., Ltd. (Dingxi, Gansu, China). Microbial transglutaminase (MTG) was purchased from Sinorey Foods Co., Ltd. (Wuxi, Jiangsu, China) and stored at 4 °C.

2.2. Preparation of the surimi–beef gels

Sample preparation was based on test formulation (Table 1). Frozen surimi and beef were thawed at 4 °C for 12 h and followed by mixing in a HR7625 food processor (Philips, Hong Kong, China) for 1 min. The mix ratio of surimi and beef was 7:3 (w/w). Salt (2%), MTG (0.5%), starch (0, 3%, 6%, 9%) and ice/water (0 °C) were added into the mixture and then homogenized for 3 min. Ice/water was used to adjust the moisture level to 80% (w/w) for all treatments during the processing. The paste was split into two parts. One part was stored at 4 °C for dynamic rheological measurement. The rest was stuffed into polyethylene casing (inner diameter, 2 cm; length, 20 cm), heated in a water bath at 40 °C for 90 min, and then followed by heating at 90 °C for 30 min. The gels were chilled quickly in ice water (0 °C) for 2 h and stored at 4 °C overnight.

2.3. Cooking loss

Gels were removed from the polyethylene casing, dried with filter paper (Xinhua Paper Co., Ltd., Hangzhou, Zhejiang, China) and reweighed. Cooking loss was determined as described by Castro-Briones et al. (2009). Four replicates of each treatment were measured.

2.4. Puncture test

Gels (4 °C) were placed at room temperature for 2 h and cut into cylinders (2 cm in diameter and 2 cm in height) prior to the test. The puncture test was conducted on a texture analyzer (TA-XT2i, Stable Micro Systems, UK). A spherical probe (P/0.25 s) was used to penetrate 15 mm into the samples at a speed of 1 mm/s. Breaking force (maximum penetration force, g) and deformation (penetration depth, mm) were determined on at least eight specimens per treatment. Gel strength was calculated by

$$\text{Gel strength} = \text{Breaking force} \times \text{Deformation}$$

Table 1
Experimental formula for surimi–beef complexes.

Ingredients (g)	A	B	C	D
Surimi	157.5	130.8	103.5	76.2
Beef	67.5	56.1	44.4	32.7
Salt	6.0	6.0	6.0	6.0
MTG	1.5	1.5	1.5	1.5
Starch	0	9	18	27
Ice/water	67.5	96.6	126.6	157.5
Total	300	300	300	300

Each formula was based on equal moisture (80%), salt (2%) and MTG (0.5%). The surimi and beef were prepared at the ratio of 7:3 (w/w).

2.5. Dynamic rheological measurements

Dynamic rheological measurements were performed on an AR2000ex dynamic rheometer (TA Instrument Ltd., New Castle, Delaware, USA). A parallel-plate geometry of 40 mm diameter and a gap of 1 mm were set for measurement. The paste sample was placed between the parallel plates of the rheometer. The excess sample protruding beyond the upper plate was removed. Silicone oil was gently applied to the edge of each exposed sample to prevent moisture loss during measurement. Paste samples on the parallel plates were allowed to rest for 2 min before analysis to ensure both thermal and mechanical equilibrium at the time of measurement. For temperature sweep, samples were heated at a speed of 1 °C/min from 10 to 90 °C with 10 Pa stress and 1 Hz frequency. Storage modulus (G') was recorded from the temperature sweep test. Two replicates of each treatment were measured.

2.6. Color measurement

Gels were equilibrated to reach room temperature and then L^* (lightness), a^* (redness "+" or greenness "−") and b^* (yellowness "+" or blueness "−") of samples were obtained by a colorimeter (WSC-S, Shanghai Jingke Instrument Co., Ltd., Shanghai, China). The samples have the same size as for puncture test.

2.7. Statistical analysis

Statistical analysis was carried out using SPSS (13.0) (SPSS, Chicago, IL, USA). Data were analyzed by one-way ANOVA. Differences among the mean values of the various treatments were determined by the least significant difference (LSD) test and the significance was defined at $P<0.05$.

3. Results and discussion

3.1. Cooking loss

Fig. 1 shows the cooking loss of surimi–beef gels with different starches. The contents and varieties of starches significantly affected the cooking loss ($P<0.05$). The cooking loss of all the gels exhibited the increasing trend except the gel with 3% tapioca starch (TS). The highest cooking loss was given by the gels with corn starch (CS), while the lowest was given by the gels with TS. Lyons, Kerry, Morrissey, and Buckley

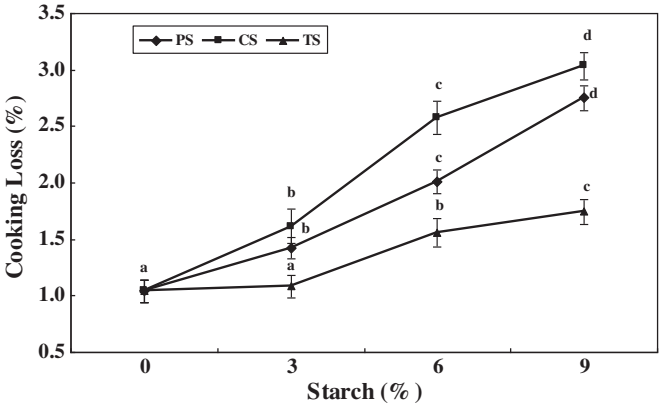

Fig. 1. Effects of starches on the cooking loss of surimi–beef gels. Different letters indicated differences of the same starch ($P<0.05$).(potato starch (PS), corn starch (CS), tapioca starch (TS)).