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Research Article

Effect of Puerarin Powder on Quality of Grass Carp Fish Surimi

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Abstract: Grass carp surimi was chosen as the research object to investigate the effect of Puerarin powder on the quality of fish surimi with water holding capacity, folding strength, hardness, elasticity and sense as indexes. The results showed that 6.0% Puerarin powder was added after adding antifreeze agent, which made the water-holding reached up to the highest value with the method of two-stage heating. The level of gel folding strength improved to class B at concentration varying from 2.0 to 8.0%, and when the Puerarin powder concentration attached to 8.0%, the textural characteristics was excellent and the sensory quality was of the highest.

Keywords: Grass carp surimi, puerarin powder, quality, texture property

INTRODUCTION

After fish had been chopped, blenched, moulded and heated, surimi, a new aquatic food raw material, was obtained. Such products included fish balls, fish cakes, fish rolls and so on, which was warmly welcomed by consumers for the sake of its rich nutrient, unique flavor and eating convenience. Since the 1960s, Japan, the United States and other countries had used a narrow fin as the main raw material for surimi and its products. Due to the impact of global climate change and overfishing, marine fishery resource has been unable to meet market demand, therefore developing the world's freshwater fish farming has become an inevitable trend. China is rich in fishery resources (Martín-Sánchez *et al*., 2009; Bouraoui *et al*., 1997). Freshwater aquaculture production in 2010 amounted to 24 million tons, accounting for more than 60% of the total freshwater aquaculture around the world and providing about one-third of high-quality animal protein sources in China. Grass carp is one of four major Chinese carps, and more suitable for processing into raw freshwater fish surimi due to its high yield, fast-growing and less disease. Freshwater fish surimi contains more calcium, phosphorus and other minerals (Jafarpour and Gorczyca, 2008; Benjakul *et al*., 2004). However, the freshwater fish is difficult to gelation, and accessories are needed to enhance their gelling property (Kong *et al*., 1999). During processing of surimi productions, starch is the most widely used as filler.

Puerarin powder, drying root of kudzu from leguminous plant, is recognized as medicinal and edible resources in China. Kudzu contains starch, cellulose, about 12% of flavonoids as well as 10 kinds of amino acids and vitamins. Besides, it is rich in calcium, iron, zinc and other mineral elements. Recently, more attention is paid to explore functional food, such as drink, starch-based product, baking products, tofu, jelly and so on. Forthermore the content of amylose and amylopectin in Kudzu starch were 18.29 and 77.24% respectively (Guerra *et al*., 2000; Lee *et al*., 2002). Starch with high amylopectin content, taking potato starch as example, was able to form a strong and elastic gel, whereas starch with less amylopectin content, such as corn starch, was able to form a weak and brittle gel (Benlhabib *et al*., 2004). Previous study showed that, among various starch, potato starch endowed surimi the best water-holding capacity. Moreover, sucrose and sorbitol contributed to higher gel strength (Benlhabib *et al*., 2004; Guerra *et al*., 2000).

Gel property is a key factor to determine the quality of fish products, and a very important indicator of protein products in food application (Chen *et al*., 2010). It was not only subjected to heating mode, temperature and other external factors, but also influenced by accessories added during the production process. Thus different textural property could be achieved by adjusting above factors (Martín-Sánchez *et al*., 2009; Chen *et al*., 2010). Gel hardness, elasticity,

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water-holding capacity, taste were indicators of gel properties and texture analyzer, electronic nose and electronic tongue and so on were usually applied (Lee *et al*., 2002). In this study, hardness and elasticity were measured by textural analyzer and flavor sensory was evaluated by the sense for investigating the effect of Puerarin powder on the quality of fish surimi, in order to provide a theoretical and experimental basis for the application of the Puerarin powder in food industry.

MATERIALS AND METHODS

Materials: Puerarin powder was purchased from Zhangjiajie popular food Co. Ltd. Grass carp waspurchased from Jishou vegetable market.

Experiment design: Without adding Puerarin powder, surimi was obtained by a single-stage or two-stage heating, and its impact on the gel property was measured by texture analyzer with elasticity and hardness as indicators. According to above results, Puerarin powder was added at different heating stage, then renewed surimi was obtained. The effect of Puerarin powder on hardness, elasticity, water holding capacity, folding strength, sensory quality of grass carp surimi was investigated.

Technological process of grass carp surimi: Handling raw materials→taking the meat→getting rid of the smell→washing with cold water and fine filtering→ dehydrating→smashing (empty ground, salt ground, additives beat) (adding Puerarin powder and antifreeze agent) →making meatballs→heating→cooling→ finishing product→packaging→refrigerated packaging.

Operating points of technological process: Handling raw materials: cleaning grass carps, picking the meat, washing 2 to 3 times and controlling the water temperature to be 3-10°C:

Washing in cold water: firstly, washing twice with water (fish:water = 1:5), stirring slowly for 10 min and then putting it aside 10 min. Secondly, rinsing once with 0.25% saline solution.

Smashing: Blank ground for 5min, salt ground for 5min and maintaining a low temperature during smashing process.

Antifreeze agent: adding sucrose and sorbitol amounting 4% of meat quality.

Molding: extruding surimi between the thumb and forefinger, then catching fish balls with a spoon.

Heating: using two different heating mode such as one-stage and tow-stage heating.

Table 1: Surimi gel rating criteria

Grade	Characters
AA	Four-fold without cracking
A	Double fold without cracking
B	Half of the double-folding labyrinth of cracks
C	Labyrinth double fold all cracks
D	Elastic fragile, with finger pressure will produce collapse

Heating mode: One-stage heating mode: placing molded surimi in constant water-bath temperature at 60, 70, 80, 90°C, respectively, and heating for 30, 40, 50 and 60 min.

Two-stage heating mode (from low temperature to high temperature): putting molded surimi at constant water-bath temperature for a certain time. Heating temperature and time were as follows: from 40°C for 60 min to 80°C for 30 min, from 40°C for 60 min to 90°C for 30 min, from 40°C for 40 min to 80°C for 30 min, from 40°C for 40 min to 90°C for 30 min, from 30°C for 60 min to 80°C for 30 min, from 30°C for 60 min to 90°C for 30 min, respectively.

Adding time and amount of puerarin powder: The adding time obtained by comparing the textural property of surimi added antifreeze before puerarin powder and after puerarin powder.

Taking 10 copies of the 100g/copy of the chopped meat of fish divide into 2 groups, each group had 5 copies. One group added puerarin powder before antifreeze, but the other added puerarin powder after antifreeze. It was required that puerarin powder quality accounted for 0, 2.0, 4.0, 6.0 and 8.0%, respectively of the weight of fish respectively. After heating and gelling, textural properties were measured by texture analyzer, then the optimal amount of puerarin powder was obtained.

Water-holding capacity determination: The sample surimi was cut into 5 mm slices with two filter papers above it and three filter papers under it. Then 5 kg constant force was applied and maintained for 2 min. The samples was taken out and weighted (Benjakul *et al*., 2004). Water-holding capacity was calculated as follow equation:

$$\text{Water-holding capacity (\%)} = (m_2 - m_1)/m_1 \times 100\%$$

where, m_1, m_2 were original mass of samples and mass of samples after force applied, respectively.

Gel strength evaluation: The sample surimi was cut into 3 mm slices, and then the slices were folded into double or four layers. Whether the crack was appeared and the size of crack was observed (Tabilo-Munizaga and Barbosa-Canovas, 2004). Based on above phenomenon, standard was established and divided into five grades (Table 1).

Table 2: Sensory evaluation criteria

Sensory evaluation items	Evaluation criteria (score)				
Color (10 points)	White color and smooth (10-8)	White and less smooth (8-6)	Less white (6-4)	Grey White (4-2)	White with red (2-1)
Taste (10 points)	High water holding capacity, refreshing but not sticky (10-8)	Refreshing but not sticky, having less water holding capacity (8-6)	Refreshing but not sticky, water holding capacity is not good (6-4)	Taste slightly worse, water holding capacity is bad (4-2)	Taste is worse, water holding capacity is bad (2-1)

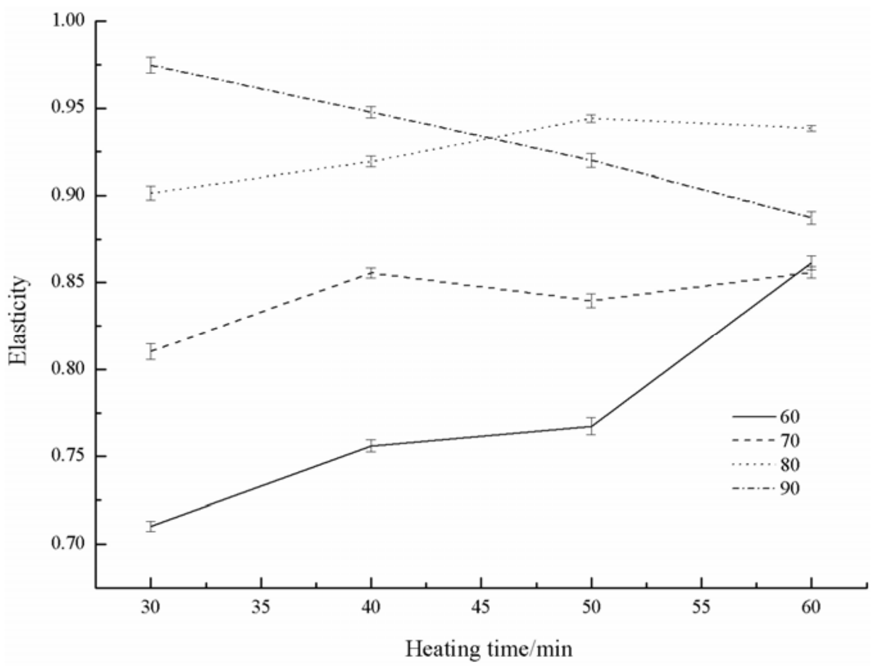

Fig. 1: Influence of 1-phase on elasticity of surimi

Sensory evaluation: The quality of grass carp fish surimi was judged by 10 points method. Briefly, the sensory properties, such as color, flavor and elasticity of the sample, were assessed and scored by panels containing 20 people (Chaijan *et al*., 2006). A comprehensive evaluation was conducted according to the scores and comprehensive evaluation criteria were shown in Table 2.

Textural property measurement: The textural properties were measured by texture analyzer (TPA) with cylindrical p/0.5 probe (Lee and Chung, 1989; Kim and Lee, 1987). Pretest speed, test speed, after test speed were set as 5.0, 2.0, 5.0 mm/s, respectively. And the distance, interval, data acquisition rate were 10.0 mm (about 30% of the height of the gel), 5S, 200 pps, respectively.

RESULTS AND DISCUSSION

Influence of heating mode on elasticity and hardness of grass carp fish surimi: Figure 1 showed that when the heating temperature was 60°C, with the extension of heating time, the gel elasticity increased gradually. When the heating temperature was 70°C, with the heating time ranging from 30 to 40 min, elasticity increased gradually. When the heating temperature was 80°C, with the heating time increasing from 30 to 50 min, elasticity increased gradually. When temperature was 90°C, heating for 30 min, gel elasticity reached to a peak of 0.975. With the heating time elapsed, the gel elasticity reduced gradually. This might be explained by high endogenous protease activity. The Myosin Heavy Chain (MHC) was degradated into a large amount of small peptides, leading to serious gel deterioration (Tabilo-Munizaga and Barbosa-Canovas, 2004).

Figure 2 shows that when the temperature was 60°C, heating time from 30 to 50 min, the hardness increased gradually. When the temperature was 70°C, heating from 30 to 40 min, the hardness increased gradually. When the temperature was 80°C, the heating time between 30-40 min, the hardness increased gradually. When the temperature was 90°C, heating for 30 min, hardness value reached up to a maximum of 498.056. This could be the cause that minced fish protein denaturation was a slow process. After reaching up to the required denaturation temperature and time, the protein molecule was fully developed and the gel with higher hardness was formed. Rising temperature and prolonging heating time might result in the decreased gel hardness.

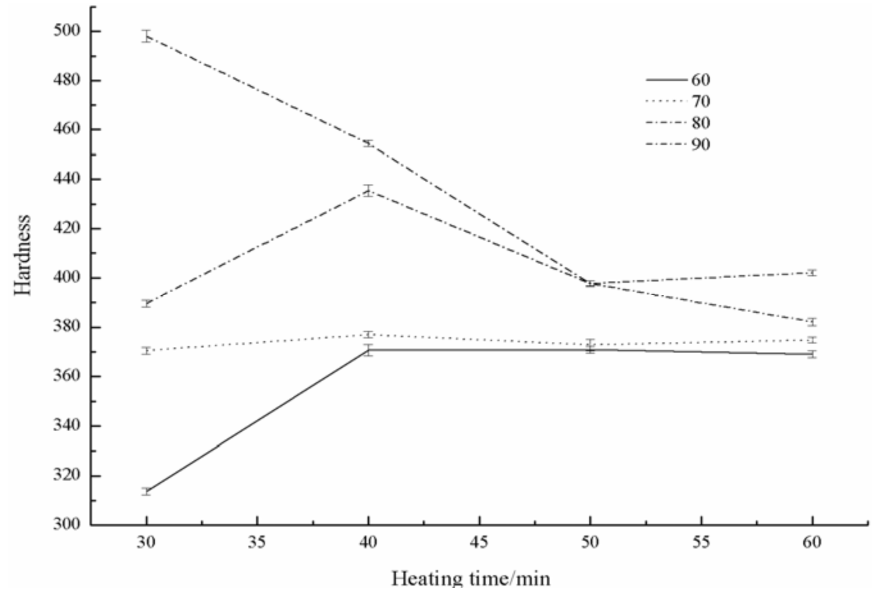

Fig. 2: Influence of 1-phase heating method on hardness of surimi

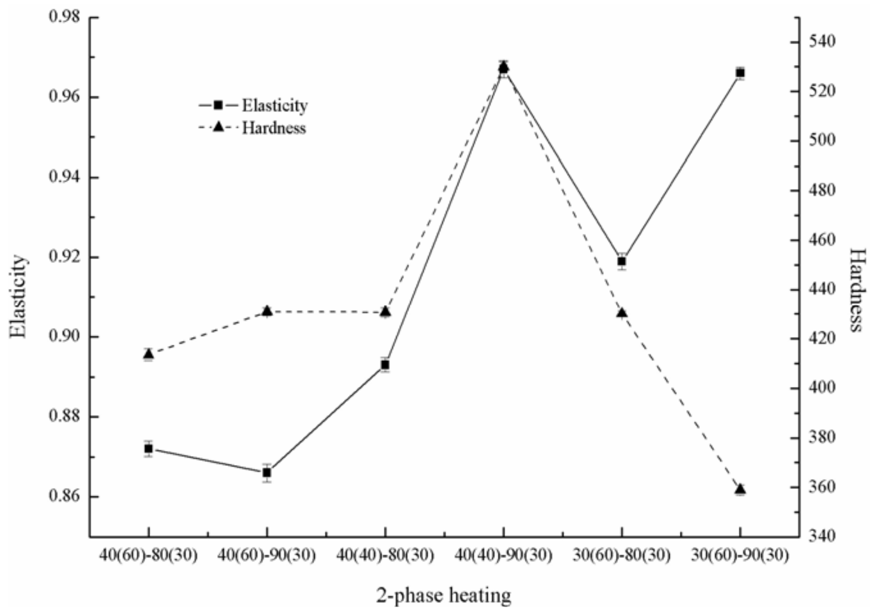

Fig. 3: Influence of 2-phase heating on characteristic property of surimi

Figure 3 showed that when the low gelation temperature was 30°C, the heating time was 60 min and the heating time of high gelation temperature was 30 min, with the increase of high gelation temperature, elasticity increased sharply, from 0.919 to 0.966 g, whereas the hardness decreased significantly from 430.141 to 358.92g. When low gelation temperature was 40°C, the heating time was 60 min and the heating time of high gelation temperature was 30 min, with theincrease of high gelation temperature, gel hardness rose slowly while the elasticity gradually decreased. When the low gelation temperature was 40°C, the heating time was reduced from 60 min to 40 min, the high gelation temperature decreased from 90 to 80°C and heated for 30 min, the rise of elasticity was bigger than that of hardness. When low gelation temperature and heating time were 40°C and 40 min respectively, and the high gelation temperature heating time was 30 min, with the increase of high gelation temperature, elasticity and hardness were dramatically increased, reaching a maximum value. In a word, gel properties improved significantly if low gelation temperature was applied.

Figure 3 indicated that the use of two-stage heating (40 and 90°C) was better than another one (40 and 80°C), which was related to the fact that gel was easier to pass the degradation temperature zone at 90°C. Besides, the temperature (90°C) in the center of surimi was high enough to kill bacteria, mold, and small parts of spores. Taking the elasticity as well as the hardness into consideration, it could be concluded that the gel hardness was relatively appropriate when the heating temperature and heating time were 40°C (40 min) and 90°C (30 min) respectively. Previous studies had shown that the gel strength could be enhanced significantly and soluble protein ratio of surimi was decreased by pre-gelation, which was due to the catalysis of endogenous TGase (Cardoso *et al*., 2010).

Influence of puerarin powder on water-holding capacity of grass carp fish surimi: According to Fig. 4, with the increase of puerarin powder, the water-holding capacity was improved. When the puerarin powder amount reached to 6.0%, the water-holding capacity achieved the highest and then decreased. A small part of water was entrapped in the inner of protein molecules, which might account for the above phenomenon. These combinations were related to gel structure. However, it was influenced ultimately by internal structure of the protein and external processing conditions and so on. Free water of fish surimi was passivated by starch with the characteristic swelling after absorbing water, but could not separated out (Kim and Lee, 1987). After heated, Puerarin powder containing a large amount of amylopectin had strong water absorption capacity, which conferred it the high water holding capacity. When the amount of puerarin powder was 0-6%, it was beneficial to cross-linking between protein inter or intramolecular, and promoted the water holding capacity. But excessive puerarin powder (8.0%) might cause excessive aggregation of the protein molecules, which would seriously alter the structure of surimi gel and be bad for the water holding capacity (Cardoso *et al*., 2010).

Table 3: Rating results of Surimi gel

Amount of puerarin powder (%)	Grade
0	C
2	B
4	B
6	B
8	B

Influence of puerarin powder on folding strength of grass carp fish surimi: Table 3 describs the effect of different amount of puerarin powder to the folding strength of grass carp fish surimi. It showed that fold test results of grass carp surimi gel without puerarin powder was C-class. However, after adding the puerarin powder, fold test results of grass carp surimi reached B-class. It was suggested that adding puerarin powder could improve the folding strength of grass carp fish surimi (Tabilo-Munizaga and Barbosa-Canovas, 2004; Martín-Sánchez *et al*., 2009).

Impact of adding quantity and time of Puerarin powder on hardness and elasticity of grass carp surimi: Figure 5 showed that when the amount of puerarin powder was 2.0, 4.0, 6.0, 8.0%, the elasticity increased sharply, reduced slightly, increased slightly, and reduced slightly respectively. With the amount of puerarin powder increasing to 2.0%, the hardness decreased rapidly and then increased gradually until 6.0%. But when concentration reached to 8.0%, the hardness started to decrease.

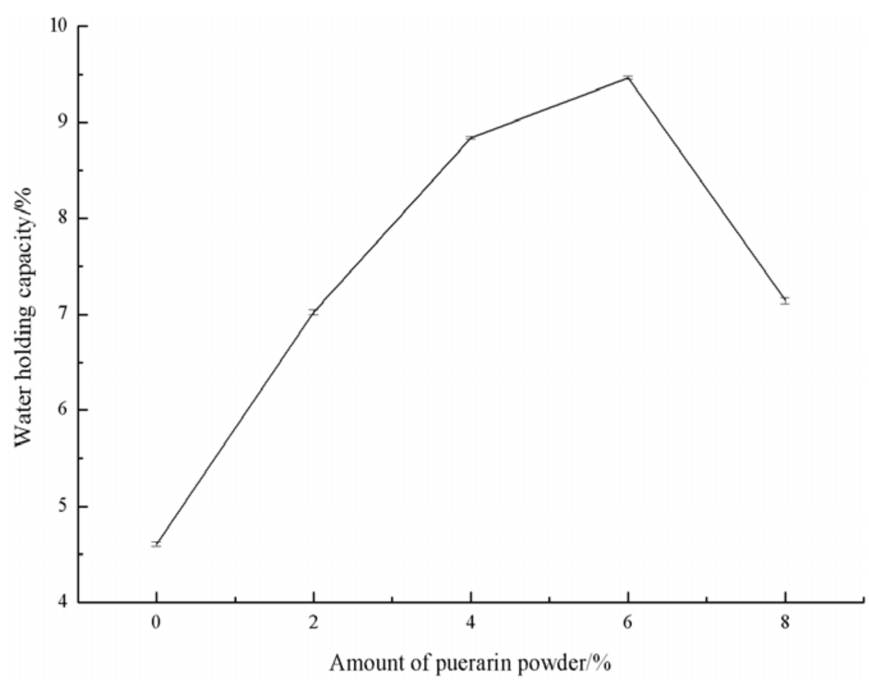

Fig. 4: Influence of puerarin powder on holding water of surimi

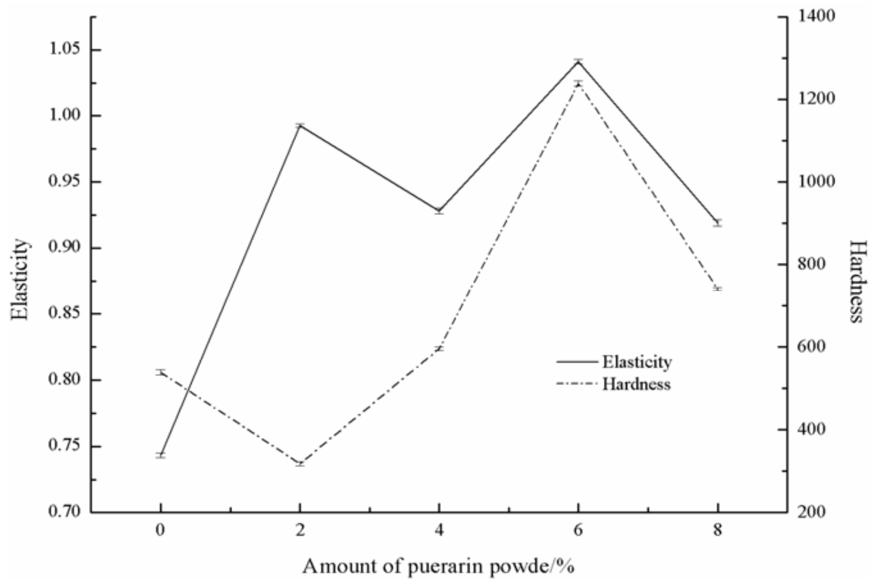

Fig. 5: Influences of puerarin powder adding before antifreeze on hardness and elasticity of surimi

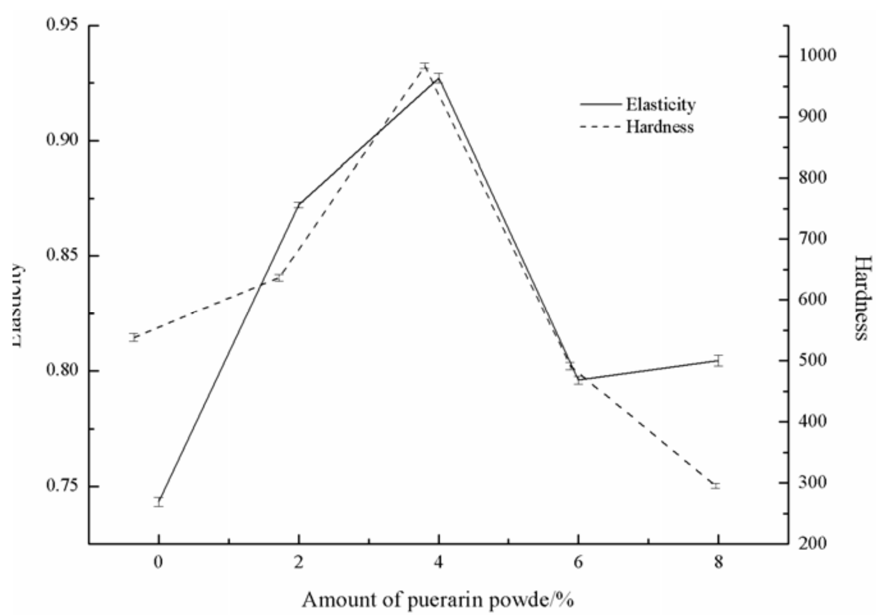

Fig. 6: Influences of puerarin powder adding after antifreeze on hardness and elasticity of surimi

Figure 6 shows that when the amount of puerarin powder was 4.0, 6.0 and 8.0%, the elasticity increased, reduced slightly, and increased respectively. As puerarin powder increased to 4.0%, the hardness increased sharply and then decreased. This might due to that the added antifreeze (sucrose, sorbitol) bonded with protein reactive group, so the protein molecules were saturated and maintained the spatial structure of proteins by stabilizing the water around. During the heating, the puerarin powder was capable of form a gel by absorbing water to swell, and then the gel was filled into protein gel network structure making surimi gel network structure more compact (Bouraoui *et al*., 1997; Tabilo-Munizaga and Barbosa-Canovas, 2004).

Taking elasticity and hardness into account, when puerarin powder added after antifreeze, elasticity as well as hardness changed regularly with puerarin powder dosage and the gel properties was better when 8.0% of puerarin powder was added.

Effect of puerarin powder on sense of grass carp surimi: As shown in Fig. 7, with the increase of puerarin powder, the comprehensive quality including odor, color and taste of surimi was improved. When the concentration of puerarin powder was 8.0%, the best flavor was obtained. Puerarin powder was white and delicious, besides it contained abundant of starch, which improved the gel properties, the structure state of

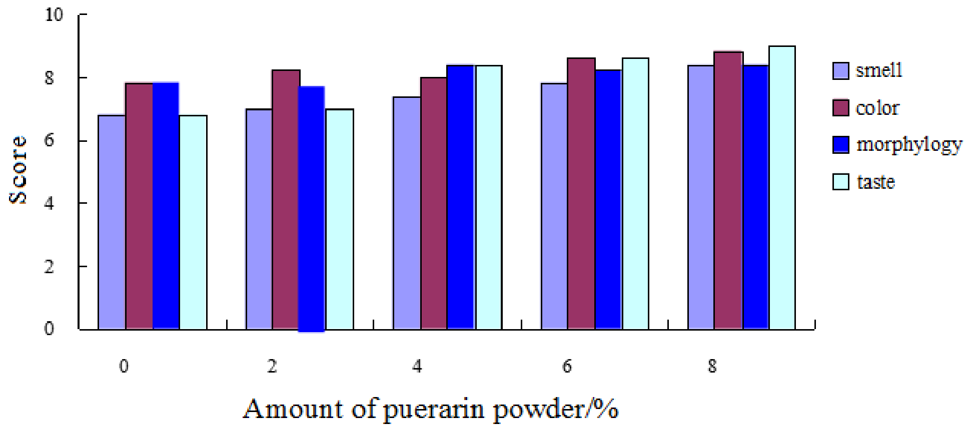

Fig. 7: Effect of puerarin powder to sense of surimi

surimi gel as well as the sensory quality of the product (Cardoso *et al*., 2010; Tabilo-Munizaga and Barbosa-Canovas, 2004).

CONCLUSION

Grass carps was chosen as raw material, and the surimi was obtained by a series of processing. The single factor experiments was performed and the results showed that the best heating method was two-stage heating mode (from low temperature gelation to high temperature gelation), whose heating temperature and time were 40°C (40 min) and 90°C (30 min), respectively. In order to explore the effect of puerarin powder on quality of fish surimi, the gel hardness, elasticity, water holding capacity, folding strength and taste were chosen as indicators. The results showed that when Puerarin powder added after antifreeze and the concentration was 6.0%, the highest water content was desired. When the amount of Puerarin powder was from 2.0 to 8.0%, the folding level of the fish surimi increased to Class B. And when 8.0% of Puerarin powder was added, the textural properties was the greatest and the sensory quality scored highest.

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