Iran Agricultural Research, Vol. 32, No. 1, 2013
Printed in the Islamic Republic of Iran
Shiraz University

Comparing the Textural properties of Surimi and Fish Protein Isolate Gels Produced from Silver Carp

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Received 20, November, 2011, Accepted 6, January, 2013, Available online December 30, 2013

ABSTRACT- In this study, texture profile analysis and a creep test were used to determine the textural quality attributes of fish protein isolates and conventional surimi. These isolates were made from raw materials obtained from filleting processes of Silver carp (*Hypophthalmichthys molitrix*) using acid and alkaline aided treatments. Texture profile analysis was performed in order to obtain hardness, cohesiveness, springiness and chewiness of the samples. Added to this, a creep test was applied to measure the elasticity value of the samples. Results were compared to the attributes of conventional surimi produced from the fish. Textural assessment was performed on gel samples formed by heating in hot water at 85 °C for 30 min. Comparison of fish protein isolate gels and the conventional surimi indicated significant differences in texture profile analysis parameters except for springiness value. Furthermore, the results of the creep test revealed that conventional surimi had significantly lower elasticity (29.8±0.9%) than fish protein isolate gels.

Keywords: Creep test, Fish protein isolate, Surimi, Silver carp, TPA test

INTRODUCTION

Consumption of fish and fish meat based products has great health benefits including high contents of proteins, minerals and distinctive lipids (14, 17). Fish stock faces a big

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menace because of increased demands for traditional raw materials to produce fish protein ingredients (6). This issue has caused overfishing of species requiring governmental care to prevent the shortage of important species (7). A way to prevent this problem is production of fish protein ingredients such as surimi, minced fish, and fish protein isolate from inconsequential species (16). Using conventional technologies to produce value added fish products leads to a great restriction to the full and efficient use of the whole fish by losing proteins and lipid-rich by-products without any recovery for human use (9). Finding a way to use these materials has always been of great interest; however, only few successful attempts have been made to promote functional and acceptable products. Although production of surimi has indicated some progress in recovering fish proteins, the yields are low because of several washing procedures (10). Surimi is normally produced from low value white flesh fish, such as *Alaska pollock*, with a yield of 25-28% of the body weight of the fish (12, 15). Production of surimi from dark muscles results in products with poor gelation characteristics and color, as well as lipid oxidation issues (13). On the other hand, separation of undesirable constituents such as skin, scales and fat from the desirable muscle proteins is extremely difficult (7). Production of fish protein isolates from dark muscle and other undesirable ingredients is, therefore, a suitable answer to the problem of utilizing such undesirable left-overs. Fish protein isolate production technology is based on the use of pH-dependent solubility properties of muscle proteins from the undesirable components. The protein yield in alkaline assisted fish protein isolates is more than that of the conventional method, because in the alkaline assisted process sarcoplasmic proteins such as haemoglobin, myoglobulin and proteolytic enzymes can be retained (8). Fish protein isolate production process is a new technique for recovering fish proteins from more than 50 million tons of underutilized fish species (10) and saves considerable parts of the fish flesh remaining around the fish bones after the filleting step (5). Because of the suitable rheological and functional characteristics of fish proteins, they can be used for many applications such as the production of surimi or protein enrichment of the fillets (14). The purpose of this study was to investigate the textural characteristics of the gels obtained from conventional surimi as well as fish protein isolates obtained from Silver carp (*Hypophthalmichthys molitrix)*.

MATERIALS AND METHODS

Production of Surimi and Fish Protein Isolates

Conventional surimi:

The Silver carp fish was purchased from local markets in Shiraz and transferred to the Department of Food Science and Technology of Shiraz University, Iran and kept chilled before further processing. According to the method described by Moosavi-Nasasb et al. (2005), the fish was filleted or eviscerated, then deboned and washed prior to mincing by a meat grinder (National, Iran) equipped with a die (pore diameter 4 mm) to obtain the flesh of the fish. Fish flesh was processed to surimi. The process involved three washing steps by cold water for removing water soluble proteins and then dewatered

using cheese cloth filtration. In each step, the ratio of water to meat was 4:1 (w/w). During each washing step, the mixture was stirred for 5 min. For more dewatering, at the third step 0.2% NaCl (Merck Co.) was added to the mixture. Also, a 15 kg dead weight was placed on the cloth filter for 10 min dewatering (11).

Fish protein isolate:

The chilled Silver carp fish were eviscerated, filleted and washed to eliminate the contaminants. Finally, they were minced with the low pore diameter of a meat grinder (2 mm) to facilitate the solubility of the proteins in acidic or basic solutions. The solubilisation was accomplished by adding water to the minced fish (6:1 ratio). Then alkali (NaOH, 0.1 N) was added to obtain pH 11 and 12 and acid (HCl, 0.1 N) was added to attain pH 2.5 and 3.5 during the homogenization of the mixture. Following solubilisation of the proteins to remove skin bits, bones, scales and other impurities, the homogenized mixture was filtered at 10000×g for 10 min at 15 ^{o}C. After centrifugation, the supernatant containing the proteins and other soluble materials was separated. To precipitate all soluble proteins including sarcoplasmic and myofibrillar, the pH was adjusted to 5.5, a value near the isoelectric point of most proteins. Finally, by centrifugation at 10000×g for 10 min the precipitated proteins (FPI) were collected. The non-protein soluble materials from the muscle tissues remained in the supernatant fraction after centrifugation and were subsequently removed. The remaining water in the collected protein contained the same concentration of impurities found in the supernatant fraction. Additional washing of the sedimented proteins at the same pH was used to decrease the concentration of these soluble impurities.

Preparation of gel from FPI and conventional surimi:

At first, the moisture content of the samples was adjusted to 40% (w.b). Subsequently, one kg of FPI and conventional surimi were separately grinded with a silent cutter. Then, 3% salt was added, and the mixture was mashed into a homogenized paste for 10 min. The homogenized paste was fed into a 20 mm diameter plastic tube, and both ends of the tube were tied. The sealed plastic tubes were kept in a refrigerator at 4 °C for an hour. The surimi and the FPI were then heated in 85 °C hot water for 30 min to make gels. The resulting gels were immersed into cold water (10-15 °C) and kept in a refrigerator at 4 °C for 24 h.

Chemical Analysis

After removing the plastic tubes, chemical analyses were performed on all samples in triplicates. The pH was determined in a distilled water homogenate (1:10 w/v) of the sample with a digital pH-meter with an accuracy of 0.01 (CG-824, Germany). Dry matter (DM) was determined by drying the sample at 105 °C to a constant weight and the results were expressed as a percentage of the initial sample weight. Total fat, protein and ash content of the samples were determined according to AOAC (1).

Determination of Gel Textural Characteristics

Creep test:

To show the viscoelastic behavior of the samples, a creep test was performed using a TA-XT2i texture analyzer (Stable Micro Systems, Surrey, UK) 24 h after cooking. Prior to the texture test, the samples were left at room temperature and allowed to equilibrate. The plastic tubes of cooked FPI and conventional surimi gel samples were removed and cylindrically shaped samples with lengths and diameters of 10 and 20 mm were cut into test specimens. A cylindrical probe (25 mm diameter) was used to compress the sample (20% of its height) at the cross head speed of 0.2 mm/min. The force versus time curve was recorded. From the recovered portion of the maximum force, the viscous and elastic components of the samples were determined.

Texture Profile Analysis:

In general, three cylinders, each 10 mm in length and 20 mm in width were prepared from each sample. An aluminum cylinder probe with a diameter of 25 mm was used to carry out the test. A two bite compression test was performed up to 20% of the original height. 5 seconds were allowed to elapse between the two compression cycles (2, 3, 4). Force-time deformation curves were obtained with a 25 kg load cell at a cross-head speed of 3 mm/s. The following parameters were quantified: hardness (N) maximum force required to compress the sample, springiness (m), ability of the sample to recover its original form after removal of the deformation force, cohesiveness, the ratio of the area under positive compression force in the second bite to that in the first bite and chewiness, work required to masticate the sample before swallowing.

Statistical Analysis

A one-way ANOVA and Duncan's test for means comparison at a 5% level of significance were performed to analyze the obtained data. The statistical analysis was carried out on FPI and conventional surimi data using SPSS version 13 (SPSS inc. USA).

RESULTS AND DISCUSSION

Chemical Analysis

Table 1 shows the chemical analysis of the samples. The moisture content of conventional surimi was significantly ($p<0.05$) lower than FPI samples due to its lower protein content. Several washing cycles for conventional surimi production drastically reduced the amount of soluble sarcoplasmic proteins, whereas all proteins such as sarcoplasmic and myofibrillar proteins were nearly not removed from the FPI final product. The fat content of FPI was significantly ($p<0.05$) lower than conventional surimi. A considerable amount of fat content was removed during the first stage of FPI centrifugation. After adjusting the pH by acid or alkali, the presence of cationic and

anionic groups increased the ash content of FPI samples, so such significant difference between ash content of FDI and conventional surimi was observed.

Table 1. Chemical analysis of gel samples from surimi and the fish protein isolate (FPI)

Gel samples	Moisture content (% w.b)	Fat content (% d.b)	Protein content (% d.b)	Ash content (%)
FPI at pH, 2.5	83.12^{cd}±0.32	7.24^{b}±0.20	79.05^{d}±2.99	1.65^{d}±0.01
FPI at pH, 3.5	84.52^{d}±0.74	6.97^{b}±0.23	76.19^{cd}±2.45	1.59^{b}±0.01
FPI at pH, 11	82.15^{c}±0.28	5.09^{a}±0.19	75.57^{cd}±2.86	1.61^{bc}±0.01
FPI at pH, 12	80.54^{b}±0.25	4.76^{a}±0.21	72.05^{bc}±2.95	1.62^{c}±0.01
Conventional surimi	77.95^{a}±0.41	12.77^{c}±0.53	69.54^{a}±1.16	1.40^{a}±0.01

*** Mean of three replicates± standard deviation ** Different letters indicate significant differences ($p<0.05$)**

Creep Test

Figure 1 shows a typical creep test graph of the surimi sample. The elasticity results of cooked FPI and conventional surimi are shown in Table 2. The elasticity of conventional surimi gel (29.76±0.9%) was significantly lower than the produced FPI in all pH ($p<0.05$). Among the FPI samples, those produced at pH 11 and 2.5 had the maximum (44.63±2.7%) and the minimum (32.87±1.9%) elasticity, respectively.

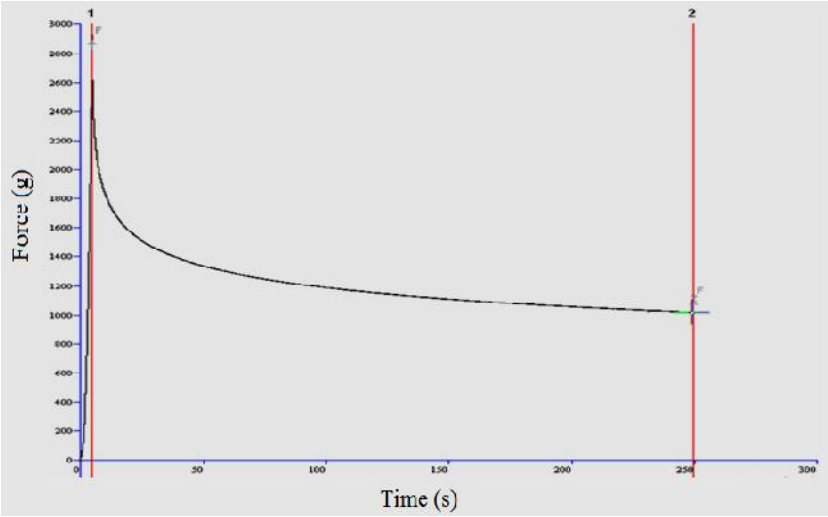

Fig. 1. An example of a creep test graph for the samples

TPA Test

Figure 2 shows an example of TPA graph of the samples. Table 3 shows the hardness of the samples. The results showed significant variation ($p<0.05$) indicating a great dispersion of hardness property between all studied samples except for the produced FPI at pH 2.5 and conventional surimi. The results demonstrated that obtained FPI at pH 11 and 2.5 had the highest and lowest hardness values among the others. Kim et. al (2003) reported similar results (8).

Table 2. Elasticity values of the gel samples from surimi and fish protein isolate (FPI)

Gel samples	Elasticity (%)
FPI at pH, 2.5	32.9^{b} ±1.9
FPI at pH, 3.5	41.6^{d} ±0.9
FPI at pH, 11	44.6^{e} ±2.7
FPI at pH, 12	36.2^{c} ±6.2
Conventional surimi (control sample)	29.8^{a} ±0.9

*** Mean of three replicates± standard deviation**

**** Different letters indicate significant differences (p<0.05)**

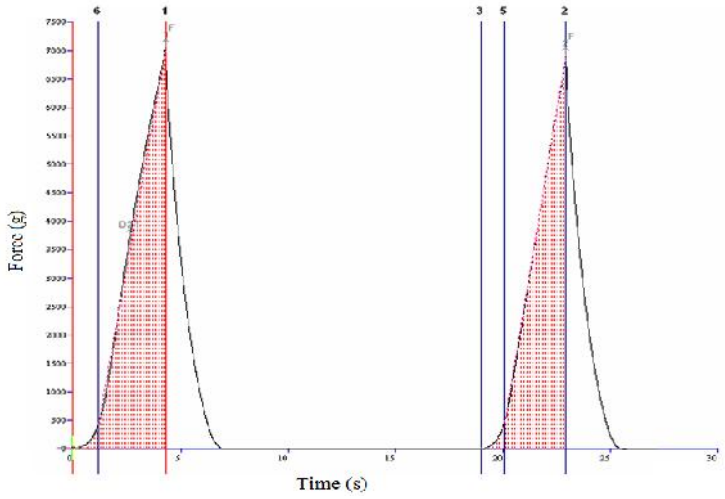

Fig. 2. An example of a TPA test graph for the samples.

Table 3. Hardness values of the gel samples from surimi and fish protein isolate (FPI)

Gel samples	Hardness (N)
FPI at pH, 2.5	26.94^{a}±1.88
FPI at pH, 3.5	63.15^{c}±5.76
FPI at pH, 11	87.56^{d}±4.97
FPI at pH, 12	46.47^{b}±1.01
Conventional surimi (control sample)	22.43^{a}±1.91

*** Mean of three replicates± standard deviation**

**** Different letters indicate significant differences (p<0.05)**

Cohesiveness, as attributed to conventional surimi, was significantly different ($p<0.05$) as compared to FPI samples (Table 4). No significant difference was seen amongst the springiness of any treatment. This revealed that the deformation of 20% of the initial length could not activate different viscous parts of the samples (Table 5).

Table 4. Cohesiveness values of the gel samples from surimi and fish protein isolate (FPI)

Gel samples	Cohesiveness
FPI at pH, 2.5	88.5^{b}±1.5
FPI at pH, 3.5	80^{b}±0.7
FPI at pH, 11	88.9^{b}±1.5
FPI at pH, 12	87^{b}±1.7
Conventional surimi (control sample)	68^{a}±0.3

*** Data are the mean of three replicates± standard deviation**

**** Different letters indicate significant differences (p<0.05)**

Table 5. Springiness values of the gel samples from surimi and fish Protein isolate (FPI)

Gel samples	Springiness (%)
FPI at pH, 2.5	100^{a}
FPI at pH, 3.5	99^{a}
FPI at pH, 11	100^{a}
FPI at pH, 12	99^{a}
Conventional surimi (control sample)	99^{a}

*** Data are the mean of three replicates± standard deviation**
**** Different letters indicate significant differences (p<0.05)**

Table 6 represents the chewiness textural parameter of the samples. The chewiness value for conventional surimi with the lowest value was significantly different ($p<0.05$) from the others. In case of FPI samples, the one treated in the basic conditions at pH 11 was the chewiest.

Table 6. Chewiness values of the gel samples from surimi and fish protein Isolate (FPI)

Gel samples	Chewiness (J×100)
FPI at pH, 2.5	22.87^{a} ±3.34
FPI at pH, 3.5	54.94^{c} ±5.39
FPI at pH, 11	71.18^{d} ±5.11
FPI at pH, 12	40.80^{b} ±1.68
Conventional surimi (control sample)	14.51^{a} ±0.56

*** Data are the mean of three replicates± standard deviation**
**** Different letters indicate significant differences (p<0.05)**

General assessment of all textural analyses showed that the FPI samples had a stronger gel structure as compared to the conventional surimi, especially in case of the FPI at pH 11. This occurs because of the changes in the proteins' configuration as well as the exposure of chemical active agents and better charge contribution on the proteins'

surface (18). In addition, more charge contribution causes more repulsion that leads to partial disentangling of the protein chains, an increase in thiol groups (-SH), and exposure of hydrophobic groups (19). At higher pH (12 or higher) more repulsion due to the highest level of net charge contribution causes high level disassociation of protein chains. This leads to an almost complete disappearance of the linkages between protein chains and consequently weakens the textural property of the FPI. On the contrary, in the case of the acid aided method, when producing FPI, especially at pH 2.5, the protein chains become shorter and reveal weaker textural properties due to protein refolding and degradation (19).

CONCLUSION

In this study, textural assessment of conventional surimi and FPI gels was performed. The results showed that textural quality attributes, which were measured by a TA-XT2i texture analyzer using creep and TPA tests for the conventional surimi were considerably different as compared to the FPI.

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مقایسه ویژگی های بافتی نمونه های ژل سوریمی و پروتئین ایزوله ماهی تولید شده از ماهی کپور نقره ای

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چکیده– در این مطالعه از دو آزمون بافت TPA و Creep برای بررسی ویژگی های بافتی سوریمی سنتی و پروتئین ایزوله ماهی استفاده شد. پروتئین ایزوله ماهی کپور نقره ای (*Hypophthalmichthys molitrix*) با استفاده از روش های قلیایی و اسیدی تولید شد. با استفاده از آزمون TPA ویژگی های بافتی نمونه ها شامل سفتی، پیوستگی، فنریت و قابلیت جویده شدن مورد بررسی قرار گرفت. همچنین میزان الاستیک بودن بافت نمونه ها به وسیله آزمون Creep مورد مطالعه قرار گرفت. سپس ویژگی های بافتی ذکر شده مربوط به نمونه های پروتئین ایزوله ماهی با نمونه های سوریمی سنتی تولید شده از همان ماهی مقایسه شد. کلیه ارزیابی های بافتی روی نمونه های ژل پروتئین ایزوله ماهی و سوریمی سنتی که در دمای ۸۰ درجه سانتی گراد و به مدت ۳۰ دقیقه تهیه شده بودند صورت گرفت. مقایسه ویژگی های بافتی نمونه های ژل پروتئین ایزوله ماهی و سوریمی سنتی نشان داد که به جز در مورد پارامتر فنریت بین بقیه پارامتر های آزمون TPA تفاوت آماری معنی دار وجود دارد ($p<۰/۰۵$). همچنین نتایج آزمون Creep نشان داد که میزان الاستیسیته نمونه های ژل سوریمی سنتی (۰/۹±۲۹/۸درصد) به طور معنی داری کمتر از الاستیسیته نمونه های ژل پروتئین ایزوله ماهی می باشد ($p<۰/۰۵$).

واژه های کلیدی: آزمون Creep، آزمون TPA، پروتئین ایزوله ماهی، سوریمی، کپور نقره ای

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