Indian J. Fish., 68(3): 105-110, 2021
DOI: 10.21077/ijf.2021.68.3.103195-14

Quality evaluation of fish protein soluble (FPS) injected seabass (*Lates calcarifer*) fillets through texture profile analysis during chilled storage

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ABSTRACT

Fish fillets are very popular products that have been dominating the world fish market. Seafood industry is always looking for innovative processing technologies to improve the quality of raw fish fillets. Texture profile analysis is a modern technique to indicate the quality of fish muscle by measuring various parameters like hardness, cohesiveness, springiness, chewiness, resilience and adhesiveness. Texture of the fish muscle is dependent on its composition which can be treated in various ways to maintain and/or improve the quality throughout cold chain. Soluble protein injection is an alternative method to improve the fillet texture and quality. In this study, fish protein soluble (FPS) was recovered from seabass filleting waste and injected to fish fillets prepared from same fish species *i.e.* seabass (*Lates calcarifer*). FPS was injected in 4 different incorporation levels at 0, 5, 10 and 15% (v/w) and denoted as C, T_{I1}, T_{I2}, T_{I3} respectively. Texture profile of the samples was analysed during chilled storage and highest hardness values were obtained in T_{I2} samples (13451.67±27.45 g) and lowest in control (C). T_{I1} samples showed better adhesiveness (-1338.20±12.32 g/s) compared to other samples. Cohesiveness, gumminess, springiness, chewiness and resilience showed that the protein injection had significant effect ($p<0.05$) on the textural attributes of fish fillets. The texture profile analysis clearly indicated fillet injected with 10% FPS to have better results compared to control under chilled storage.

Keywords: Fish fillets, Fish protein soluble, Protein injection, Texture profile analysis

Introduction

India recorded seafood export to the tune of 13,77,244 t in the year 2017-18 and being the second largest export item, frozen fish contributed 25.64% in quantity and 10.35% in USD earnings with a positive growth of 9.03% in terms of USD (MPEDA, 2018). Frozen fish is mainly exported as fillet form with increasing demand in international seafood trade due to its quality and texture. The freshness of fish fillet is important for providing supreme quality product to consumer as quality is a main concern of the modern agri-food industry. Edible coating (He *et al.,* 2014) and protein injection are the methods which can fulfil the requirements. Texture is a critical sensory quality attribute of fish fillets in relation to overall quality and acceptability of fish product (Gallart-Jornet *et al.,* 2007). Textural features come from the properties and concentrations of the tissue components and their complicated arrangement of connective tissue and the myofibrils in fish fillets (Cheng *et al.,* 2014). For fish products, tenderness is one of the most important characteristics related to texture, softness and eating quality of fish products which mainly depends upon the quality of the raw material. Normally, tenderness of fish fillets is evaluated by ‘‘finger’’ test and by visually assessing the fish flesh (Quevedo and Aguilera, 2010). This is not desirable to the consumers as it dose not provide subjective assessment, information concerning product acceptability and preference for one fish product over another. Now a days, textural attribute of food is analysed by several instrumental methods. According to Vacha *et al.* (2013), for texture profile analysis (TPA) a number of texture profile parameters are quantified from force-generated time curve and then results are correlated with sensory evaluation. The main techniques applied for fish are puncture, compression, shear, tensile stress as well as cutting and pulling. The shearing force and compression methods are recommended as most suitable for analysis of fresh fish texture (Gallart-Jornet *et al.,* 2007). The most important variable for texture of raw fish are hardness and springiness. Double compression or puncturing allows a texture profile analysis (TPA), giving plots of force *vs.* distance *vs.* time (Nishinari *et al.,* 2013). The texture profile of fish fillets can be improved through various treatments which can help in maintaining the composition throughout the processing journey to reach consumers and protein injection is considered as an effective alternative. The world population is increasing so rapidly that, it will be difficult to meet human nutritional needs from aquatic resources in the future. So, new and more efficient recovery technologies are needed to reduce the amount of processing byproduct by increasing the recovery yields of aquatic food products and utilising them in proper way for human consumption. A potential challenge will be to find proper application for the recovered materials so that the processing can be economically sustainable (Gehringa *et al.,* 2011). Filleting generates large amount of waste, which are simply discarded that would lead to environmental pollution without proper utilisation of resource. Fish protein can be recovered from this filleting waste and used for improving the fish fillet quality and yield by injecting this protein in the form of fish protein soluble (FPS). FPS is a kind of semi-solid protein-in-water colloid prepared by acid/alkaline aided process. Salt and other optional ingredients (cryoprotectants) may be used based on the final use. Fish protein soluble can be made by resolubilising proteins isolated by the acid/alkali-aided methods, or by directly using the solubilised ground fish muscle, in the acid or alkaline state, for injection into fillets. In the present study, effect of protein injection from seabass filleting waste on textural properties of seabass fillets was analysed during storage.

Materials and methods

Preparation of protein soluble for injection

For the preparation of FPS, protein recovered from filleting waste of seabass was used and certain amount of cold water (0-1^{0}C) along with 1.5% salt was added to get a final solution with 3% protein content. Then mixture was homogenised at 7000 *g* for 10 to 15 mins to get a solution with 3% protein content and sieved to obtain final solution having a particle size ranging from 0.5 to 1.0 mm.

Protein injection in fish fillets

Injection was carried out manually, immediately after filleting using an injector. Four levels of incorporation was done @ 0, 5, 10 and 15% (v/w) with FPS maintained at 4^{0}C and denoted as C, T_{11}, T_{12}, T_{13} respectively. Samples were drawn periodically (day 0, 3, 6, 9, 12) for texture profile analysis during the study. After injection, fillets were placed carefully on a grid for 10 min to guarantee that the solutions injected effectively spread into the muscle before packaging and to facilitate draining of excess solution (Akse *et al.,* 2008). Further the fish fillets were stored under chilled condition (4±1^{0}C).

Texture measurements

Texture parameters like hardness, cohesiveness, springiness, chewiness, gumminess, adhesiveness and resilience were determined according to Caine *et al.* (2003). Texture profile analysis (TPA) of fish fillets was performed at ambient temperature with TA-XT plus texture analyser (Stable Micro System, Surrey, UK) using a 50 kg load cell. Each cube, weighing about 45 g with an average thickness of 2.6±0.1 cm, was compressed vertically in two consecutive cycles using a flat plunger (SMS-P/75) and a heavy duty platform. This test was done according to the specifications by Mao and Wu (2007).

The adopted test settings for this experiment were:

Pre-test speed	: 1.5 mm s^{-1}
Test speed	: 0.5 mm s^{-1}
Post-test speed	: 1.5 mm s^{-1}
Strain	: 50% compression
Interval (time)	: 5 s
Trigger type	: Auto (Force)
Trigger force	: 25 g

Statistical analysis

All the data were checked for normal distribution with normality plots prior to analysis of variance (ANOVA) to determine significant differences among means at $\alpha = 0.05$ level, using statistical tools of Microsoft Excel (2007). Duncan's multiple range test (DMRT) was used to determine significant differences between treatments.

Results and discussion

Texture profile analysis of fillets injected with fish protein soluble (FPS)

Texture is an extremely important sensory attribute of foods like fish that is quantified by instrumental methods (Nga, 2002). It includes a variety of characteristics, such as hardness (toughness), adhesiveness, springiness, chewiness and some authors also include juiciness and greasiness (Rosenthal, 2010). Texture profile analysis (TPA) is a force-generated time curve which is used to quantify the textural properties that correlates properly with the results from sensory evaluation (Vacha *et al.,* 2013).

Maximum force value was obtained from the texture profile analysis which is considered as hardness (Nga, 2002) and in the present study, the highest hardness values were obtained in T_{12} samples (13451.67±27.45 g) and lowest in control (C) (Table 1). This may be due to the effect of salt used and protein solubility (Gallart-

Jornet *et al.,* 2007). Variation in chemical composition and physical structure may affect the textural properties of fillets (Jonsson *et al.,* 2001). The hardness of fillets was significantly decreased ($p<0.05$) during chilled storage and lowest value was obtained in control whereas T_{I2} showed the highest value (Table 1). The fish muscle softens due to weakening of the Z-discs of the myofibrils, degradation of connective tissue and weakening of myosin actin junctions (Hultmann and Rustad, 2002). The muscle of fish is prone to become soft and mushy due to autolytic degradation during the post mortem condition, which further affects the textural quality of fish muscle (Cheng *et al*., 2014) and soft flesh may lead to reduced consumer acceptability. The changes of pH and extent of proteolysis also may influence the fish muscle texture as it causes breakdown of myofibrils (Hultmann and Rustad, 2002) and mechanical damage of the structure increased drip loss and declined water holding capacity also affects the hardness of fish fillets (Huss 1998).

Adhesiveness which is an important TPA parameter, is the property of different molecules or surfaces to cling to each other. This is due to the adhesive force between the sample molecules and the molecules of the surface. It can also be described as the stickiness between two different materials. Here, control showed the lowest adhesiveness and T_{I1} samples showed the highest adhesiveness (-1338.20±12.32 g/s). Among all threated samples, T_{I2} can be considered as better as lowest adhesiveness is desirable. The results of adhesiveness showed significant difference ($p<0.05$) among the samples (Table 2). The adhesiveness value in the present study significantly increased ($p<0.05$) for all samples during storage study as the samples became soft due to the degradation of muscle protein.

Cohesion is the property where the molecules of the same substance stick to each other due to mutual attraction. Cohesiveness was obtained from the texture profile analysis as the ratio between two maximum force areas (Nga, 2002). In the present experiment, cohesiveness were significantly decreased ($p<0.05$) during storage for all samples (Table 3). The decrease in cohesiveness could be due to denaturation of the muscle proteins and structural damage of membranes (Tryggvadottir and Olafsdottir, 2000). Regarding cohesiveness, all the treatments showed the same significant trend as in hardness ($p<0.05$). The highest value was found in sample T_{I2} and lowest in control at the end of storage (Table 3).

Table 1. Changes in texture hardness value (g) during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	13362.17±30.02^a	13427.71±28.35^a	13451.67±27.45^a	13418.32±25.23^a
3	10983.73±22.10^b	11192.10±20.15^b	11862.53±19.35^b	11452.20±18.25^b
6	7748.73±24.31^f	8772.13±25.22^d	9728.54±23.24^c	9372.18±22.14^c
9	5883.82±10.25^g	6473.28±14.32^g	8137.37±21.22^e	7537.38±20.21^f
12	4492.19±12.42^i	5437.50±11.25^h	6153.83±12.22^g	5836.71±11.31^g

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference ($p<0.05$).

Table 2. Changes in texture adhesiveness value (g s^{-1}) during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	-1376.43±10.56^a	-1338.20±12.32^a	-1362.16`±11.25^a	-1351.72±12.22^a
3	-873.29±14.25^b	-936.71±13.25^b	-917.01±15.25^b	-971.84±14.32^b
6	-418.27±12.22^d	-635.49±11.31^c	-677.80±13.42^c	-681.61±13.25^c
9	-294.61±11.12^f	-342.74±12.21^f	-418.31±11.12^d	-370.00±10.14^e
12	-124.08±10.25^j	-275.59±14.25^g	-230.14±12.25^h	-204.13±13.12^i

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference ($p<0.05$).

Table 3. Changes in texture cohesiveness value during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	0.52±0.08^d	0.55±0.09^b	0.58±0.05^a	0.54±0.07^c
3	0.44±0.06^h	0.49±0.08^e	0.47±0.06^f	0.46±0.09^g
6	0.38±0.09^k	0.44±0.10^h	0.42±0.07^i	0.40±0.10^j
9	0.33±0.07^n	0.38±0.10^k	0.36±0.09^l	0.35±0.11^m
12	0.30±0.10^p	0.35±0.12^m	0.33±0.11^n	0.32±0.12^o

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference ($p<0.05$).

Springiness is used to express how well a product physically springs back after it has been deformed during the first compression and has been allowed to wait for the target wait time between strokes. Springiness was initially called elasticity in the original TPA parameters which is measured by distance of the detected height during the second compression divided by the original compression distance. Gumminess is mutually exclusive with chewiness since a product would not be in both semi-solid and solid condition at the same time. Resilience is how well a product fights to regain its original height. Resilience can be measured with a single compression, if the withdrawal speed is same as the compression speed. Gumminess (Table 5), springiness (Table 4), chewiness (Table 6) and resilience (Table 7) showed the same significant trend in order to obtain an overview of the main effects of protein injection on the textural attributes which is in agreement with the findings of Olafsdottir *et al.* (2004) and Gallart-Jornet *et al.* (2007). Factors like species used, habitat, pH of fish muscle, storage temperature during handling and operating processes generally has a distinctive effect on fish texture measurement (Hultmann and Rustad, 2004 and Pearce *et al.,* 2011).

With the increase in world population there is a growing demand for protein. The large amount of waste

Table 4. Changes in texture springiness value during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	1.52±0.09^c	1.61±0.05^a	1.55±0.04^b	1.53±0.06^c
3	1.08±0.11^e	1.19±0.07^d	1.21±0.06^d	1.16±0.07^d
6	0.77±0.13^g	0.82±0.09^f	0.85±0.12^f	0.81±0.05^f
9	0.56±0.10^j	0.65±0.13^h	0.61±0.11^i	0.68±0.10^h
12	0.43±0.14^m	0.51±0.12^f	0.55±0.10^j	0.52±0.11^k

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference (p<0.05).

Table 5. Changes in texture gumminess value during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	6948.33±12.20^c	7385.24±11.02^b	7801.97±13.35^a	7245.89±12.42^b
3	4832.84±9.52^g	5484.13±10.42^e	5575.39±12.01^d	5268.01±10.25^f
6	2944.52±10.23^k	3859.74±9.41^i	4085.99±11.03^h	3748.87±9.26^j
9	1941.66±11.32^m	2459.85±8.10^l	2929.45±7.05^k	2638.08±8.25^l
12	1347.65±5.14^h	1903.13±7.02^m	2030.76±5.02^m	1867.75±6.31^m

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference (p<0.05).

Table 6. Changes in texture chewiness value during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	10561.32±6.10^b	11890.24±7.21^a	12093.05±8.20^a	11086.21±6.03^b
3	5218.93±8.23^f	6526.12±8.03^d	6746.22±5.31^c	6110.89±7.06^e
6	2267.28±7.31^h	3164.99±6.10^g	3473.09±4.03^g	3036.58±5.23^g
9	1087.33±6.25^k	1598.90±5.03^j	1786.96±6.21^i	1793.89±4.23^i
12	579.49±3.21^l	970.60±4.05^k	1116.92±5.31^k	971.23±5.21^k

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference (p<0.05).

Table 7. Changes in texture resilience value during chilled (4±1^{0}C) storage

Days after injection of FPS	C	T_{I1}	T_{I2}	T_{I3}
0	0.22±0.04^b	0.21±0.03^c	0.24±0.05^a	0.21±0.04^c
3	0.20±0.06^d	0.19±0.04^e	0.21±0.03^c	0.20±0.02^d
6	0.17±0.03^g	0.16±0.06^h	0.18±0.04^f	0.17±0.06^g
9	0.14±0.05^j	0.14±0.04^j	0.15±0.02^i	0.15±0.04^i
12	0.13±0.07^k	0.12±0.06^l	0.13±0.03^k	0.12±0.03^l

*Results are mean of five determinations (n=5) with SD
#Values of means with different superscripts indicate significant difference (p<0.05).

generated during fish processing leads to improper utilisation of the resource as well as environmental pollution. There is a need for better use of resources which will be beneficial for industry as well as environment. Protein can be recovered from the fish filleting waste and utilised to prepare FPS (fish protein soluble). The results of the present study clearly indicated that the FPS can further be injected into the fish fillets at 10% incorporation level to improve their textural properties. Preparation of FPS from filleting waste would contribute to the improvement of the product quality as well as optimal utilisation of the fish protein source that will provide a practical solution to the fish processors.

Acknowledgements

Authors are thankful to the West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal for providing all the facilities to carry out the research work. Authors also thank the staff, Faculty of Fishery Sciences, WBUAFS, Kolkata, for the support rendered during the study.

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Date of Receipt : 04.08.2020

Date of Acceptance : 13.09.2021