Effect of Connective Tissue and Cooking Regime on the Properties of Shark Meat

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The content of total collagen in shark, (*Scoliodon sorrakowah*) is found to be 2.99 g.100g^{-1} wet meat, which includes 2.13 g.100g^{-1} wet meat of soluble collagen and the rest 0.86 g.100g^{-1} wet meat of insoluble collagen. In terms of total protein, the total collagen content of shark is 13.11%. Proximate composition and microbiological analysis of washed and unwashed mince was done. Microbiological analysis of equipment parts of the mincing machine was also carried out during the study. Quality attributes of *surimi* connected with its rheological property carried out in the present study are gel strength (GS), % of expressible water (EW), folding test score (FT), and sensory texture score (TS). On statistical analysis a high correlation was observed among these attributes. The correlation between TS and GS was 0.94; TS and EW was –0.85; TS and FT were 0.87. Between GS and EW the correlation was found to be –0.94, and between GS and FT it was 0.89 and between EW and FT the correlation was –0.94. The present study revealed that shark *surimi* showed highest GS when it was incubated at 60°C for two hours in water bath.

Key words: Cooking regime, shark meat, *Scoliodon sorrakowah*

The connective tissue proteins (stroma proteins) constitute only a small fraction of the total protein content in fish meat and contribute to the overall texture. Among connective tissue proteins, collagen is the major protein, and is seen to influence the texture of raw fish meat considerably (Hatae *et al.*, 1984; Sato 1988).

Any food product must have a certain degree of toughness as decided by the consumer (Beltran *et al.*, 1991). Textural aspects such as toughness or softness, elasticity and gellying properties are important considerations in the production of texturised fish products and analogues. Gel forming

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ability is the most important functional requirement for *surimi*-based products. Though in cooked fish, the influence of collagen in contributing to the texture of fish meat is reduced due to its breakdown to gelatin, it decides the gel forming property of mince. Gelation of muscle protein contribute desirable texture in processed foods. Formation of gel with desirable texture depends upon heating temperature and rate of heating (Hamann, 1988; Nielson and Pigott, 1994; Lan *et al.*, 1995). Cheng *et al.* (1971a) demonstrated that, the extent of muscle protein degradation during thermal processing is closely related to texture of fish gels. Cheng *et al.* (1971b) indicated that low correlation between protein solubility of raw tissue and gel texture of cooked gels probably resulted from variation in protein degradation during thermal processing. They also showed the relationship between texture and water holding capacity of cooked fish gels, and indicated that the muscle proteins like connective tissue and actomyosin play a key role in influencing these properties.

Water washing can improve the quality and functional characteristics of minced fish. By repeated washing of minced meat, most of odour imparting compounds, pigments, water-soluble proteins *etc* are removed and a translucent bland material, *surimi*, is obtained. *Surimi* is mostly a myofibrillar protein concentrate. But in shark *surimi*, in addition to myofibrillar protein it also contains soluble collagen. One of the objectives of this study is to find out the quality attributes of *surimi* in connection with rheological property of *surimi* and the correlation among these factors. The study also aimed to elucidate the gel forming characteristics of shark *surimi* at different cooking regime.

Materials and Methods

A commercially important marine shark, *Scoliodon sorrakowah* was used for the study. They were collected from Cochin Fisheries Harbour in fresh condition, iced in 1:1 ratio and brought to the processing hall without delay. They were beheaded, eviscerated, removed the inner lining of the peritoneum and washed with potable water at 10° C. The fish is then divided into two lots. One lot was used for analysis. Proximate composition was analysed as per the standard method (AOAC, 1984). Collagen estimation and its fractionation were done as per the method of Sato (1988).

The second lot was minced in a Baader 694 meat bone separator (Nasan, Nova Scotia Corporation, New York), equipped with a 5 mm diameter

perforated drum. Before fishes were fed to the machine, sample was taken for microbiological analysis. Also swabs were drawn from the machine parts of perforated cylinder, rubber belt and discharge chute. All the samples were analysed for microbial load as per the method of AOAC (1984). After mincing, yield of mince was calculated and its proximate analysis was also done. Method of Hassan & Mathew (1999) was followed for the preparation of *surimi* and for studying the gel strength (GS), % expressible water (EW), folding test score (FTS) and sensory texture score (TS).

The *surimi* prepared was divided into two lots. One lot was used for frozen storage studies. Other part was used to study the gel forming characteristics at different cooking regimes. For this purpose, the *surimi* prepared was divided into nine parts for studying the characteristics of gel incubated at 10, 20, 30, 40, 50, 60, 70, 80 and 90°C. At each incubation temperature three durations were set, *viz.*, 1, 2 and 3 h. These heated gels were immediately chilled to 5°C in iced water and gel strength was measured as above.

Results and Discussion

Proximate composition and microbiological properties of washed and unwashed mince of shark is presented in Table 1. The shark meat used in the study has got moisture content 72.00%, protein 22.80%, fat 1.09% and ash 1.50%. *Surimi* contains less protein than unwashed mince as most of the water-soluble proteins are lost during washing.

Table 1. Proximate composition and microbiological properties of washed and unwashed shark mince

Item	Unwashed mince	Washed mince
Yield (%)	36.2±3.2	21.4±2.2
Moisture (%)	72.00	77.26
Protein (%)	22.8	23.34
Fat (%)	1.09	Negligible
Ash (%)	1.5	0.5
TPC	$2.8x10^4 cfu.g^{-1}$	$3.8x10^5 cfu.g^{-1}$
E. coli	ND	ND
Staphylocci	ND	ND
Salmonella	ND	ND
Vibrio	ND	ND

ND- Not Detected

The microbial load of a frozen product depends upon various factors such as the nature of raw material, its pre and post process treatments, sanitary conditions of the processing area and the rate and nature of freezing (Chen *et al.*, 1990). In the present study TPC of unwashed mince was found to be $2.8x10^4$ cfu.g^{-1} and for *surimi* it is $3.8x10^5$ cfu.g^{-1}. The flesh of fish caught from the sea is sterile. After death, bacterial attack from the surface, gut and gill will increase the microbial load of fish muscle. So the environment has got a role in contributing to the bacterial load of muscle. During processing of *surimi* due to beheading, gutting and washing, there is reduction in bacterial load, but at the same time the increased handling will increase the number of bacteria in the *surimi*. The ingredients like cryoprotectants also will increase the bacterial load. The washed or unwashed mince did not show any incidence of *E. coli, Staphylococcus, Salmonella* and *Vibrio*, during the experiments. The microbiological analysis of equipment parts of mincing machine is given in Table 2.

Table 2. Microbiological properties of equipment parts of mincing machine

Machine part	Colonies.cm^{-2}
Perforated cylinder	7.8
Rubber belt	459
Discharge chute	5

The total collagen content in shark meat was found to be 2.99 g.$100g^{-1}$ wet meat, it includes 2.13g.$100g^{-1}$ wet meat of soluble collagen and 0.86 g.$100g^{-1}$ wet meat of insoluble collagen. The total collagen content in terms of total protein content was found to be 13.11%. These findings are in agreement with the findings of Sato (1988). The physical attributes deciding gel quality of *surimi* studied are gel strength (GS), % expressible water (EW), and folding test score (FT). Along with this, sensory analysis of texture in terms of sensory texture score (TS) was also done. These attributes were measured for a storage period of 360 days (Fig. 1). These quality attributes are actually deciding the toughness of gel formed on cooking. The correlation coefficients between these factors are given in Table 3. High positive correlation existed between gel strength and sensory texture score (0.94); gel strength and folding test score; folding test score and sensory texture score (0.87). With respect to % expressible water, the attributes gel strength, folding test score and sensory texture score showed a negative correlation. This means that as the gel strength increases, there is corresponding increase in folding

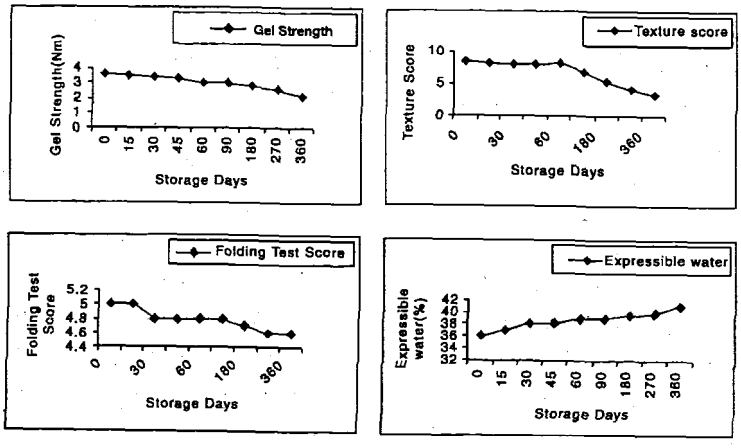

Fig. 1. Various rheological quality attributes of shark *surimi* at different frozen storage periods

test score and sensory texture score and decrease in % expressible water. The results also show that the quality of *surimi* goes on decreasing with increase in storage period. This is in agreement with the findings of Lee *et al.* (1976), who reported after studying the unwashed mince of Spanish mackerel that the gel resilience and cohesiveness gets decreased with storage. Gel forming ability of *surimi* is the most important functional requirement for *surimi*-based products. In processed meat products, gelation of protein contributes desirable texture. *Surimi* is suitable for product development till its GS reaches 1.5 Nm. Since the GS of shark *surimi* after one year is 2.1 Nm, it is clear that shark *surimi* retains its functional property and hence it is suitable for product development even after one year. Iwata *et al.* (1971) also reported that gel forming ability of *surimi* made from fresh fish does not change significantly up to one year when held at constant temperature below –20°C. MacDonald *et al.* (1990), after studying the GS of washed and unwashed mince also reported similar results.

Table 3. Correlation coefficient between different rheological quality attributes of shark *surimi*

Parameter	TS	GS	EW	FT
TS	1			
GS	0.94353	1		
EW	-0.8489	-0.9365	1	
FT	0.8661	0.8882	-0.9415	1

TS-Sensory texture score; GS- Gel strength; EW- % expressible water; FT- Folding test score

Once the protein is denatured, the water holding capacity (WHC) of protein is lost and the GS of *surimi* is affected by the moisture content present in it. When water is immobilised within the three dimensional protein matrix, a gel is formed. The WHC of collagen allows more water to be held in the *surimi*. Since shark *surimi* has high collagen content it helps to increase the gel strength. When gelatinised, collagen absorbs more water and becomes pliable and elastic, thus it improves the texture of *surimi*. The higher resistance offered by gelatinised collagen to mechanical force than that of muscle protein is responsible for higher GS, FT, and TS. This in turn will give lesser value for EW. Yoon *et al.* (1991) also reported that EW of gel is inversely proportional to compressive force and penetration force. The tighter the water is bound, the stronger is the gel. Good correlation between texture and WHC of cooked fish gels was also reported by Cheng *et al.* (1971b) and Deng *et al.* (1981).

Table 4. ANOVA of variation in gel strength of shark *surimi* with incubation temperature and period of incubation

Source	SS	df	MS	F-ratio	p
Incubation time	0.002	2	0.001	0.034	0.967
Temperature	100.690	6	16.782	742.653	0.000
Incubation time x Temperature	0.099	12	0.008	0.364	0.969
Error	0.949	42	0.023		

Salted *surimi* paste incubated at 10°C and 20°C did not form gel (Fig. 2). The gel formation in shark *surimi* started from 30°C and the highest gel strength was observed to be at 60°C. It was also noted that further increase

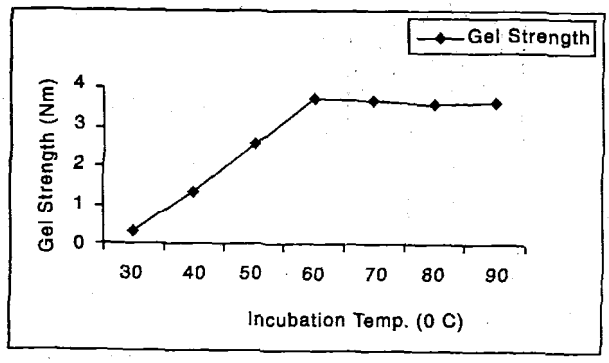

Fig. 2. Average gel strength of shark *surimi* with different incubation temperature

in incubation temperature, does not show corresponding increase in GS. The texture profile of the heat induced gel varies with the heating schedule of salt ground meat. That is when salted *surimi* paste of shark incubated at 60°C and subsequently heated to 90°C; a highly elastic gel is produced. However, there is reduction in the gel strength of heat-induced gel on further increase in incubation temperature. Statistical analysis shows that among different temperatures of incubation, there is significant difference in gel strength ($p<0.05$) and that duration of incubation at each temperature has no significant effect on gel strength ($p<0.05$) (Table 4). *Surimi* is actually considered as concentrate of myofibrillar protein. Compared to teleosts, shark is having high content of collagen. During preparation of *surimi*, though fibrous collagen is removed, there is no method to remove soluble collagen from the mince. These characteristics of shark *surimi* are important in the manufacture of *surimi*-based products. Gel strength of each species of fish exhibits this type of peculiarity according to its protein structure (Saeki *et al.*, 1992; Kamath *et al.*, 1992). According to them this can be correlated with a covalent cross-linking reaction of myosin heavy chain. These earlier reports showed that higher gel strength is observed at an incubation temperature of 40°C.But in the present study, the highest gel strength observed for shark *surimi* was at 60°C. This may be because shark surimi contains higher amount of soluble content in the meat.

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