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Five Tropical Freshwater Fish Species: Setting Ability and Other Characteristics of the Minces

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Abstract

Setting ability and other characteristics of the minces of freshwater snakehead, wild mullee, wild tilapia, genetically improved farmed tilapia and river shad were studied in order to investigate their potential use in the manufacture of surimi. Mince was prepared from fillet. A portion of the mince was washed with water containing 0.1% NaCl. Both washed and unwashed minces were ground with 3% NaCl for 20 min at 4°C and incubated at various temperatures for one- and two-step heating. The resulting gels were subjected to punch, expressible moisture and folding tests. Gel hardness and colour of the minces were evaluated organoleptically.

Wild mullee, snakehead and tilapia minces showed good setting ability. Genetically improved tilapia produced better quality gel compared to the wild ones. Optimum gel strength was observed in between 40-50°C and gel disintegration occurred at 60-70°C. Gels prepared by two-step heating had higher gel strength except the river shad. A single washing of the mince substantially improved the texture and colour of the gels. River shad mince produced very poor quality gel even after two washings. A comprehensive investigation on the river shad with improved washing technique is required.

Introduction

Surimi is deboned and leached fish flesh mince mixed with cryoprotectants. Surimi is produced mainly from various species of marine fishes, because the marine fish is superior in surimi making compared to freshwater fish (Shimizu et al. 1981). Increased consumption of surimi based products and continous decrease of marine raw material have led surimi manufacturers to search for alternate sources (Kim et al. 1996). Various attempts have been made to investigate the surimi making ability of underutilized marine species (Poon et al. 1981; Chen et al. 1997; Nowsad et al. 1998b), dark-fleshed fatty species (Lanier 1988; Shimizu et al. 1992), krill, squid and cuttle fish as well as red meat (Park et al. 1996). However, little is known about the mince quality of freshwater species. Freshwater fishes are excellent sources of high quality protein since they are well balanced in essential amino acids and highly digestible (Karmas and Lauber 1987). On the other hand, freshwater desired species has the potential ability to increase its production through the best culture practices which most of the marine species do not. The surimi making ability of many freshwater species could be upgraded by manipulating processing techniques (Onibala et al. 1997).

Very recently, some investigations have been done on the quality of the minces of freshwater fish for the manufacture of surimi (Ismond and Tonogai,1994; Lin and Morrissey 1995; Kim et al. 1996; Onibala et al. 1997; Nowsad et al. 1998a). Onibala et al. (1997) studied the gel forming ability and the characteristics of protein subunit in the heat-induced gel of tilapia. Lin and Morrissey (1995) investigated the quality of surimi produced from Northern squawfish. Ismond and Tonogai (1994) studied the potential of Manitoba whitefish for fabrication of texturized seafood analog. Setting ability of cultured Indian and Chinese carps was also critically examined (Nowsad et al. 1998a). All these results explicate that much potentials also lie on freshwater fish which could successfully be used in the surimi industry.

The setting or gel forming ability of fish flesh is the most important determinant to understand the quality of surimi. Setting is a process which generally occurs at > 40°C in salt-ground marine fish paste (Suzuki 1981). During this low temperature treatment, the fish paste sol transformed into gel, resulting in a three-dimensional protein network (Niwa 1992). The mechanism of setting involves denaturation of myofibrillar proteins, mainly myosin heavy chain and interaction of denatured myosin to form crosslinked myosin by non-covalent and covalent bonds (Niwa 1992). Subsequent to the sol-gel transformation the gel achieves various degrees of changes in rigidity, elasticity, and brittleness depending on variation of species, protein concentration, and heat processing methods (Shimizu and Kaguri 1986). High fat content, instability of muscle proteins, large amount of sarcoplasmic proteins and high proportions of dark to ordinary muscles prevent the material to form good gel. A great degree of variation in the gel elasticity within the species is observed due to freshness, harvest season, age, sex, death condition and fishing place (Shimizu et al. 1981; Shimizu and Kaguri 1986; Roussel and Cheftel 1988). The present work was designed to study the setting ability of four wild and one cultured freshwater species in Bangladesh, in order to investigate their suitability in the manufacture of surimi.

Materials and Methods

Material

Four wild freshwater fish, *viz.*, snakehead (*Channa punctatus*, Channidae), wild mullee (*Wallago attu*, Siluridae), Nile tilapia (*Oreochromis niloticus*, Cichlidae) and river shad (*Tenualosa ilisha*, Clupeidae) and one cultured species, genetically improved farmed tilapia (*O. niloticus*, Cichlidae), popularly known as GIFT tilapia were used to study the setting ability of their muscles. Snakehead, wild mullee, tilapia Wild and river shad were bought from the local fish market. GIFT tilapia was obtained from the fish farm in Bangladesh Agricultural University campus, Mymensingh. The biological data on fishes are presented in Table 1. The fishes were obtained live except the river shad. The iced river shad (20-30 hour in ice) was used. Freshness of the fishes was assessed using the organoleptic methods. Adult, moderate sized, healthy, single sex fishes were used.

Analysis of proximate composition

Proximate composition of both unwashed and washed fish minces was analyzed according to AOAC (1980).

Preparation of fish paste

Upon arrival at the laboratory the fishes were decapitated and gutted before washing with chilled fresh water. Sufficient time was provided to drain excessive blood. The washed fish was filleted very carefully eliminating scales, skin and kidney tissues. The fillet was deboned and minced by a manually operated meat mincer. Remaining bones and connective tissue fibers were removed from the meat using a fine mesh sieve. A portion of the mince was washed twice with cold water containing 0.1% NaCl. The mince was stirred in four volumes of washing solution for 2 min. and then allowed to settle for 5 min. Washed meat was drained in a nylon bag after leaching. The excess water was removed by pressing (15 kg/cm^2 for 15

Table 1. Biological data on the freshwater fish species used in determining the setting ability.

Fish	No. Used	Sex	Season	Condition of Fish	Average Size Length (cm) (range)	Average Size Weight (g) (range)
Snakehead	41	F	September	Live	15.5	177.0
SN. *Channa punctatus*					(10.0 - 20.8)	(150.6 - 200.8)
F. Channidae						
Wild mullee	4	M	December	Live	74.5	1830
SN. *Wallago attu*					(53.0 - 86.5)	(1620 - 2250)
F. Siluridae						
Nile tilapia	39	F	Sept. - Oct.	Live	16.6	169.0
(Wild strain)*					(12.1 - 21.6)	(155.5 - 210.0)
SN. *Orechromis niloticus*						
F. Cichlidae						
Nile tilapia	22	F	October	Live	26.4	360
(GIFT strain)					(22.4 - 36.7)	(270.6 - 456.0)
SN. *O. niloticus*						
F. Cichlidae						
River shad	7	M	Oct. - Nov.	Iced	40.0	1250
SN. *Tenualosa ilisha*				(20-30 hr.)	(27.6 - 56.5)	(1030 - 1725)
F. Clupeidae						

*Mostly crossbred with *O. mossambicus*.
SN: Scientific name; F: English name; GIFT: Genetically improved farmed tilapia.

min.). The unwashed and washed minces were ground with 3% NaCl in a mortar for 20 min at 4°C. The paste was carefully stuffed into polyethylene tube (2.8 cm diameter, 12.0 cm long). The two ends of the tube were wrapped by parafilm and plastic paper before chilling in iced water to retard changes in the meat until heating.

Preparation of gel

The paste in the tube from unwashed mince was heated under one-step and two-step heating while the paste of washed mince was heated under one-step heating. All heating treatments were done three times. Under the one-step heating, samples were heated for 60, 120 and 180 min. in water baths at a temperature of 25, 30, 35, 40, 50, 60, 70 and 80°C. Under the two-step heating, a preheating was done for 60, 120, 180. min at temperatures of 25, 30, 35, 40, 50, 60, 70 and 80°C. After preheating, the samples were immediately heated for 30 min. at 85°C.

Measurements of the gel strength

The pH of the mince, paste and gel was measured by inserting an electrode of a pH meter (JENWAY, 3020). The resulting gels were immediately cooled in iced water and kept at room temperature (24-26°C) for one hour. After acclimation the gels were removed from the tube and subjected to puncture, folding and expressible moisture tests for physical measurement.

Puncture test measured the breaking strength (in g) of the gel against the penetration of a ball type plunger (6 mm diameter).

The amount of expressible moisture of the gel was measured by compressing a gel slice (about 1.0 g) put between two double layers of filter paper (Whatman No.1) at a pressure of 1 kg/cm^2 for 3 min. and calculated from its weight before and after compression.

The folding test measured the resistance against breaking along the folds when the sample discs of 1 mm thickness were folded into halves and quarters. The grading of folding test were: a- no crack was visible when the disc was folded into quarter; b- no crack was visible when disc was folded into half but one or more cracks were noticed when folded into quarter; c- one or more cracks were visible when the disc was folded into half; d- the disc broke but did not split into halves; e- the disc split into halves when folded into half.

A nine-person panel as described by Poon et al. (1981) provided the organoleptic assessments. Panelists were graduate students and teachers at the Department of Fisheries Technology who had been previously trained about the assessments and participated in such organoleptic tests before. For the teeth cutting test (TCT), a spherical disc of 1 mm thick gel was supplied to each panelist to recognize the hardness by cutting it through incisors and gel strength was evaluated using the numerical scores up to 10. Panel score of ≤ 5 were taken for frail or poor quality gel. Colour of the minces were also evaluated organoleptically. The test scores are given as a foot-note in Table 4.

Statistical analysis

Statistical analysis of the data was done by ANOVA (STATGRAPHICS 1992). A least significant difference at $p < 0.05$ was used to determine significant differences between mean values.

Results

Proximate composition

Snakehead and tilapia were leanfish having low fat but high protein content while wild mullee and river shad contained 4.20 and 15.49 % lipid in unwashed minces (Table 2). Washing of the mince markedly reduced lipid content in all fishes (56-72%). However, 4.25 % lipid was still retained in washed river shad mince. All unwashed and washed minces had pH above 6.8 except the river shad. After two washings pH of river shad mince was elevated to 6.4. Average pH were 6.8±0.10, 6.6±0.05, 6.7±0.04, 6.6±0.10 and 6.3±0.14 respectively for snakehead, mullee, tilapia wild, tilapia GIFT and river shad gels.

Effect of heating

BREAKING STRENGTH (BS)

The BS of the gels prepared from the unwashed minces is presented in Fig. 1. When incubation temperature and time were raised, BS increased in all fishes except in the river shad until a peak elasticity was achieved at around 40-50°C and then decreased suddenly at 60-70°C, followed by a gradual increase again. At 40°C highest BS of the gels from the minces of snakehead and tilapia was observed. Wild mullee showed the highest BS at 50°C. River shad mince did not produce set gel, although a maximum BS was achieved at 50°C. The temperature when BS was the highest for a particular gel may be denominated as peak setting temperature (PST). Higher BS among the species was observed in the order of wild mullee > tilapia GIFT > snakehead > tilapia Wild > river shad. Gel disintegration occurred at 70°C in snakehead and wild mullee and at 60°C in both strains of tilapia.

Table 2. Proximate composition (% wet wt.) and pH of fish mince.

Fish	Unwashed				Two-washings			
	Moisture	Protein	Lipid	pH	Moisture	Protein	Lipid	pH
S-head	78.5±0.7^a	20.0±0.9^a	0.9±0.2^d	6.9^a	82.1±2.0^a	17.3±0.7^a	0.4±0.01^c	6.9^a
W.mullee	77.3±1.8^a	18.0±0.8^b	4.2±0.6^b	6.8^a	81.8±2.0^a	16.1±0.9^a	1.8±0.05^b	6.8^a
Tilapia W	78.4±0.8^a	19.8±0.5^a	1.6±0.2^c	6.8^a	82.3±0.9^a	16.9±0.3^a	0.6±0.00^c	6.8^a
Tilapia G	78.1±1.3^a	19.4±0.4^a	2.1±0.6^c	6.9^a	81.5±1.3^a	17.2±0.6^a	0.7±0.08^c	6.8^a
R. shad	64.7±2.3^b	17.1±0.2^b	15.5±1.8^a	5.9^b	79.7±1.0^b	13.9±0.7^b	4.3±0.72^a	6.4^a

Values are the means (±S.E. in parentheses) from three independent measurements. Within a column means with different superscripts are significantly different ($p<0.05$).

Gel strength was greatly improved in the gels heated for two-step heating. Greater increment was observed in the order of snakehead > wild mullee > tilapia GIFT > tilapia Wild. Two-step heating did not influence the gel strength of river shad. Both PST and disintegration temperature in the two-step heated gels were almost similar to those of one-step heated gels.

FOLDING TEST (FT)

Folding test was done on the gels obtained after 120 min of incubation and shown as alphabatic grade along Fig. 1. At 25°C most of the pastes did not transform into gel. Firm gels were observed during incubation at 35-50°C in snakehead, wild mullee and tilapia GIFT and at 40-50°C in tilapia Wild. At 60-70°C, a crack upon folding the gel into quarters due to modori was found in both one-step and two-step heating. Firmness was recovered again at 80°C. River shad produced very fragile gel in one-step heating and the gel strength was further reduced after two-step heating.

EXPRESSIBLE MOISTURE (EM)

EM could not be measured on some gels as shown in Table 3 due to their strong adherence to the filter paper. EM gradually decreased with the raise in temperature and time. However, at 40-50°C when BS was the highest, EM showed its lowest value ($P<0.05$) and then increased further till 80°C. The variation within the incubation temperatures and times were significant ($p<0.05$) in most of the fishes. At the temperatures of higher BS (30-50°C), EM increased significantly in two-step heated gels compared to one-step heated gels ($p<0.05$). The increment was higher in snakehead and tilapia Wild compared to wild

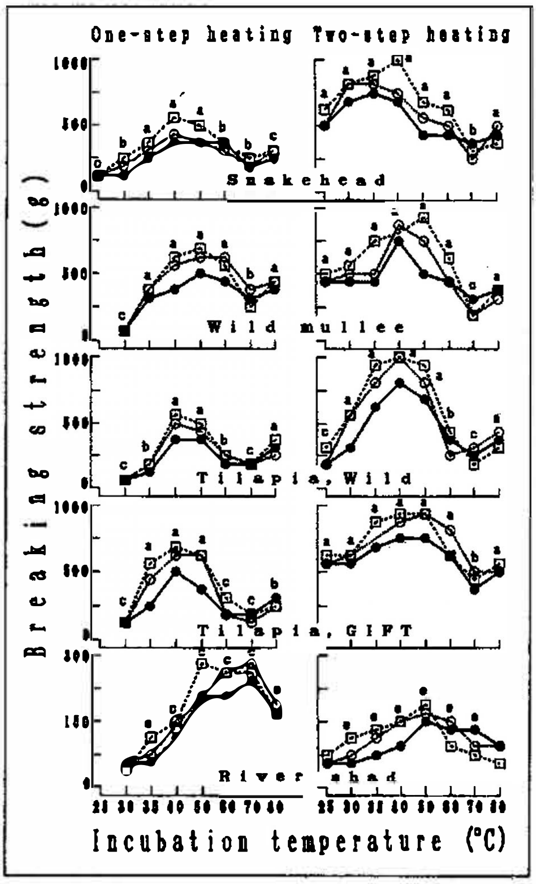

Figure 1. Breaking strength and folding test score of the gels of unwashed minces in one-step and two-step heating.
Incubation time: - • -, 60 min.; - o - , 120 min.; - □ - , 180 min.
Folding test was done on the gels obtained after 120 min. of incubation.

Table 3. Mean scores for the expressible moisture (%) of the gels obtained by one-step and two-step heating.

Species	Duration	Incubation Temperature (°C)							
	(min.)	25	30	35	40	50	60	70	80
One-step Heating									
Snakehead	60	58.21^{c}	59.24^{c}	52.21^{b}	40.27^{a}	40.70^{a}	54.18^{c}	55.55^{bc}	53.99^{b}
	120	54.78 ^{c}	56.2^{cd}	51.59^{b}	39.39^{a}	40.17^{a}	61.06^{de}	62.30^{de}	54.74^{c}
	180	53.53^{b}	52.11^{b}	52.52^{b}	39.48^{a}	41.41^{a}	61.15^{c}	60.56^{c}	55.76^{bc}
W. Mullee	60	*	59.78^{b}	57.24^{ab}	54.08^{a}	54.99^{a}	56.65^{ab}	57.55^{ab}	59.26^{b}
	120	*	57.88^{bc}	54.22^{ab}	52.59^{a}	53.08^{a}	54.96^{ab}	56.56^{b}	59.52^{c}
	180	*	52.72^{b}	46.43^{a}	45.23^{a}	50.49^{ab}	58.78^{c}	58.75^{c}	56.17^{bc}
Tilapia Wild	60	*	52.08^{bc}	49.18^{b}	42.08^{a}	40.12^{a}	57.50^{c}	60.19^{cd}	57.25^{c}
	120	*	53.50^{bc}	50.15^{b}	41.18^{a}	39.37^{a}	56.90^{c}	59.18^{cd}	57.39^{c}
	180	*	51.10^{b}	51.00^{b}	39.50^{a}	39.12^{a}	60.10^{d}	55.25^{c}	60.28^{d}
Tilapia GIFT	60	54.03^{bc}	54.28^{bc}	50.18^{b}	42.59^{a}	43.12^{a}	60.50^{c}	59.10^{c}	59.25^{c}
	120	53.59^{bc}	53.80^{bc}	51.21^{b}	52.18^{b}	38.47^{a}	53.90^{bc}	56.18^{c}	57.39^{c}
	180	57.34^{cd}	54.30^{c}	50.50^{b}	43.50^{a}	43.12^{a}	60.10^{d}	57.25^{cd}	60.39^{d}
River shad	60	*	*	*	60.19^{b}	57.50^{a}	56.51^{a}	61.71^{b}	*
	120	*	*	*	60.59^{a}	60.47^{a}	60.81^{a}	59.25^{a}	*
	180	*	*	*	58.81^{b}	55.38^{a}	57.90^{ab}	58.27^{b}	*
Two-step Heating									
Snakehead	60	45.24^{a}	47.45^{ab}	52.63^{a}	52.75^{b}	60.88^{c}	62.52^{c}	60.78^{c}	51.98^{b}
	120	48.33^{a}	51.14^{ab}	51.43^{ab}	54.64^{b}	55.49^{b}	59.49^{c}	63.24^{d}	55.79^{b}
	180	44.54^{a}	44.42^{a}	43.59^{a}	54.87^{b}	55.93^{b}	59.15^{c}	56.21^{c}	53.93^{b}
W. Mullee	60	57.60^{b}	56.97^{b}	58.65^{bc}	55.00^{ab}	52.48^{a}	55.57^{ab}	59.26^{c}	60.76^{c}
	120	59.84^{c}	59.87^{c}	53.02^{b}	53.06^{b}	47.76^{a}	59.13^{c}	60.05^{c}	58.88^{c}
	180	50.71^{b}	52.18^{bc}	52.28^{bc}	54.40^{c}	45.73^{a}	58.56^{d}	58.03^{d}	57.24^{d}
Tilapia Wild	60	58.50^{d}	55.70^{c}	54.82^{c}	50.09^{b}	46.37^{a}	55.75^{c}	58.90^{d}	57.87^{cd}
	120	55.08^{c}	52.18^{bc}	53.54^{c}	49.17^{b}	43.39^{a}	55.52^{c}	59.25^{d}	59.76^{c}
	180	54.12^{b}	53.35^{b}	52.18^{ab}	46.21^{a}	46.62^{a}	55.78^{bc}	57.30^{bc}	58.18^{d}
Tilapia GIFT	60	56.03^{bc}	55.98^{bc}	52.18^{b}	44.59^{a}	44.98^{a}	62.50^{c}	61.20^{c}	61.45^{c}
	120	55.50^{bc}	55.70^{bc}	53.23^{b}	54.18^{b}	40.77^{a}	55.96^{bc}	58.78^{c}	60.39^{c}
	180	59.84^{cd}	56.30^{c}	52.59^{b}	45.60^{a}	45.92^{a}	61.90^{d}	58.95^{cd}	62.51^{d}
River shad	60	*	*	*	*	*	*	*	*
	120	*	*	*	*	*	*	*	*
	180	*	*	*	*	*	*	*	*

*Gel too soft to measure.
Values (means of 4 measurements) bearing the same superscripts in the same row do not differ significantly ($p<0.05$). In two-step heating, after preheating at the said incubation temperatures the gels were further cooked at 85°C for 30 min.

mullee and tilapia GIFT. Overall, snakehead and two strains of tilapia showed lower EM values than wild mullee. River shad showed the highest EM values in one-step heating but the value could not be calculated in two-step heating.

Effect of washing

BS AND FT

Washing of mince distinctly improved the BS of the gel of all fishes except river shad (Fig. 2) compared to unwashed minces. Marked improvement was observed in the order of wild mullee > snakehead > tilapia GIFT > tilapia

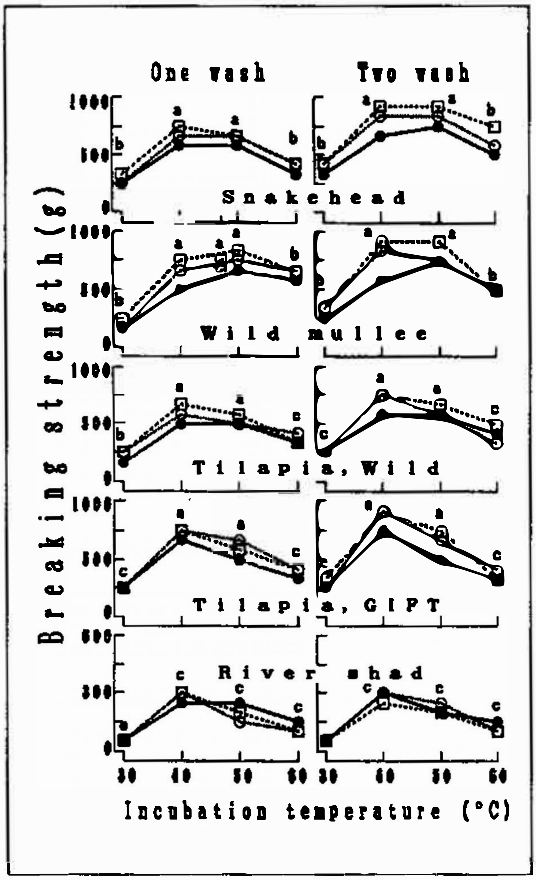

Figure 2. Effect of washing of minces on the breaking strength of the resulting gels. Symbols are the same as in Fig. 1.

Wild. Washing two times did not improve the gel quality of river shad mince. The BS of the gels made from minces washed two times were slightly greater than those from corresponding one time washed minces, mostly at 40-50°C. However, this variation among one time washed and two times washed lots were more in snakehead and wild mullee than Nile tilapia. Washing reduced the intensity of gel disintegration in snakehead and wild mullee but not in tilapia as observed from both BS and FT results.

SENSORY CHARACTERISTICS

TCT was done on the gels obtained at PST (Table 4). A very frail gel was obtained from river shad mince and the quality of the gel was not improved after the second washing ($p<0.05$). At PST, snakehead, wild mullee and tilapia minces produced "medium" grade gels. Mince washed once or twice showed strong gel hardness and the variation of TCT scores was significant ($p<0.05$) in snakehead and two strains of tilapia. Unwashed mince of river shad was dark in colour while that of snakehead was near to white. Washing significantly ($p<0.05$) improved the colour of the minces to "white". A significant variation ($p<0.05$) in colour was observed in all washing steps in the case of wild mullee and tilapia Wild while it was not significant in snakehead and tilapia GIFT, although the latter produced the brightest product after one washing.

Table 4. Sensory scores[1] of the products.

Species (Peak setting temperature)	TCT			Color		
	W_u	W_1	W_2	W_u	W_1	W_2
Snakehead (40°C)	5.9^a	6.8^b	8.3^c	7.3^a	8.2^b	8.4^b
Wild mullee (50°C)	5.8^a	7.2^b	7.5^b	5.5^a	7.0^b	8.1^c
Tilapia Wild (40°C)	5.5^a	6.6^b	7.9^c	6.3^a	7.4^b	8.3^c
Tilapia GIFT (40°C)	5.7^a	7.1^b	8.2^c	5.2^a	8.4^b	8.7^b
River shad (50°C)*	3.3^b	3.5^b	2.0^a	3.5^a	6.8^b	7.8^b

W_u: unwashed; W_1: one washing; W_2: two washings. TCT score: 0-1: mud-like; 2-3: very frail; 4-5: frail; 6: medium; 7-8: strong; 9-10: very strong. Color score: 1-2: dark gray; 3-4: gray; 5: gray-yellowish, pinkish; 6: grayish white; 7-8: white; 9-10: bright white. Different superscripts in the same row for the mean values of a single parameter are significantly different ($p<0.05$).
*Did not form set-gel, data shown for the temperature of highest breaking strength.
1 n=27

Discussion

The fishes were obtained from September to December, during peak feeding season. Therefore, the lipid content found might be at its highest level for any species. Bandarra et al. (1997) found the highest 18.4 % lipid in sardine in September - October after a heavy feeding period. The proximate composition could not represent the composition of whole fish or whole muscle in the present study because before mincing red muscles, belly flaps and kidney tissues were removed from the fillet. Kelleher et al. (1994) found increased moisture (6.6 %) and decreased lipid (24 %) in light muscle of Atlantic mackerel than whole muscle. Washing significantly reduced lipid levels depending on the quality of the minces: the extent of reduction was characteristically less in fatty species as in river shad (retained lipid 4.25 %). Considering washed mince as a convenient model for the surimi system in the laboratory and unwashed mince as control (Noguchi 1982) we compared the setting ability of washed and unwashed minces of five freshwater species. Of the species, river shad produced very low quality gel. Upon washing twice, the amount of protein in river shad mince was reduced to 13.87 % while moisture content increased. The retained protein in washed muscle is, however, sufficient to produce an elastic gel in surimi system (Nowsad 1995). However, we found a rare occasion when the salt-ground paste transformed into gel. High lipid content with associated low water holding ability of protein in the muscle might be responsible for its low setting ability. The setting ability of fish muscles has been extensively examined (Lee 1984; Lanier 1988; Shimizu et al. 1992). Studies revealed high improvement in visco-elastic properties when the salt-ground paste is cooked after preheating than setting or cooking alone (Okada 1959). In the present study, two-step heating greatly improved the gel quality of freshwater fish minces. The gel strength increased more in low preheating temperatures (25-30°C) which was about 4-fold corresponding to about 2-fold at around PST

(40-50°C) in snakehead, wild mullee and tilapia GIFT. Reppond et al. (1995) noticed a 3-fold increment of gel strength in set and cooked products due to two-stage heating treatment of Pacific herring surimi. The PST and gel disintegration temperature were found to vary with the species. The results are in accordance with that of Shimizu et al. (1981) and Kinoshita et al. (1990). Tilapia GIFT was found superior to its wild strain in respect to setting. In the natural habitat of Bangladesh *O. niloticus* was supposed to be crossbred with another strain *O. mossambicus* introduced almost at the same time into the country, resulting in a dramatic reduction in average size as well as production. Variations in biological characteristics between true and naturally crossbred strains have been noticed (Aminul Islam, Pers. Comm.).

Gel disintegration slowly occurred at 60-70°C in snakehead and wild mullee and the disintegration intensity was not as strong as in tilapia. The results support the view that most freshwater species are slow setting and modori-stable (Shimizu et al. 1981).

The water retention ability of the gel has a positive correlation with the gel strength: the firmer the gel, the lower the expressible moisture (Kim et al. 1987). Water retention ability of tilapia and snakehead gels were found higher compared to river shad and mullee which also corresponded with the results of the BS and FT of the gels. However, the water retention ability of these freshwater species was much lower compared to that of commercial 'SA grade' Alaska pollack surimi measured by the same procedure (Niwa et al. 1991). On the other hand, Kim et al. (1996) found commercially acceptable the water holding ability of the gels prepared from unwashed fresh channel catfish mince. EM increased significantly in the gels obtained by two-step heating at PST. This was because cooking after preheating although it strengthened the protein network structure by the formation of new bonds, the homogeneity of dispersion of the network was lost slightly with some of the water liberated from the gel (Niwa 1992).

Washing fish mince with water to remove blood, fat, soluble proteins and other nitrogenous compound for improved texture, color and odor of the final product is a very critical step in the surimi making process (Lee 1984). Washing methodology has been extensively examined and standardized depending on the quality of minces (Suzuki 1981; Lee 1985; Pacheco-Aguilar et al. 1989; Nomura et al. 1993; Chen et al. 1997). In the present study, the fish minces were washed two times with 0.1 % NaCl with a meat-water ratio of 1:4. We kept the time of contact between mince and water for 7 min (2 min agitation; 5 min settling). For agitation we mixed the mince and water in plastic container manually and very gently. This process substantially improved the texture and colour of the minces except the river shad. Due to retention of pigments of dark muscle the unwashed minces of river shad was darker, but the colour was improved to moderately white after two washings. However, the gel quality of this mince was not improved after such washing. Because of high lipid, water soluble protein, pigments and trimethylamine oxide in dark fleshed fish mince (Shimizu et al. 1992) adequate washing with improved methodology may be required to get high textured light coloured product (Wang et al. 1980; Chen et al. 1997).

Conclusion

Freshwater fishes like wild mullee, snakehead and tilapia have good setting ability. GIFT tilapia produced better quality gel compared to wild tilapia. Optimum gel strength was observed in between 40-50°C and gel disintegration occurred at 60 - 70°C. Gels prepared by two-step heating had higher gel strength except the river shad. A single wash of the mince substantially improved the texture and colour qualities of the gels. River shad mince produced very poor quality gel even after two washings. A comprehensive investigation on the species with improved washing technique is required.

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