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Effect of Ice Storage on the Characteristics of Common Carp Surimi

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Abstract

The characteristics of surimi prepared from common carp (*Cyprinus carpio*) after storing the fish in ice for different periods were compared. Surimi was prepared by washing the mince once with a mince to water ratio of 1:4 for 10 min at 3 - 5°C and the yield was 80%. The washing of mince resulted in significant removal of the characteristic muddy odour and improved the colour and appearance. Total soluble protein decreased by 26% as a result of washing. Gel strength measurement showed that washing improved the functionality of protein significantly. However, gelling and elasticity of surimi prepared from ice stored fish showed a decreasing trend in relation to the length of storage. The results of the study indicate that common carp is a good resource for the preparation of good quality surimi.

Key words: Myofibrillar protein concentrate, surimi, washing, texture, common carp

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Introduction

The shift in consumer preference to convenient foods contributed to increased demand for value added products from fish. Problems encountered in the effective utilization and commercialization of freshwater fish include their soft texture, pin bones and peculiar muddy flavour. This calls for appropriate measures for their effective utilization through diversified processing techniques. Production of myofibrillar protein concentrate from Indian major carps has been studied by Sankar (2000). Effect of soy protein isolate on gel properties of Alaska Pollock and common carp surimi at different setting conditions was studied by Luo et al. (2004a). Characteristics of mince from pond breed silver carp and its uses in sausages were studied by Gleman & Benjamin (1989). Gel properties of surimi from silver carp (Luo et al., 2008) and big head carp (Luo et al., 2004b) were studied extensively. At present, a large quantity of common carp (*Cyprinus carpio*) is produced in India and is mainly consumed fresh. Preservation of this fish in various forms and development of value added products, particularly mince based products will help in better utilization of the species. Hence, the present work was undertaken with the objective of studying the yield, proximate composition and effect of chill storage on the protein constituents and on the characteristics of surimi from common carp.

Materials and Methods

Common carps *(Cyprinus carpio*) weighing 400 g each were collected from a fish farm in Cochin located about 15 km away from the laboratory. Fish collected in absolutely fresh condition were brought immediately to the laboratory in iced condition (1:1). After keeping overnight to resolve rigor, the post rigor fish (0 h) were manually filleted, de-skinned and minced in a mechanical mincer. Mince from the skin free fillets was prepared using a meat mincer (Hobart No.12 meat mincer, Hobart, UK). The temperature was maintained below 10°C throughout the process.

The single washing schedule reported for Indian major carps (Sankar, 2000) was followed using a mince to water ratio of 1:4. Chilled water (3 - 4°C) containing 0.2% (w/v) of NaCl was employed to facilitate the removal of excess water. De-watered mince was packed in polyethylene pouches and

frozen in air blast freezer at -40°C and stored in frozen store at -18°C for further analysis. Moisture, crude protein, crude fat and ash were determined by the method of AOAC (2000). The sarcoplasmic protein was extracted by homogenizing 3 g fish meat or washed fish meat in 0.02 M sodium bicarbonate (pH 7 to 7.5) (instead of plain water). The homogenate was centrifuged at 6900 g for 20 min in a refrigerated centrifuge at 4°C to collect the water soluble sarcoplasmic protein. The total salt extractable proteins were extracted according to King & Poulter (1985). The total salt soluble and water-soluble proteins were estimated by biuret method (Gornall et al., 1949).

To understand the changes in the different protein fractions during different ice stored conditions, SDS-PAGE was performed (Laemmli, 1970) using a 10% separating gel and 4% stacking gel. The mobility of protein bands was calibrated with broad range molecular weight markers (Sigma Chemicals, USA). After the electrophoretic run (200V) in 0.375 M tris glycine – SDS buffer, the gels were stained with 0.12% coomassie blue in methanol for 30 min. The gel was de-stained in 7% acetic acid and was photographed and scanned. Heat-induced gels were prepared from myofibrillar protein concentrate by grinding with 3% (w/w) sodium chloride for 2 min using a kitchen mixer. To preserve the functionality of the actomyosin, the temperature of the surimi gel was kept below 10°C by pre-cooling the mixer bowl in a freezer and also by keeping the same in a freezer for 30 sec after every one min of grinding. The paste so obtained was stuffed into polypropylene tubing of 5.0 cm diameter using a laboratory model hand stuffer, taking care to eliminate the trapped air as much as possible. The ends of the tubes were tied and cooked by immersing in a water bath maintained at 90°C for 30 min. The gels were immediately cooled in ice and kept over night at 5°C.

Texture of the heat-induced gel was analysed with the help of food texture analyzer (Model LRX plus, Lloyd instruments limited, UK) using a 50 mm cylindrical probe with 500 N load cell. The texture parameters measured include hardness, springiness, chewiness and cohesiveness. Gel strength of the heat-induced gel was evaluated with the help of Food texture analyzer using a 10 mm spherical probe using 500 N load cell. Specimens of 2.5 cm length and 3 cm diameter were used for measurement. The gel strength (g.cm) is the peak force at rupture (g), multiplied by deformation, *viz*., the distance travelled by the probe (cm). The grade of the myofibrillar protein concentrate was determined according to the extent of folding or crack formed when a gel of 3 cm diameter x 3 mm thickness was folded between thumb and index finger (Lee, 1984).

Results were expressed as mean ± SD. One way analysis of variance (ANOVA) test was performed to find out significant difference in the mean values at 95% confidence level ($P<0.05$) and post-hoc analysis was done using Duncan multiple comparison test. All statistical analyses were carried out using SPSS version 10 (SPSS Inc., Chicago, IL).

Results and Discussion

The filleting yield of the initial samples was around 25%. Upon icing the fish, the yield showed an increase of about 6% in 24 h, which more or less remained constant in fish iced upto 48 h (Table 1). However the filleting yield for common carp was lower than the other fishes, which could be due to pin bones in the dorsal side and also due to nature of arrangement of meat in the fish.

Table 1. Yield (%) of fillets, mince and surimi prepared from ice stored common carp

Product	Yield (%)		
	Duration of ice storage (h)		
	0	24	48
Fillet	24.4±1.75 [a]	25.9±1.86 [a]	25.7±1.85[a]
Mince	22.8 ±1.64[a]	23.1±2 [a]	23.2 ±1.67[a]
Surimi	18.3 ±1.31[a]	16.2 ±1.16[a,b]	15.8±1.13 [b]

Values that have a different superscript letter within the column differ significantly ($p<0.05$) from each other.

Yield of mince was 22.8% which increased slightly with ice storage upto 48 h. The yield obtained in the present study was comparable with marine species like *Tachysurus* spp., *Megalaspis cordyla* and *Johnius* spp. while it was lower than *Saurida tumbil, Upeneus vittatus* and *Trichiurus savala* (Muraleedharan et al., 1996a) and Indian major carps (Sankar, 2000). About 41 to 45% yield of deboned meat from silver carp (Gleman & Benjamin, 1989), 40% from Pacific hake, 45% from cod (Crawford et al., 1972) and 44 to 46% from thread fin bream (Joseph et al., 1980) have been reported. The yield of mince depends on the

processing and the machine used for picking meat (Crawford et al., 1972; Venugopal & Shahidi, 1995). Yield of surimi from mince was 80%, which decreased with the duration of icing. The yield for common carp compares slightly lower than that reported for major carp (Sankar, 2000), Pacific whiting (Lee et al., 1990) and other marine fish (Muraleedharan et al., 1996b; Muraleedharan et al., 1997). Yean (1993) reported decrease in yield of surimi prepared from thread fin bream stored in ice.

Freshly harvested common carp (*Cyprinus carpio*) had a moisture content of 80.4% (Table 2) and a protein content of 17.2%. The fish belonged to medium fat category (1.4 %) and ash content (1.2%) was comparable to other fishes. Moisture content of 74.8 to 79.75% has been reported for common carp (Nair & Suseela, 2000; Neelima, 2002). The fat content particularly depends upon the season of the year, type of feed and age besides other unidentified variables and there is an inverse relation between the water and fat content (Nair, 2002). Washing the mince helps to remove materials which interfere with the functional properties of the meat and to improve the mince quality (Regenstein, 1986). In the present study, water washing of post rigor meat resulted in the removal of about 42% (Table 2) of interfering substances. Ice storage for 24 and 48 h had no effect on the removal of fat content in the common carp and comparable fat loss of 38 to 48% was reported for Indian major carps (Sankar, 2000). The higher moisture noticed in surimi than in mince could be due to hydration of protein during the washing process. Besides, washing helped in the removal of pigments, blood and enzymes. The variation in ash content between surimi and mince was due to presence of salt (0.25%) in wash water. Similar increase in ash (mineral) in washed meat has been reported by Sankar (2000).

Initial total soluble protein content in common carp was 80.51% (Table 3) of which, myofibrillar and sarcoplasmic proteins constituted 61 and 39% respectively. Upon washing, the total soluble protein content decreased by 26%. The decrease was mainly observed for water soluble sarcoplasmic protein (48%) followed by loss in myofibrilar protein (11%). Loss of water-soluble protein to the tune of 50–60% has been reported in croakers and Walleye pollock (Saiki & Hirata, 1994; Lin & Morrissery, 1995) which is comparable with the observations of the present study. Loss of myofibrillar protein during the washing process has also been reported in Pacific whiting (Lee, 1992) and in Catla (Sankar & Ramachandran, 1998). A decrease in salt soluble protein on washing of mince due to aggregation was noticed by Sarma et al. (1999). The chill stored and washed mince also did not show any significant difference in sarcoplasmic and myofibrillar protein. Tokiwa & Matsumiya (1969) reported degradation of myofibril at 0°C by cathepsins and serine proteinase enzymes. Myosin degradation leading to 45% decrease in myosin heavy chain was noticed within eight days of ice storage in Pacific whiting and was attributed to the proteolytic degradation (Benjakul et al., 1997). Changes in the solubility of protein fractions during ice storage have been attributed to the loss of water-soluble proteins in the melted ice and to the denaturation of myofibrillar proteins (Bramste, 1961; Chen et al., 1997; Reddy & Srikar, 1993).

Table 2. Proximate composition of mince and surimi stored in ice for different periods

Product Type	Proximate Composition (%) (Mean ± SD)											
	Moisture			Protein			Fat			Ash		
	Duration of ice storage (h)											
	0	24	48	0	24	48	0	24	48	0	24	48
Mince	80.4 ±5.79	81.2 ±5.84	81.8 ±5.89	17.2 ±1.23 (87.75)	16.9 ±1.21 (89.89)	16.1 ±1.16 (88.46)	1.4 ±0.10 (7.14)	1.38 ±0.09 (7.34)	1.41 ±0.09 (7.74)	1.2 ±0.09 (6.12)	1.2 ±0.09 (6.38)	1.1 ±0.07 (6.04)
Surimi	81.8 ±5.88	81.2 ±5.85	82.7 ±5.95	16.5 ±1.18 (90.65)	16.1 ±1.15 (85.64)	16.01 ±1.15 (92.54)	0.8 ±0.06 (4.39)	0.79 ±0.05 (4.20)	0.81 ±0.06 (4.68)	0.9 ±0.06 (4.94)	1.12 ±0.08 (5.95)	1.41 ±0.10 (8.15)

n = 4, Values in parenthesis indicate values in dry weight basis

Table 3. Changes in soluble protein of common carp mince and surimi stored in ice for different periods

Duration of ice storage (h)	Product type	Soluble protein		
		Total soluble protein (g 100 g^{-1})	Myofibrillar protein (g 100 g^{-1})	Sarcoplasmic protein (g 100 g^{-1})
0	Mince	80.51±5.79 [a]	49.05±3.53 [a]	31.46±2.26 [a]
	Surimi	59.3±4.26 [a]	43.47±3.12 [a]	15.86±1.14 [a]
24	Mince	79.11±5.69 [a]	48.19±3.46 [a]	30.92±2.22 [a]
	Surimi	57.89±4.16 [a]	42.41±3.05 [a]	15.48±1.11 [a]
48	Mince	75.36±5.42 [a]	45.91±3.30 [a]	29.45±2.12 [a]
	Surimi	57.61±4.14 [a]	42.20±3.03 [a]	15.41±1.10 [a]

Values are mean ± SD
Values that have different superscript letter within the column differ significantly (p<0.05) from each other

The total soluble protein from the fresh meat showed about 17 bands (Fig. 1). Among these bands, two bands with molecular weight of 205KD and 45KD Dalton were prominent. One band at 35KD, three bands between 29KD and 35KD, two bands below 6.5KD were the prominent low molecular weight bands. In this case, the electropherogram showed changes in high molecular weight proteins. Electrophoresis of surimi of major carps showed decrease in the high molecular weight band with the number of washing cycles (Sankar, 2000). The loss of myofibrillar protein increased with increase in meat to water ratio (Lin & Park, 1996).

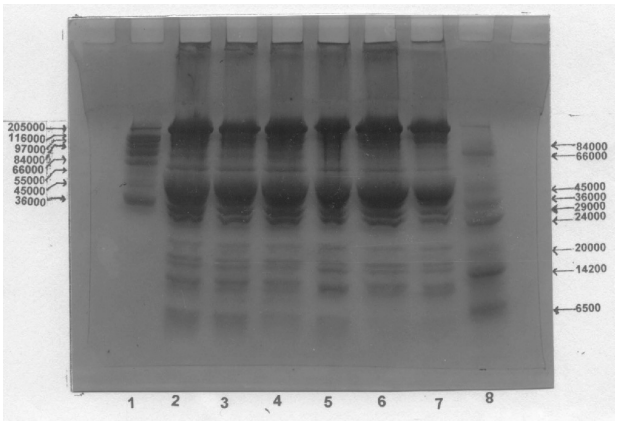

Fig. 1. SDS-PAGE profile of soluble proteins

Lane 1 - High molecular weight marker; lane 2-4 - Total soluble protein from mince (control, 24h, 48h iced samples respectively); lane 5-7 - Total soluble protein from surimi (control, 24h, 48h iced samples respectively); lane 8 - Low molecular weight marker

Initial mince showed gel strength of 650 g.cm (Table 4). A single washing improved the gel strength to 980 g.cm showing an increase of 51%. Gels are formed when partially unfolded proteins develop uncoiled polypeptide segments that interact at specific points forming a three dimensional cross linked network (Zayas, 1997). Gel strength of mince was lower than that of surimi because the sarcoplasmic protein in mince coagulates during the heat setting of salt added sol and does not participate in the formation of gel network. In the case of surimi, the salt solubilisation of myofibrillar protein concentrate with adequate amount of water results in the formation of sol, which subsequently turns into an elastic gel upon heating (Lee, 1992). Ice storage affected the gel strength of common carp surimi. A reduction in gel strength of 18.47 and 34.61% for unwashed and 2.04 and 13.26% for washed common carp surimi stored in ice for 24 and 48 h respectively was observed. The initial gel strength decreased from 650 g cm to 425 g cm for mince whereas for surimi it decreased from 980 to 850 g cm within 48 h. This could be due to the alterations in the physicochemical properties of protein during iced

Table 4. Gel strength (g cm) of heat induced gel of common carp mince and surimi

Product	Duration of ice storage (h)		
	0	24	48
Mince	650 ± 11.1 [a]	530 ± 12.8 [b]	425 ± 11.9 [c]
Surimi	980 ± 15.5 [a]	960 ± 14.7 [a]	850 ± 16.1 [b]

Values that have a different superscript letter within the column differ significantly (p<0.05) from each other

storage which subsequently affected the functional properties of proteins. Similar findings were reported for Northern squawfish (*Ptychocheilus oregonensis)* (Lin & Morrissery 1995) and Rohu (Mohan et al., 2006). As protein gel consists of protein matrix and water, water will be immobilized within a three dimensional protein matrix. In the case of ice stored fish, the alteration in physico chemical properties affects the three dimensional structure of protein, affecting the water holding capacity of proteins. Lee (1992) also reported that the gel strength of comminuted fish mince decreased linearly with increase in the amount of added water. The gel-forming ability of silver carp surimi has been reported by Luo et al. (2008). The influence of the soy proteins on the gelling properties of silver carp and bighead carp have been reported by Luo et al. (2004a, b; 2008).

Folding test analyzes the elasticity of the prepared gels. Mince had very good elasticity (grade AA) initially which decreased with the storage in iced conditions, reaching a final grade of A. However, the surimi had grade AA (Table 5) initially and after 48 hours of ice storage. This indicates that the iced storage did not affect the elasticity characteristics of surimi.

Table 5. Folding test grade of common carp gel

Product	Duration of ice storage (h)		
	0	24	48
Mince	AA	A	A
Surimi	AA	AA	AA

n = 10

AA - No crack occurs after folding twice
A - Crack occurs after folding twice, but no crack occurs after folding once
B - Crack occurs gradually after folding once
C - Crack occurs immediately after folding once
D - Breakable by finger press without folding

(Alvarez & Tejada,1997) while the springiness of the gel was almost comparable with that of sardine. The textural characteristics reported are mainly related to the quality of myosin in the myofibrillar protein. Myosin is the essential component contributing to the elasticity of the fish gel and the conformational state of myosin molecule is the most important factor in the development of kamaboko gel network (Chan et al., 1995). There is no general agreement about the exact mechanisms involved in the texture changes observed during ice storage of fish. During storage in ice, some myofibrillar protein degrades and fish muscle generally becomes softer (Verrez-Bagnis, 1997).

Table 6. Texture profile of heat induced gel of common carp surimi

Duration of ice storage (h)	Hardness kgf	Springiness mm	Chewiness kgf	Cohesiveness
0	5.089 ± 0.52^{a}	6.622 ± 0.64^{a}	13.976 ± 0.79^{a}	0.415 ± 0.07^{a}
24	4.595 ± 0.54^{a}	6.058 ± 0.58^{a}	11.524 ± 0.92^{b}	0.414 ± 0.09^{a}
48	4.324 ± 0.41^{a}	6.043 ± 0.45^{a}	10.770 ± 0.64^{b}	0.412 ± 0.08^{a}

Values that have a different superscript letter within the column differ significantly from each other (p<0.05)

Results of texture profile analysis of gels from common carp surimi are presented in Table 6. Hardness of the heat - induced gel material was above 5 kgf initially which decreased on storage of fish in ice reaching a value of 4.324 kgf at the end of 48 h. Chewiness also changed in response to storage condition. Cohesiveness gives an indication of how well the samples withstand the deformation and it was around 0.41 for all the samples irrespective of storage. Springiness of the sample was 6.6 mm initially which changed to 6.0 mm after 48 h of iced storage. Hardness and cohesiveness of gels from common carp surimi showed a lower value compared to that of surimi gels from sardines

In conclusion, the yield and quality of surimi prepared from common carp was found to be comparable with surimi produced from other conventional fish species. Storage of carp in ice for 24 h did not change the gel strength and folding score of surimi significantly. The gel forming ability of surimi from common carp exhibited good gelling properties and can be used for the preparation of value added convenience products.

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