Effect of Water Washing on the Functional Properties of Fish Meat

Nityananda Das[1], B.K. Khuntia[2], U. Raychaudhuri[3], K.C. Dora[4,*], S. Ganguly[5]

[1,2]Orissa University of Agriculture & Technology, BBSR-3, [3]Department of Food Technology & Biochemical Engineering, Jadavpur University, Kolkata, [4,5]Department of Fish Processing Technology, Faculty of Fishery Sciences, West Bengal University of Animal & Fishery Sciences, Kolkata

***Corresponding Author:**
Email: kc_dora@yahoo.co.in

ABSTRACT
To know the effect of water washing on functional properties of meat four different species like sardine, mackerel, pink perch and croaker were used. Meat to water ratio used for washing was 1:3 oil sardine and mackerel; but for pink perch and croaker, meat to water ratio was 1:2. Again the washing process was repeated three times for oil sardine and mackerel; but two times for pink perch and croaker. The studied functional properties were solubility, gel strength, expressible water, emulsion capacity, reduced viscosity, water and fat absorption capacity. The gel strength of fresh meat of sardine, mackerel, pink perch and croaker were 259.67, 280.61, 401.72 and 410.45 g-cm respectively. But, after washing the value of gel strength increased 17% on an average. The value of emulsion capacity and reduced viscosity were increased also. But other properties were decreased after washing.

Key Words: *Washing, Fish meat, Functional property*

INTRODUCTION

Washing not only removes undesirable matters, but mostly it increases the concentration of functional protein (actomyosin). This gives washed meat the elasticity essential to surimi based products. The process surimi production involves repeated washing the fish mince to remove sarcoplasmic proteins and to concentrate the myofibrillar proteins. It has been shown that the use of unwashed mince results in a poor gel strength (Iso et al., 1985). Hasting (1981) compared the properties of gel prepared from unwashed and washed cod mince and found that washed samples had more elasticity than unwashed samples. Adu et al. (1983) studied the effect of washing on the nutritional quality and characteristics of mince from rock fish flesh. Washing has significant effect in improving the colour, reducing many of oxidative changes and enhancing frozen shelf life of minced fish (Grantham, 1981; Rodger, 1980).

In the present study the effect of water washing on the functional properties of both fatty fishes like oil sardine and mackerel and lean fishes like pink perch and croaker were studied.

MATERIALS AND METHODS

Indian oil sardine (Sardinella longiceps), Indian Mackerel (Rastrelliger kanagurta), Pink perch (Nemipterus japonicus) and Croaker (Johinus dussumieri) were used in the present study. In laboratory the fishes were washed and dressed by removing scales, skin, viscera and head. After washing and dressing, the meat was picked by meat picking machine and the picked meat was minced by mincer. The proximate composition and functional properties of unwashed meat was measured. The minced meat of each species was then washed with chilled potable water. Meat to water ratio used for washing was 1:3 for fatty fish like oil sardine and mackerel; but for lean fish like pink perch and croaker, meat to water ratio was 1:2. Again the washing process was repeated three times for oil sardine and mackerel; but two times for pink perch and croaker. Each washing was done for 2 minutes only. The pH of used water for water washing was 7. After each wash the meat was gently squeezed in a cotton cloth to remove excess water. Unwashed meat served as control. The proximate composition and physico-chemical properties of fishes were measured at each wash. A functional property of meat was measured after last wash.

Moisture, crude protein, crude fat and ash content were estimated by standard method (AOAC, 1984). Non protein nitrogen content was estimated by the method of Velankar and Govindan (1958). Calcium ATPase activity was measured by using the method of Noguchi Matsumoto (1970). Extractability of protein, from meat was determined using EB by Kjeldahl method. The relative viscosity of total protein samples were measured, using Ostwald Viscometer. The relative viscosity and reduced viscosity of the samples were calculated by the formula given by Yang, 1961. Emulsion Capacity was determined according to the method of Swift et al. (1961). Gel strength was measured by using Rheotex (Sunshine) instrument by mixing the washed meat with 2.5% NaCl. A piece of about 25 mm thickness taken from gel was placed under the plunger of gellometer. The pressure on gel piece was applied by the plunger. Expressible water was determined by the method of Okada (1963). Water absorption capacity of freeze dried material was determined by the method of Sosulki (1962). The fat absorption capacity of freeze dried meat was estimated according to the method of Lin et al., (1974).

RESULTS AND DISCUSSION

The functional properties of fresh fish meat are presented in Table 1. Solubility varied from 76.75% to 83.93%. Gel strength varied from 259.67 to 410.45 g-cm and expressible water varied from 25.30% to 26.99%. As the gel strength increases the expressible water % decreases (Suzuki, 1981). The ability of meat to form a good gel, gives an indication about the quality of proteins present in the muscle. The gel strength of sardine meat as measured by Rheotex was 259.67 g-cm in the present study and this value is low in comparison to other marine species which is usually in the range of 300-500 g-cm (Cross-Victor, 1984; Shamasundar et al., 1988). This gives an indication that sardine meat has poor gelling ability and cannot be used as such is for kamaboko type of products. The reason for the poor gel strength of sardine is its high content of sarcoplasmic protein, which hinders the elastic gel formation. The type and quality of gel formed is direct result of specific responses of the proteins to applied forces encountered during preparation, processing and storage.

The EC values vary greatly on the choice of method of determination and the condition of meat itself. It varied from 0.42 to 0.81 ml of oil/ mg protein in the studied fishes The EC value for pink perch was 0.73 ml of oil/ mg protein (Rathnakumar, 1999).

Reduced viscosity varied from 0.20 to 0.28 dl/g. Measurement of viscosity of macromolecules can be related to their shape (Bradhury, 1970). The measurement of reduced viscosity will give an index of extent of aggregation/dissociation and is a useful index for protein denaturation, if it is monitored as a function of physical and chemical treatments. Similar result was reported Tiwari (1995), Mandal (1998) and Rathnakumar (1999).

Water absorption capacity was highest as 5.19 g of water/g of dried material in croaker and was lowest as 3.15 g of water/g of dried material in sardine meat. Commercially, higher WAC value is preferred as it increases the yield of fish products. Mandal, 1998 observed 5.22 and 3.71 g of water/g of dried material in croaker and mackerel respectively. Fat absorption capacity was 5.49 and 3.51 g of oil/g of dried material in croaker and sardine meat respectively. Similar result was obtained by Tiwari (1995); Mandal (1998); Rathnakumar (1999).

The changes in proximate composition, physico-chemical properties of meat during washing with water are presented in Tables 2 to 5 and Table 6 represents proximate composition and properties of washed meat. In the present study, results indicate that washing of meat resulted in reduction of fat, protein and ash content, while there was an increment in the moisture content of the meat. The percentage increase in moisture content was 12.15, 8.27, 6.35 and 6.81% in sardine, mackerel, pink perch and croaker respectively. This may be explained by the fact that during the process of washing some amount of water is held by the meat as reflected by the increase in moisture percent of washed meat compared to unwashed meat. The hydrophobic residues of myofibrillar proteins may be responsible for retention of water.

The protein reduction was observed as 24.96, 30.55, 30.17 and 31.40% in sardine, mackerel, pink perch and croaker respectively. Generally washing process removes sarcoplasmic protein. A reduction of 27.77% in total protein was observed after washing which is mainly contributed by water soluble protein (WSP) reported by Tiwari, 1995. Roussel and Cheftel (1990) have observed a protein loss 21.27% in European sardine, while Bligh et al (1973) and Grantham (1981) found the loss of protein to the extent of 25% due to washing.

Likewise, the fat content reduced 66.59, 71.87, 72.19 and 73.39 % in sardine, mackerel, pink perch and croaker respectively. A reduction in fat content was observed in oil sardine as 73.52% and the fat content was reduced to 65% in rock fish as observed by Adu et al. (1983). Joseph and Perigreen (1986) have reported a decrease of 27.7% in cat fish.

Ash content reduced to 76.75, 70.43, 70.37 and 70.19% in sardine, mackerel, pink perch and croaker respectively. This may be due to the fact that various soluble inorganic constituents might have washed out during washing process of meat.

Chilled water washing also resulted in the loss of non-protein nitrogen. The washed meat of sardine, mackerel, pink perch and croaker washed meat had 2.93, 2.95, 2.97 and 3.00 timeless NPN in comparison to their unwashed meat respectively. Considerable loss in NPN was observed by Joseph et al. (1989), who found that 65-70% TVBN was lost during washing of minced cat fish, threadfin bream and lizard fish. Joseph and Perigreen (1986) noticed a loss of 50% NPN during chilled water washing in cat fish mince. The present findings are in agreement with the observation made by the authors.

A gradual decrease in the calcium activated ATPase activity of fish meat was found with successive steps of washing. It was decreased to 63.44, 59.86, 57.05 and 56.71 % in sardine, mackerel, pink perch and croaker respectively. This loss of Ca++ ATPase activity can be attributed to the structural changes and loss of sarcoplasmic protein as indicated by the measurement of the intrinsic viscosity in the myofibrillar proteins during washing process.

The ability of meat to form gel was improved after washing. The marginal increase of 17% on an average in the gel strength of washed meat of fishes may be due to loss of sarcoplasmic proteins and modori inducing proteases (MIP) during washing, which are known to inhibit the gel formation (Kimura et al., 1991).

Emulsion capacity and reduced viscosity was increased after washing But after washing water and fat absorption capacity was decreased. The decrease in values of water absorption capacity of washed meat would be due to structural rearrangement of major protein components as affected by washing. Again decrease in values of fat absorption capacity of washed meat would be due to structural rearrangement of major protein components as affected by washing.

Table 1: Proximate composition and properties of fish meat

Characteristics	Values			
	Sardine	Mackerel	Pink perch	Croaker
Moisture (%)	72.26(±0.21)	77.97(±1.51)	80.96(±1.41)	81.05 (±1.24)
Protein (%)	15.34(±0.27)	15.81(±0.84)	16.21(±1.08)	16.75(±0.35)
Fat (%)	8.32(±0.28)	3.91(±0.15)	1.69(±0.50)	1.24(±0.27)
Ash (%)	1.20(±0.12)	0.81 (±0.02)	0.66 (± 0.01)	0.51 (±0.08)
NPN (mg/100 g of meat)	218.45(±10.24)	205.47(±0.17)	195.61(±0.19)	184.52(±0.19)
Ca++ATPase activity in µg Pi/mg of protein/minute	0.14 (±0.12)	0.15(±0.021)	0.16(±0.009)	0.16 (±0.015)
Solubility (% of total protein)	76.75(±0.07)	78.56(±0.05)	81.85(±0.06)	83.93(±0.04)
Gel Strength (g-cm)	259.67(±11.92)	280.61(±12.0)	401.72 (±4.0)	410.45(±2.12)
Expressible water (%)	26.99(±0.14)	26.52(±0.32)	25.39(±0.03)	25.30(±0.23)
Emulsion capacity (ml of oil /mg protein)	0.42(±0.001)	0.51 (±0.015)	0.73(±0.014)	0.81(±0.052)
Reduced viscosity at zero protein concentration (dl/g)	0.28	0.26	0.22	0.20
Water absorption capacity (g of water/g of dried material)	3.15(±0.38)	3.68(±0.25)	4.97(±0.15)	5.19(±0.19)
Fat absorption capacity (g of oil/g of dried material)	3.51(±0.14)	3.93(±0.29)	5.18(±0.11)	5.49(±0.15)

Values in parenthesis indicate standard deviation, n=3

Table 2: Effect of number of washing on composition and physico-chemical properties of sardine meat

No. of washes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Solubility (% of total protein)	Ca++ATPase activity(µPi/mg protein/min)
Unwashed	72.26(±0.21)	14.22(±0.25)	8.32(±0.28)	1.20(±0.32)	76.75(±0.34)	0.14 (±0.017)
1st Wash	76.21(±0.05)	12.17(±0.26)	5.12(±0.85)	0.62(±0.03)	74.17(±0.02)	0.09(±0.012)
2nd Wash	79.11(±0.03)	11.14(±0.42)	3.89(±0.72)	0.42(±0.01)	73.83(±0.06)	0.07(±0.011)
3rd Wash	81.04(±1.01)	10.67(±0.32)	2.78(±0.05)	0.28 (±0.01)	72.14(±0.02)	0.04(±0.003)

Values in parenthesis indicate standard deviation, n=3

Table 3: Effect of number of washing on composition and physico-chemical properties of mackerel meat

No. of washes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Solubility (% of total protein)	Ca++ATPase activity(µPi/mg protein/min)
Unwashed	77.97(±0.46)	15.81(±0.84)	3.91(±0.15)	0.81(±0.01)	78.56(±0.06)	0.15(±0.002)
1st Wash	80.58(±0.63)	12.64(±0.13)	1.57(±0.85)	0.41(±0.05)	76.48(±0.01)	0.09(±0.002)
2nd Wash	82.87(±0.15)	11.29 (±0.14)	1.39(±0.05)	0.32(±0.04)	74.89(±0.17)	0.07(±0.001)
3rd Wash	84.42(±0.11)	10.98(±0.23)	1.05(±0.04)	0.24(±0.02)	74.45(±0.04)	0.06(±0.004)

Values in parenthesis indicate standard deviation, n=3

Table 4: Effect of number of washing on composition and physico-chemical properties of pink perch meat

No. of washes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Solubility (% of total protein)	Ca++ ATPase activity(µPi/mg protein/min
Unwashed	80.96(±1.41)	16.21(±0.28)	1.69(±0.05)	0.661(± 0.01)	81.85(±0.46)	0.16(±0.009)
1st Wash	83.04(±0.013)	13.14(±0.113)	0.84(±0.06)	0.301(±0.02)	79.62(±0.11)	0.09(±0.011)
2nd Wash	86.10 (±1.05)	11.32(±0.13)	0.47(±0.02)	0.097(±0.01)	77.57(±0.02)	0.07(±0.002)

Values in parenthesis indicate standard deviation, n=3

Table 5: Effect of number of washing on composition and physico-chemical properties of croaker meat

No. of washes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Solubility (% of total protein)	Ca++ATPase activity µPi/mgprotein/min
Unwashed	81.05(±1.24)	16.75(±0.35)	1.24(±0.27)	0.515(± 0.08)	83.93(±0.53)	0.164(±0.015)
1st Wash	83.61(±0.016)	13.31(±0.126)	0.79(±0.056)	0.315(±0.03)	81.82(±0.42)	0.099(±0.012)
2nd Wash	86.57(±0.84)	11.49(±0.23)	0.33(±0.08)	0.101(±0.01)	78.87(±0.04)	0.071(±0.003)

Values in parenthesis indicate standard deviation, n=3

Table 6: Proximate composition and properties of washed fish meat

Characteristics	Values			
	Sardine	Mackerel	Pink perch	Croaker
Moisture (%)	81.04(±1.01)	84.42(±0.11)	86.10 (±1.05)	86.57(±0.84)
Protein (%)	10.67(±0.32)	10.98(±0.23)	11.32(±0.13)	11.49(±0.23)
Fat (%)	2.78(±0.05)	1.05(±0.04)	0.47(±0.02)	0.38(±0.08)
Ash (%)	0.28(±0.01)	0.24 (±0.02)	0. 09 (±0.01)	0.10 (±0.01)
NPN (mg/100 g of meat)	74.46(±0.04)	71.12(±0.049)	65.04(±0.17)	63.11(±0.14)
Ca ++ ATPase activity in µg Pi/mg of protein/minute	0.04(±0.003)	0.06(±0.004)	0.07(±0.002)	0.07(±0.003)
Solubility(% of total protein)	72.14(±0.02)	74.45(±0.04)	77.57(±0.02)	78.87(±0.04)
Gel Strength (g-cm)	304.47(±5.39)	332.25(±7.13)	468.38(±5.0)	481.42(±3.18)
Expressible water (%)	26.36(±0.18)	26.02(±0.18)	24.72(±0.13)	24.59(±0.23)
Emulsion capacity (ml of oil /mg protein)	0.49(±0.001)	0.57 (±0.015)	0.76(±0.014)	0.85(±0.017)
Reduced viscosity at zero protein concentration (dl/g)	0.65	0.63	0.60	0.57
Water absorption capacity (g of water/g of dried material)	2.46(±0.35)	2.84(±0.25)	4.07(±0.10)	4.26(±0.43)
Fat absorption capacity(g of oil/g of dried material)	2.89(±0.13)	3.02(±0.28)	4.35(±0.09)	4.64(±0.08)

Values in parenthesis indicate standard deviation, n=3

CONCLUSION

The present study indicates that in the preparation of surimi washing increases the protein functionality of meat. For the preparation of surimi-based products the enhanced protein functionality of meat gives rise to better organoleptic characteristics. Again among the studied species croaker meat provided the best protein functionality. So for the preparation of surimi-based product comparatively croaker meat is the best.

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