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Full Length Article

Post-Harvest Chemical and Microbial Evaluation of *Catla catla* under Different Storage Conditions

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Abstract

The present project was designed to investigate the post-harvest chemical and microbial changes in *Catla catla* **(**farmed and wild) under storage conditions of icing, salting and sun drying for 0, 14 and 30 days. Proximate analysis of farmed and wild *C. catla* meat was performed at said intervals showed that after 14 and 30 days of storage, moisture contents of meat differed non-significantly in icing but significantly decreased in salting and sun-drying conditions. Crude protein (CP) and crude fat (CF) were observed higher in sun-drying and lower in icing and salting conditions as compared to 0 day value. Ash contents of fish meat were found significantly higher in salting condition followed by sun-drying whereas ash contents remained non-significant in both farmed and wild *C. catla* stored under icing condition. Among chemical and microbial analysis, at the end of 30 days storage condition, protein solubility (PS) of meat was decreases whereas total volatile base nitrogen (TVBN) increases with upmost in sun-drying while the values after 14 days of storage among different treatments are non-significant. High pH and total plate count (TPC) of fish meat were observed at the end of 30 days storage in sun-drying condition, while minimum pH in icing and TPC observed in salting condition respectively. The correlation matrix analysis indicated that most of the interactions among moisture, CP, ash, PS, TVBN, pH and TPC are significant while fat has non-significant interactions except with pH in both farmed and wild specimens under different storage conditions. © 2018 Friends Science Publishers

Keywords: *Catla catla*; Microbial; Icing; Salting; Sun drying; Storage

Introduction

Fish industry serves as a major source of food, livelihood, and decor recreational activities worldwide which is a kernel of its development. Aquaculture and capture fisheries contributed about 179 million tons of fish in 2015 around the world (FAO, 2015). Cyprinids are the most cultured species in the world with 40% production by volume. Pakistan's total fisheries production stood at 725,000 tons in 2012. Fish exports declined to 126,200 tons in the financial year 2012 which were 128,900 tons during the year 2011. A decline in exports and loss of foreign exchange may be due to poor management and storage issues. Pakistan fishing industry is facing problems in technical, regulatory and operational fields. Fishing makes a considerable contribution to the economy of many countries that have fishing as an established field. Small-scale fisheries of developing countries are very important because they provide a nutritious food, which is often cheaper than meat; therefore, accessible to a larger number of people (Jim *et al*., 2017).

Fish is a major source of protein, fat, minerals, vitamin and valuable omega-3 fatty acids contributing to food and nutrition security (Mohan *et al.,* 2016). Despite such a nutritional importance fish is highly perishable food, which could be rendered unfit for human consumption within twelve hours of capture at tropical temperature conditions (Jim *et al*., 2017). The quality of fish meat and its usefulness is affected by the capture methods, handling practices, processing methods, distribution techniques and storage conditions (Tesfay and Teferi, 2017).

A number of post-harvest methods for storage are being used and these modern and improved preservation and processing techniques like drying, smoking, chilling and salting greatly minimize the spoilage of fish meat (Getu *et al*., 2015). One such method for preservation of fish is the icing where a fish can be stored for up to three months without changing the colour, texture, and taste of the fish flesh (Mohan *et al.*, 2016). There are very limited reports on the evaluation of functional properties of fish protein stored under icing and icing storage (Mohan *et al.,* 2016). However, the quality of fish meat during iced storage deteriorates because the fish meat has a high proportion of proteins and unsaturated fatty acid (Tesfay and Teferi, 2017). Another method for the preservation purpose is drying (Kumar *et al*., 2013), which is a physical process wherein the fish is exposed to air and direct sunlight for different intervals of time depending upon its type.

Fish products when treated with high temperature for a long time increase the degradation of protein and oxidation of fatty acids (Kumar *et al*., 2013). Another method used for fish preservation purpose is salting, which is considered as the most primitive method and is still being used around the globe (Ormanci and Colakoglu, 2015). This method is very popular in many parts of the world and has been proven to be very safe for decades (Getu *et al*., 2015). Salting of fish is done to reduce the moisture content and inhibits the growth of microorganisms (Ormanci and Colakoglu, 2015).

The present project was therefore been carried out with the objective of comparing the effect of storage time and conditions on the nutritive values of *C. catla* an indigenous carp. The other main objective was to evaluate the functional properties of proteins of *C. catla* in relation to conformational changes using different preservative techniques.

Materials and Methods

The research was conducted at Fisheries Research Farms and Saline Fisheries Laboratory, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan. The fishes were collected from two different sources (farmed and wild). Ten fishes from each source were subjected to three selected post-harvest techniques i.e., icing, salting and sun drying. The post-harvest chemical and microbial changes evaluated in terms of proximate composition, proteins solubility, total volatile base nitrogen, pH and total plate count following the standard methods of AOAC (2010). For this, samples were drawn at 0, 14 and 30 days interval.

Preparation of Sample

The fish fillets were prepared according to the methodology described by Khan *et al.* (2011).

Icing: The fish fillets were collected and transferred to thermocol boxes and iced in the ratio of 1:1. The boxes were placed in a chill room around 4°C for storage studies. The ice was replaced on daily bases after draining water.

Salting: Fish fillets were weighed by using a digital balance for the purpose of salting, salt was estimated 25% of the fish weight.

Sun drying: During sun drying surface water of fillets was removed by soaking paper before conducting the experiments. A steel wire mesh tray of 0.30 x 0.25 m was used for open sun-drying of fish. During experiments, the ambient air temperature was 35–40°C.

Chemical and Microbial Analysis

Moisture: The moisture contents were determined by hot air oven method (AOAC, 2010). Percentage of moisture contents was calculated using following formula:

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight after drying (g)}}{\text{Initial weight of sample (g)}} \times 100$$

Crude protein (CP): The protein contents of the fish meat were calculated by estimating its total nitrogen by Kjeldahl method (AOAC, 2010). The protein value of meat was determined by multiplying thevalue of nitrogen with 6.25.

$$\text{Nitrogen (\%)} = \frac{\text{Volume of N/10 } H_2SO_4 \text{ x 0.014 x Vol. of sample dilute}}{\text{Weight of sample x Volume of sample}} \times 100$$

Crude fat (CF): Crude fat contents were determined using the Soxhlet apparatus (AOAC, 2010). The fat contents were calculated as:

$$\text{Crude fat (\%)} = \frac{\text{Weight of residue}}{\text{Weight of taken sample}} \times 100$$

Ash: Ash was determined by placing the samples in the muffle furnace at 550°C for 8–12 h (AOAC, 2010). The ash was calculated as;

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of taken sample}} \times 100$$

Protein solubility (PS): The solubility of proteins was determined according to the method of Rodriguez-Ambriz *et al.* (2005). Protein contents in the supernatant were calculated by using the Bradford (1976) method as follow;

$$\text{Protein solubility (\%)} = \frac{\text{Protein content in supernatant}}{\text{total protein content in sample}} \times 100$$

Total volatile base nitrogen (TVBN): The total volatile base nitrogen was determined by Conway's micro-diffusion analysis. The TVBN content was expressed as milligram nitrogen per 100 g sample.

pH: pH value was determined by using a glass electrode of a newly calibrated digital pH meter (JENWAY-3015 pH meter).

Total plate count (TPC): Fish meat (10 g) meat was homogenized aseptically with 90 mL of sterile physiological saline (0.85% NaCl) for 3 min. Appropriate dilutions were made and poured onto agar plates by spread plate technique. The plates were incubated for 24 h at room temperature. Total plate count (TPC) was enumerated and expressed as a number of colonies forming units per gram.

$$N = \frac{\sum C}{V(n1 - 0.1\, n2)d}$$

Statistical Analysis

Analysis of variance and the significance of interaction were computed by Duncan's Multiple Range Test (DMRT) and three ways factorial analysis. Correlation analysis was performed to determine particular trends and relationships among various variables.

Results

In farmed and wild *C. catla*, maximum values of moisture contents in meat were measured at 14 days and 30 days during icing followed by salting, and sun drying conditions respectively. Among post-harvest techniques, moisture contents of meat were significantly reduced during sun drying and salting conditions but moisture content remains non-significant in icing condition. The contents of crude protein in the meat of farmed and wild *C. catla* were statistically significant and much higher in fish subjected to sun drying condition as compared to icing and salting techniques (Table 1).

The values of crude fat contents measured during icing, salting, and sun drying conditions after different intervals in farmed and wild *C. catla* were statistically significant during post-harvest analysis as maximum in sun drying technique and non-significant in case of icing and salting conditions compared with 0 day value. It was observed in farmed and wild *C. catla* that the ash contents of meat were changed significantly in fish subjected to salting followed by sun drying and icing techniques also (Table 1).

Among chemical and microbial analysis protein solubility (PS), total volatile base nitrogen (TVBN), pH and total plate count (TPC) of farmed and wild *C. catla* meat were recorded during icing, salting, and sun drying conditions after selected intervals. The post-harvest results showed that the PS, TVBN, pH and TPC of meat remained statistically significant in fish subjected to icing, salting and sun drying techniques (Table 2). Maximum values of all selected parameters except PS were recorded under sun drying technique either in the cases of time or wild and cultured stock (Table 2).

Correlation matrix for overall data of farmed and wild *C. Catla* showed that moisture contents was negatively correlated with CP, CF, ash, TVBN, pH and positively correlated with PS. Correlation between moisture and other parameters showed that P-value remained highly significant except for TPC in both cases (Table 3 and 4).

Discussion

The results revealed a significant difference ($p<0.05$) in moisture content among farmed and wild *C. catla* during storage conditions of icing, salting and sun drying. Under post-harvest icing treatment, moisture content remained maximum in farmed as well as in wild catla and decreased significantly during salting and sun drying conditions respectively (Table 1). An increase in moisture content attributed to the increase in water holding capacity of fish meat during icing. These findings are consistent with the finding of Siddique *et al.* (2011) that water contents increased with low temperature/freezing in different fish species after harvesting. Dry salting produces considerable loss of constituent water due to the heavy uptake by salt the fish muscles in the present study, which are in line with the findings of Ormanci and Colakoglu (2015). Kumar *et al.* (2013) also reported that dried fish has lower moisture contents due to evaporation than that of fresh fish.

Just after harvesting (0 day treatment), mean crude protein values of farmed and wild fish were observed higher but at the end of the storage period of icing and salting, it decreased, showing the protein degradation during storage. Percent crude protein values of both farmed and wild fish in sun drying condition were found significantly higher at the end of 14 and 30 days of storage as compared to the initial value. This is due to exclusion of peculating water contents. This increase of crude protein content under sun drying storage condition was mainly because of loss of water that existed among the protein resulting in aggregation of protein, therefore protein contents remained high in dry fish meat (Immaculate *et al.*, 2012). Similar results regarding increase in protein contents after drying was also reported by Kumar *et al.* (2013). Ogbonnaya and Shaba (2009), described that protein was not denatured during sun drying, therefore protein increases with the reduction of moisture in the fish samples.

The crude fat values of farmed and wild *C. catla* were found significantly different at the end of 30 days of storage conditions of icing, salting and sun drying as compared to the initial value of fish meat on 0 day. The crude fat contents in fish meat were increased significantly in the sun drying condition, but a decrease in icing and salting conditions during the present investigation. Al-Ghanim (2016) narrated that the fat content in *Cyprinus carpio* and *Clarias gariepinus* decreased during icing storage at $-21\pm2^{\circ}$C.The decrease in fat content in icing condition is related to fat oxidation as explained by Al-Ghanim (2016). Salting processes and different level of salt concentration do affect fat contents of fish. Meat loss might be due to fat with exuded fluids with osmotic effect (Gandotra *et al.*, 2012).

On 0 day just after harvesting, mean ash contents of farmed and wild *C. catla* were greater and at the end of 30 days of storage on the icing, it decreased. The decrease in ash content was attributed to the drip loss during icing (Gandotra *et al.*, 2014). A significant decrease in ash contents was reported by AL-Ghanim (2016) in *Cyprinus carpio* during ice storage. The mean ash values of farmed and wild *C. catla* were maximum at the end of 14 and 30 days of salt storage. Ormanci and Colakoglu (2015) noted an increase in ash content in fish treated by dry salting. Ash values of farmed and wild *C. catla* also increased at the end of 14 and 30 days of sun drying condition. The increase in ash content is mainly because inorganic substance remains as ash during the ignition of organic matter (Immaculate *et al.*, 2012).

At the time of harvesting, mean protein solubility (PS) values of farmed and wild *C. catla* were greater than at the end of 30 days of storage, which decreased significantly in icing, salting and sun drying conditions.

Table 1: Proximate analysis of farmed and wild *C. catla* under different storage conditions

Characteristics	Initial values	Icing		Salting		Sun drying	
		14 days	30 days	14 days	30 days	14 days	30 days
A. Farmed *C. catla*							
Moisture (%)	78.15±0.72^{a}	80.60±2.58^{a}	81.00±1.04^{a}	60.40±1.11^{bc}	57.82±1.45^{c}	35.71±0.87^{d}	21.50±0.58^{e}
Crude protein (%)	17.40±0.10^{c}	15.80±0.01^{ef}	15.30±0.09^{g}	16.20±0.12^{de}	15.70±0.13^{f}	43.74±0.24^{b}	51.63±0.20^{a}
Crude fat (%)	2.70±0.02^{c}	1.95±0.02^{de}	1.80±0.01^{e}	1.90±0.05^{de}	1.70±0.02^{e}	9.50±0.27^{b}	11.12±0.10^{a}
Ash (%)	1.55±0.01^{e}	1.40±0.01^{e}	1.28±0.00^{e}	20.80±0.61^{b}	24.25±0.16^{a}	10.35±0.06^{d}	12.65±0.08^{c}
B. Wild *C. catla*							
Moisture (%)	80.13±1.91^{a}	82.87±1.92^{a}	83.90±0.58^{a}	62.20±1.00^{bc}	59.40±0.85^{c}	38.10±0.24^{d}	25.20±0.36^{e}
Crude protein (%)	15.50±0.09^{c}	13.70±0.01^{fg}	13.10±0.08^{g}	14.30±0.09^{de}	13.90±0.06^{ef}	42.10±0.24^{b}	50.40±0.35^{a}
Crude fat (%)	2.45±0.05^{c}	1.65±0.01^{de}	1.45±0.05^{e}	1.80±0.03^{de}	1.60±0.03^{e}	8.70±0.17^{b}	10.90±0.09^{a}
Ash (%)	1.62±0.01^{e}	1.48±0.01^{e}	1.40±0.01^{e}	21.10±0.48^{b}	24.55±0.77^{a}	10.50±0.11^{d}	12.80±0.15^{c}

Means sharing the similar letter in a row are statistically non-significant (P<0.05)

Table 2: Mean±SE for chemical and microbial analysis of farmed and wild *C. catla* under different storage conditions

Characteristics	Initial values	Icing		Salting		Sun drying	
		14 days	30 days	14 days	30 days	14 days	30 days
A. Farmed *C. catla*							
Protein solubility (%)	75.40±0.60^{a}	60.40±0.62^{b}	50.60±0.00^{c}	59.10±0.56^{b}	51.00±0.07^{c}	60.13±0.69^{b}	46.24±0.56^{d}
TVBN (mg/100 g)	9.20±0.25^{d}	22.60±0.72^{c}	27.50±1.09^{ab}	21.70±0.29^{c}	25.50±0.83^{b}	24.61±0.57^{c}	28.15±0.56^{a}
pH	6.82±0.01^{d}	7.36±0.06^{bc}	7.00±0.09^{cd}	7.31±0.05^{c}	7.57±0.09^{ab}	7.30±0.06^{c}	7.78±0.07^{a}
TPC (log10 cfu/g)	5.47±0.10^{cd}	5.55±0.11^{bc}	5.86±0.09^{a}	4.51±0.03^{ef}	4.33±0.06^{f}	5.81±0.06^{ab}	6.00±0.08^{a}
B. Wild *C. catla*							
Protein solubility (%)	73.20±0.71^{a}	56.60±0.57^{b}	46.80±0.10^{d}	56.80±0.14^{b}	48.70±0.24^{c}	57.80±0.08^{b}	44.40±1.17^{e}
TVBN (mg/100 g)	10.60±0.39^{c}	24.60±1.04^{b}	29.50±1.61^{a}	23.10±0.14^{b}	27.90±1.81^{a}	26.00±0.97^{b}	29.50±1.73^{a}
pH	6.87±0.06^{f}	7.56±0.11^{bc}	7.10±0.01^{de}	7.46±0.16^{cd}	7.64±0.01^{ab}	7.40±0.11^{cd}	7.84±0.10^{a}
TPC (log10 cfu/g)	6.46±0.09^{bc}	6.14±0.16^{c}	6.67±0.06^{ab}	5.42±0.05^{d}	5.24±0.14^{e}	6.79±0.01^{ab}	6.98±0.12^{a}

Means sharing the similar letter in a row are statistically non-significant (P<0.05)

Table3: Correlation matrix for farmed *C. catla* under different storage conditions

Variable	Moisture	CP	CF	Ash	PS	TVBN	pH
CP	-0.902**						
CF	-0.832**	0.960**					
Ash	-0.538**	0.142	0.055				
PS	0.293**	-0.168*	0.021	-0.346**			
TVBN	-0.394**	0.232**	0.077	0.466**	-0.866**		
pH	-0.181*	0.048	-0.160*	0.321**	-0.892**	0.714**	
TPC	0.011	0.266**	0.219**	-0.547**	-0.285**	0.219**	0.280**

Upper values indicated Pearson's correlation coefficient

* = Significant (P<0.05);** = Highly significant (P<0.01)

Table4: Correlation matrix for wild *C. catla* under different storage conditions

Variables	Moisture	CP	CF	Ash	PS	TVBN	pH
CP	-0.917**						
CF	-0.850**	0.959**					
Ash	-0.493**	0.128	0.043				
PS	0.266**	-0.155*	0.034	-0.336**			
TVBN	-0.371**	0.212**	0.059	0.471**	-0.865**		
pH	-0.182*	0.061	-0.140	0.330**	-0.896**	0.734**	
TPC	-0.213**	0.406**	0.379**	-0.373**	-0.270**	0.204**	0.221**

Upper values indicated Pearson's correlation coefficient

* = Significant (P<0.05); ** = Highly significant (P<0.01)

The decreased protein solubility in ice stored fish is mainly due to clump and denaturation of myofibrils in fish meat as reported by Mehta *et al.* (2011). In salt storage condition mean protein solubility (PS) values of farmed and wild *C. catla* were found lower at the end of 30 days of storage. Mean protein solubility was significantly changed, due to protein denaturation associated to its hydrophobicity and hydrophilic stability (Mostafa and Salem, 2015).

Total volatile base nitrogen (TVBN) content is one way to decide the freshness of fish products. TVBN in the meat is chiefly contributed by ammonia produced as a result of deamination muscular proteins (Kumar *et al*., 2013). In the present experiment 0 day mean TVBN values of farmed and wild *C. catla* were lower and increased significantly at the end of 30 days storage conditions of icing, salting and sun drying. It is assumed that TVBN value increased due to the bacterial degeneration and enzymatic activity of endogenous enzymes with time as reported by Mehta and Shamasundra (2015) in the similar study.

The pH values of farmed and wild *C. catla* meat at the end of 30 days of storage were increased significantly in icing, salting and sun drying conditions. Mehta and Shamasundra (2015) observed similar changes in pH values of *L. rohita* during 22 days of ice storage. An increase in pH may be attributed to the production of volatile basic components such as ammonia, TMO and total volatile nitrogen by fish spoilage bacteria as narrated by Islami *et al.* (2015). The pH of meat increases during storage in sun drying condition which shows degradation over time as reported by Kumar *et al*. (2013).

TPC values of *C. catla* meat were increased during sun drying condition. These values of farmed and wild *C. catla* at the end of salt storage condition was comparable with the result obtained (Mostafa and Salem, 2015) in salted mullet. The possible sources of high microbial counts in dried sardines are poor sanitary conditions during fishing, drying, storage and transportation (Abowei and Tawar, 2011).

Correlation matrix for overall data of farmed and wild *C. catla* showed that moisture contents was negatively correlated with CP, CF, ash, TVBN, pH and positively correlated with PS. Correlation between moisture and other parameters showed that P- value highly significance except for TPC. These results are in line with the findings of Gandotra *et al*. (2012). Correlation matrix showed the positive correlation between CP, CF, TVBN, TPC and negatively correlated with PS.

Correlation between crude protein and other parameters showed that P- value highly significance except for ash and pH. Crude fat was positively correlated with TPC and negatively correlated with pH while CF showed non-significant correlation with ash, PS and TVBN. Ash showed a positive correlation with TVBN, pH and negatively correlated with PS, TPC. PS was negatively correlated with TVBN, pH and TPC. TVBN showed a positive correlation with pH and TPC while pH showed a positive correlation with TPC. P-value highly significant in case of PS, TVBN and TPC. Ormanci and Colakoglu, (2015), Mohan *et al.* (2016) reported same interactions of different proximate and biochemical parameters of carps under various storage conditions.

Conclusion

Conventional post-harvest techniques (icing, salting and sun-drying) affected meat quality of both farmed and wild *C. catla* and the fish stored in ice showed better meat and nutritive quality as compared to salted and sun-dried fish. To prevent post-harvest losses of fish, improved methods and good handling practices are required. The findings of this study could benefit all stakeholders including consumers, Fisher and policymakers. High-quality fish could create further marketing opportunities both locally and internationally. Also, the results could be used by policy makers to formulate laws and promote the application of the improved methods and good handling practices to minimize post-harvest losses will definitely add to the financial spectrum of all stakeholders, employment opportunities and ultimately can give an improved livelihood.

References

Abowei, J.F.N. and C.C. Tawar, 2011. Some basic principles of fish processing in Nigeria. *Asian J. Agric. Sci*., 3: 437–452

Al-Ghanim, K.A., 2016. Effect of different storage temperatures on chemical composition and sensory attributes of the flesh of *Cyprinus carpio* and *Clarias gariepinus. Pak. J. Zool*., 48: 305–310

AOAC, 2010. *Official Methods of Analysis*. Association of Official Analytical Chemists, Inc., Washington DC, USA

Bradford, M.M., 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Annu. Biochem*., 72: 248–254

FAO, 2015. *The State of World Fisheries and Aquaculture*. Food and Agricultural Organizations of the United Nations, Rome, Italy

Gandotra, R., M. Koul, S. Gupta and S. Sharma, 2012. Changes in proximate composition and microbial count by low-temperature preservation in the fish muscle of *Labeo rohita. J. Pharm. Biol. Sci*., 2: 13–17

Gandotra, R., V. Gupta, M. Koul, S. Gupta, D. Parihar and R. Kumasi, 2014. The effect of ascorbic acid and citric acid solution treatment on the flesh quality of *Wallago attu. Int. J. Sci. Technol*., 2: 110–115

Getu, A., K. Misganaw and M. Bazezew, 2015. Post-harvesting and major related problems of fish production. *Fish Aqua. J*., 6: 154–157

Immaculate, J., P. Sinduja and P. Jamila, 2012. Biochemical and microbial qualities of *Sardinella fimbriata* sun-dried in different methods. *Int. Food Res. J*., 19: 1699–1703

Islami, S.N., M. Faisal, M. Akter, M.S. Reza and M. Kamal, 2015. Comparative shelf life study of whole fish and fillets of cultured striped catfish (*Pangasianodon hypophthalmus*) during ice storage condition. *Res. Agricult*., 2: 177–183

Jim, F., P. Garamumhango and C. Musara, 2017. Comparative analysis of nutritional value of *Oreochromis niloticus* (Linnaeus), Nile tilapia meat from three different ecosystems. *J. Food Qual*., 2017, Article ID 6714347 (8 pages)

Khan, N., N.A. Qureshi, M. Nasir, F. Rasool and K.J. Iqbal, 2011. Effect of artificial diet and culture systems on sensory quality of fried fish flesh of Indian major carps. *Pak. J. Zool*., 43: 1177–1182

Kumar, A., P. Singh and M. Danish, 2013. Changes in proximate, chemical and microbiological characteristics of dried *Labeo gonius* fillets during storage at room temperature. *Afr. J. Biotechnol*., 12: 2997–3005

Mehta, N.K. and B.A. Shamasundra, 2015. Changes in the chemical and sensory properties of freshwater fish (Indian major carps) during ice storage. *Prog. Agric*., 15: 202–207

Mehta, N.K., K. Elavarasan, A.M. Reddy and B.A. Shamasundra, 2011. Effect of ice storage on the functional properties of proteins from a few species of freshwater fish (Indian major carps) with special emphasis on gelforming ability. *J. Food Sci. Technol*., 15: 202–207

Mohan, R. Shankar and S. Gopal, 2016. *Packaging Interventions in Low Temperature Preservation of Fish - A Review*. MOJ Food Process Technolp., 2: 00026.

Mostafa, A.A. and R.H. Salem, 2015. Characterization of microbiological and nutritional variation in processed Mullet (*Mugil cephalus)* fish. *Int. J. Microbiol. Res*., 6: 108–122

Ogbonnaya, C. and I.M. Shaba, 2009. Effects of drying methods on proximate composition of cat fish (*Clarius gariepinus*). *World J. Agric. Sci*., 5: 114–116

Ormanci, H.B. and F.A. Colakoglu, 2015. Nutritional and sensory properties of the salted fish product, lakerda. *Cogent Food Agric.,* 1: 1008348

Rodriguez-Ambriz, S., A. Martinez-Ayala, F. Millan and G. Davila-Ortiz, 2005. Composition and functional properties of *Lupinus campestris* protein isolates. *Plant Foods Hum. Nutr*., 60: 99–107

Siddique, M.N., M.J. Hasan, M.Z. Reza, M.R. Islam, M. Boduruzaman, M. Forhadur and S. Reza, 2011. Effect of freezing time on thenutritional value of Jatpunti (*Puntius sophore*), Sarpunti (*P. sarana*) and Thaisarpunti (*P. gonionotus*). *Bang. Res. Public J.,* 5: 387–392

Tesfay, S. and M. Teferi, 2017. Assessment of fish post-harvest losses in Tekeze dam and Lake Hashenge fishery associations: northern Ethiopia. *Agric. Food Secur*., 6: 1–12

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