

Original Research Article

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Biochemical and Histological Change during Chilled Storage in Farmed Raised and Wild Indian Butter Catfish (*Ompok bimaculatus* Bloch, 1794)

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ABSTRACT

The shelf life of farm raised and wild caught Indian butter catfish during ice storage were studied in terms of biochemical, microbiological and histological. The farmed and wild pabda were stored in standard ice-boxes with flake ice (1:1). The samplings were performed at 2 days interval. During storage period, the moisture, ash, protein and lipid contents of all the treatments changed significantly ($p < 0.05$) with the days of storage and also with specific treatments. The pH value increased significantly ($p < 0.05$) in all treatments with a final value was less than 7. Free fatty acids (FFA), peroxide value (PV) and thiobarbituric acid (TBA) increased significantly ($p < 0.05$) after 6th day of storage. The Total Volatile Base Nitrogen (TVB-N) and alpha amino nitrogen (AAN) compounds also increased significantly ($p < 0.05$) after 4th day of storage in all treatments, however the TVB-N content was within the acceptable level till the end of storage period of 8 days. The Total plate count (TPC) and total psychrophilic count remained below the limit (7 log cfu g-1) in Wild whole pabda (WWP) and Farmed whole pabda (FWP) after 6th days of storage which exceeded the limit on 8th days of storage in whole sample, whereas dressed sample Wild dressed pabda (WDP) and Wild whole pabda (WWP) still it remained acceptable for dressed samples. The sensory score of dressed pabda was marginally acceptable up to the 6 days of storage whole pabda was acceptable up to 4 days. The histological changes in fresh pabda muscles did not show any microstructural changes, whereas deformations of muscle fibres and optically empty areas were found in iced pabda at the end of 8th days of storage. Thus the present study advocates preservation of pabda by minimum dressing and then icing in ice-box which can extend the shelf life for at least 6 days whereas the whole iced pabda will remain acceptable for 3 days only.

Keywords

Ice storage,
Microbiological,
Histological and
Wild Pabda

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Introduction

Indian butter catfish (*Ompok bimaculatus*, Bloch, 1794) comes under the order

Siluriformes and family Siluridae. The specific name bimaculatus implies the two spots on anterior sides. In global market this species is known as the two spot glass catfish

and as pabda in Tripura, India. Pabda has a high demand in the market for its excellent taste and flavor, pin-boneless muscle and traditional delicacies associated with the fish. The total world fish production is 170.9 million tones 2016 (FAO, 2018) and India has an important role in global fish production as the second largest fish producer with 11.46 million tones. However, it is a well known fact that a huge amount of fish are lost due to meat quality deterioration, mainly because of the lack of science-based information on post-harvest fish handling and the forms of preservation that might guarantee the high quality of the product. This has been a major impediment to market development. Thus, the scientific studies on fish preservation and shelf life extension are still essentially required especially in the developing countries like India. The Biochemical and microbiological changes in fish tissue after harvest determine the quality of fish. These changes mainly depend on factors that affect substrate and metabolite concentration in living animal tissue, activity of endogenous enzymes, and natural and post-catch microbiological contamination (Fatima *et al.*, 1985, Sikorski *et al.*, 1994). The simplest method of control of spoilage in fish is by icing. In tropical condition the iced fish will remain in good condition up 10-12 days but depend on several factors. Lokuruka *et al.*, (2012) reported that the, effect of gutting on sensory, biochemical and microbiological properties of Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) stored in iced gutting increased shelf life by 4 days. The effect of gutting showed to maintain sensory acceptance and to reduce volatile amine content in lean fish (Botta *et al.*, 1982), while no effect was observed on quality for fatty fish (Karaçam and Boran, 1996). Binsi *et al.*, 2013, studied the microbiological and shelf life characteristics of eviscerated and vacuum packed *Ompok pabda* during chill storage and they reported the extension of 4 days in storage life. Menon,

and Nair (1988) studied the histological changes in fresh water fish muscle stored in chilled condition and reported that the, Structural changes occurring in the skeletal muscle of *Labeo calbasu*, a major carp, during ice storage (0-1 degree C) were studied histologically. Fresh muscle tissue showed closely packed uniform bundles of myofibrils, with well-defined striations and clearly visible nuclei. On storage, there was progressive disruption in this compact picture, with deterioration of the organization of the structure characterized by fissures and breaks in the fibres leading to dislocation and mutilation of myofibrils. Such changes were in line with concomitant softening in the texture of the muscle observed in the stored fish. In view of this, the present study was undertaken to determine the biochemical, microbiological, sensory and histological characteristics of *Ompok bimacultus* under iced storage.

Materials and Methods

Sample collection and storage technique

The wild pabda were collected from the Gomti River Tripura and farmed pabda from College of fisheries Tripura India. After collection of both samples were immediately stored in ice box by mixing ice 1:1 ratio. Sample was brought to the Laboratory of department of Fish Processing Technology College of fisheries Tripura. Fish were washed properly with water to remove the slimes and blood clots from the skin. After washing the fish were stored as whole and dressed form. The treatment was labeled as wild dressed pabda (WDP), wild whole pabda (WWP), farmed dressed pabda (FDP) and farmed whole pabda (FWP) respectively. All the treatments were stored in 4 ice boxes in alternating layers of ice and fish using flake ice in the ratio of 1:1. The boxes were kept at the ambient temperature for further storage study.

Sampling was performed at 2 days interval by estimation of biochemical, microbiological and Sensory characteristics for all the treatments.

Storage life study

Biochemical analysis

The values of the proximate composition sample were determined by the standard method of AOAC (2000). Moisture content was estimated by direct heating method in oven. Crude protein was measured by the Kjeldahl's method using a digestion unit, a distillation unit and a titration unit. Lipid content was determined by Soxhlet Extraction apparatus. Total volatile base nitrogen (TVB-N, mgN 100 g⁻¹) was determined by the Conway micro diffusion method described by Beatty and Gibbon (1937).

The peroxide value (PV) of was estimated by using iodometric titration method as described by Jacobs (1958). The free fatty acid (FFA) content in sample was determined by the method of Dyer and Morton (1956) and expressed as % of FFA oleic acid. Free α - amino nitrogen was determined by Pope and Stevens, (1939) and Thiobarbituric acid (TBA) number was determined by the Tarladgis *et al.*, (1960) all the sampled were performed in triplicate.

Bacteriological analysis

In order to assess the microbial load, 10 g of each treatment sample was aseptically collected and macerated with 90 ml sterile saline. After making serial dilution in the same diluents, spread plating was done on nutrient agar plates. Total plate count was recorded after 24 h of incubation at 37 °C and was expressed as log₁₀ cfu (colony forming units)/g.

Muscle/tissue analysis

The tissue processing, embedding and section preparation were carried out by following the method given by Menon and Nair (1987), using automated tissue processor and (Thermo scientific-Shadon, citadel 2000, USA), automated tissue embedder (Shadon Histocenter 3, processi USA) and rotatory microtome (Leica RM2245, Germany).

Statistical analysis

The data obtained from microbiological and biochemical analysis was analyzed by using Statistical Package for Social Sciences (SPSS, version 21.0 for Windows). Analysis of variance (One way- ANOVA) was performed in order to compare the changes during sampling period. The level of significance of differences was defined at $p < 0.05$.

Results and Discussion

The moisture content significantly increased with the increased in storage time. In case of wild pabda the initial moisture contents was 75.43% which increased up to 79.63% and 80.02% in WDP and WWP respectively (Table 1 and 3) at the end 8 days storage. The same increasing trends of moisture contents were also recorded in wild pabda. The moisture increment was found little higher in the dressed pabda. This may be because of exposure of more flesh to ice melt water, since dressing increased surface area of fish. Chakrabarti (2002) recorded higher moisture content with no significant changes during storage in several marine fishes. The ash contents in all samples decreased significantly ($p < 0.05$) throughout the period of storage. The initial ash content in wild fish was 0.98% which decreased to 0.58% and 0.53% in WWP and WDP respectively (Table 1 and 3). Similar decrease was also observed in samples of FWP and FDP. The decreasing trend was

observed in the all samples, which may be attributed to the leaching of mineral in the ice-melt-water. However, the loss of mineral was found to be more in WDP and FDP than the WWP and FWP. This apparently is because of exposure of more flesh surfaces in the ice melt water which enhanced the leaching mineral contents from the fish. During the storage period protein content significantly ($p < 0.05$) decreased in both sample WWP and WDP during the period of study. The initial protein value of 16.69 decreased to 14.32% and 14.46% in WWP and WDP (Table 1 and 3). Whereas, the initial protein content (16.54%) decreased to 14.45% and 14.52 respectively in FWP and FDP after 8 days.

The protein content decreased significantly ($p < 0.05$) throughout the study periods in all the samples (Table 1 and 3). The protein content decrease was comparatively more in whole fishes, i.e., WWP and FWP, It may be due to the presence of gut contents which is favourable for bacterial growth and enzymatic action and this might have resulted in more protein degradation by bacteria in the whole fish. The decrease in protein may be due to leaching of soluble nitrogenous compounds in ice melt water. The present finding also in support with finding of Kolodziejska *et al.*, (1987) who have observed that low temperature, the rate of denaturation and autolysis of fish protein was markable. The autolysis helps the bacteria to invade the tissue fast, the free aminoacids and water soluble protein content of tissue serve as an excellent source for their growth and as a resultant the quantity of protein is decreased.

The lipid contents in all the samples significantly ($p < 0.05$) decreased during the period of storage with respect to sampling. It was observed that the initial lipid content (6.66%) decreased to 4.41% and 4.37% in WWP and WDP respectively (Table 1 and 3) after 8 days of storage. On the other hand

same was also observed in farmed pabda. The current instigation also support to the finding of (Nazeer *et al.*, 2009) and Gopakumar 1997). The major factor responsible for the deterioration of fish is oxidation of lipid (Roopma *et al.*, 2012). The lipid content the fat content varies with sex, age and season (Gopakumar, 1997).

The AAN content increased significantly ($p < 0.05$) in both sample of fish as a whole and as dressed (Table 2 and 4). The AAN content in dressed fish was found to be less in comparison to that of fish which were stored as the whole. This may be because of low enzymatic (autolytic) and microbial activity due to the absence of gut content. The removal of gut resulted in removal of gut enzymes and bacteria which reduced the enzymatic and bacterial activity to a great extent, and thus, could be responsible for relatively more shelf life of pabda which was stored as the dressed.

In the present study, the TVB-N content significantly changed ($p < 0.05$) during the storage period both in farmed (FDP and FWP) and wild pabda (WDP and FDP) (Table 2 and 4). However, the TVB-N content did not exceed above acceptable limit, i.e. 35 mg N/100 g (FAO, 1986). Lower TVB-N value in dressed fish may be due to the removal of gut along with gut enzymes and bacteria which may be responsible for lower autolytic and bacterial activity, which could have resulted in longer shelf life of dressed pabda than that of whole pabda. The increasing in TVB-N value was comparable with the increasing TVBN value as reported by Ozyurt *et al.*, (2009) for chilled storage of red mullet (*Mullus barbatus*). This increase could be attributed to the production of ammonia and other volatile amines in the muscle during storage (Mazorra *et al.*, 2000). Present findings are in agreement with the Lokuruka *et al.*, (2012) who found increased level of TVBN in the ungutted and gutted experimental tilapia with storage time

in ice. In the present study the TVB-N value did not show any significant difference ($p>0.05$) after 0, 2nd and 4th days of storage in both conditions, whether whole or as dressed with respect to treatments. But after 6 days of storage, the TVB-N of WWP showed significant increase ($p<0.05$) compared to WDP and TVB-N of FWP also showed significant increase ($p<0.05$) compared to WDP on the 8th day of storage.

The Primary oxidation products of the fish sample were measured by the peroxide value and are expressed as meq O₂/kg of fat. In the present study it was observed that the PV increased significantly ($p<0.05$) both in whole and dressed pabda. The PV value was observed higher in the WWP and FWP than in the FDP and WDP. Similar results were also reported by Viji (2014) in chilled steaks of Silver carp where the PV value increased with increased in storage time. During the lipid oxidation Hydroperoxide formed as primary oxidation products at higher levels might undergo the decomposition into secondary oxidation products. Lipid oxidation in fish depends on numerous factors such as species, storage temperature, fat composition, and it produces a number of substances, some of which have unpleasant flavours and odours. Some may also contribute to texture changes, by forming covalent bonds with muscular proteins (Huss, 1995).

The Free fatty acid is the resultant products of hydrolytic rancidity of lipids which is expressed as % of oleic acid. The FFA is a result of enzymatic decomposition of lipid during storage leading to lipid hydrolysis (Tokur *et al.*, 2006). The, the initial FFA (% oleic acid) increased significantly ($p<0.05$) throughout the period of storage, whether fish was preserved whole or dressed. Free fatty acids got generated during storage mostly which may be due to the activity of lipases present both in tissue and also of microbial

origin (Koizumi *et al.*, 1990). The TBA values represent the degree of the rancidity in the product and the value 3-4 indicates quality loss (Karacam and Boran, 1996). The TBA increased significantly ($p<0.05$) in all the treatments during storage period of 8 days. In case of WWP and WDP, the initial TBA value 0.44 increased up to 1.82 and 1.72 in WWP and WDP respectively during the storage periods. Similarly in farmed pabda, the TBA value was higher in WDP and FDP (Table 2 and 4).

The pH value Increased significantly ($p<0.05$) in the farmed and wild pabda in both dressed and whole condition during storage. During later postmortem stages, there is a pH increase, due to decomposition of nitrogenated compounds, caused primarily by microbial activity (Hernandez *et al.*, 2009). The intensity of this pH change depends mainly on the storage temperature, with pH values above 7.1 being indicative of decomposition. The total plate counts (TPC) of all samples changed significantly ($p<0.05$) during the storage period of 8 days (Table 5). The TPC of whole fish was observed to be higher than that of dressed fish. This may be due to the inclusion of gut contents in fish, because the gut content harbors high the bacterial load which may percolate to the muscle during storage. Chytiri *et al.*, (2004) also reported that bacterial count of whole ungutted trouts were always lower than those obtained for filleted trout sample and in their study mesophilic count for filleted and ungutted fish exceeded the acceptable limit ($7 \log \text{cfu cm}^{-2}$) after 10 and 18 days of ice storage, respectively. The ICMSF (1986) established an aerobic mesophilic count limit of $7 \log \text{cfu g}^{-1}$ for fish that is fit for human consumption. In the present study too, TPC in whole treatments was exceeding $7 \log \text{cfu g}^{-1}$ during the storage period, however in dressed pabda the TPC was near $7 \log \text{cfu g}^{-1}$.

Table.1 Changes in proximate composition during ice storage of WWP and WDP [Values are Mean with the S.E. in parentheses, n=3]

Parameters	0 day		2 nd day		4 th day		6 th day		8 th day	
	WWP	WDP	WWP	WDP	WWP	WDP	WWP	WDP	WWP	WDP
Moisture* (%)	75.43 ^{aA} (0.23)	75.43 ^{aA} (0.23)	76.55 ^{bA} (0.82)	76.67 ^{bA} (0.14)	77.53 ^{cA} (0.93)	77.92 ^{cA} (0.15)	78.21 ^{dA} (0.86)	79.41 ^{dA} (0.41)	79.63 ^{eA} (0.56)	80.07 ^{eA} (0.18)
Ash* (%)	0.98 ^{aA} (0.04)	0.98 ^{aA} (0.04)	0.87 ^{dA} (0.03)	0.85 ^{bA} (0.02)	0.76 ^{cA} (0.05)	0.69 ^{cA} (0.03)	0.63 ^{bA} (0.05)	0.55 ^{dA} (0.02)	0.58 ^{aAB} (0.04)	0.53 ^{eA} (0.02)
Protein* (%)	16.69 ^{dA} (0.20)	16.69 ^{dA} (0.20)	15.66 ^{cA} (0.13)	15.77 ^{cA} (0.14)	15.24 ^{bA} (0.09)	15.43 ^{aBA} (0.10)	14.63 ^{aA} (0.15)	15.07 ^{bB} (0.10)	14.32 ^{aA} (0.16)	14.46 ^{aA} (0.12)
Fat* (%)	6.66 ^{dA} (0.17)	6.66 ^{aA} (0.22)	5.97 ^{aAB} (0.19)	6.22 ^{cA} (0.16)	5.40 ^{cA} (0.16)	5.46 ^{bA} (0.17)	4.96 ^{bA} (0.14)	4.88 ^{bA} (0.24)	4.37 ^{aA} (0.15)	4.41 ^{aA} (0.15)

Mean values bearing different superscripts in small letters (a, b, c etc) in the rows are significantly different (p<0.05) with respect to sampling and the values with different superscripts in Caps (A, B, C etc) in the columns are significantly different (p<0.05) with respect to the treatments

Table.2 Changes of biochemical parameters during ice storage of WWP and WDP [Values are Mean with the S.E. in parentheses, n=3]

Parameters	0 day		2 nd day		4 th day		6 th day		8 th day	
	WWP	WDP	WWP	WDP	WWP	WDP	WWP	WDP	WWP	WDP
pH*	6.38 ^{aA} (0.05)	6.38 ^{aA} (0.04)	6.57 ^{abA} (0.02)	6.48 ^{aAB} (0.04)	6.48 ^{bA} (0.02)	6.68 ^{bB} (0.04)	6.72 ^{cB} (0.05)	6.76 ^{cB} (0.03)	6.80 ^{cA} (0.05)	6.82 ^{cA} (0.03)
PV* (meq/kg fat)	11.45 ^{aA} (0.40)	11.45 ^{aA} (0.29)	12.02 ^{aA} (0.21)	11.99 ^{aA} (0.55)	14.39 ^{bA} (0.14)	14.85 ^{bA} (0.39)	18.49 ^{cB} (0.29)	16.74 ^{cA} (0.21)	23.54 ^{dA} (0.68)	21.97 ^{dA} (0.65)
TVB-N* (mg %)	7.46 ^{aA} (0.78)	7.46 ^{aA} (0.42)	12.60 ^{bA} (0.67)	10.99 ^{bA} (0.91)	15.43 ^{cA} (0.47)	14.94 ^{cA} (0.90)	23.74 ^{dB} (0.63)	20.88 ^{dA} (0.82)	26.47 ^{eAB} (0.63)	24.54 ^{eA} (0.85)
AAN* (mg %)	60.70 ^{aB} (0.78)	60.70 ^{aB} (3.34)	70.47 ^{bB} (4.70)	65.13 ^{aAA} (0.91)	74.51 ^{bB} (3.97)	72.05 ^{aAB} (0.90)	84.67 ^{cB} (3.24)	82.13 ^{cAB} (0.82)	88.93 ^{cA} (4.52)	88.89 ^{dA} (0.85)
FFA (% oleic acid)	6.44 ^{aA} (1.54)	6.44 ^{aA} (0.14)	8.46 ^{aaB} (0.44)	7.88 ^{abB} (1.46)	9.11 ^{bA} (0.40)	8.75 ^{bCA} (2.61)	10.73 ^{bbA} (0.97)	9.75 ^{cdA} (1.94)	11.64 ^{cA} (1.29)	10.70 ^{dA} (2.02)
TBA*(mgmalonaldehyde /kg)	0.44 ^{aA} (0.25)	0.44 ^{aA} (0.13)	0.87 ^{bA} (0.07)	0.81 ^{bA} (0.19)	1.03 ^{bcA} (0.03)	0.92 ^{bA} (0.56)	1.28 ^{cA} (0.03)	1.20 ^{bA} (0.84)	1.82 ^{dA} (0.06)	1.70 ^{cB} (0.72)

Mean values bearing different superscripts in small letters (a, b, c etc) in the rows are significantly different (p<0.05) with respect to sampling and the values with different superscripts in Caps (A, B, C etc) in the columns are significantly different (p<0.05) with respect to the treatments.

Table.3 Changes of proximate composition during ice storage of and FWP and FDP [Values are Mean with the S.E. in parentheses, n=3]

Parameters	0 day		2 nd day		4 th day		6 th day		8 th day	
	FWP	FDP	FWP	FDP	FWP	FDP	FWP	FDP	FWP	FDP
Moisture*(%)	75.14 ^{aA} (0.13)	75.13 ^{aA} (0.13)	76.46 ^{bA} (0.27)	75.98 ^{aA} (0.22)	78.08 ^{cA} (0.31)	77.27 ^{bA} (0.51)	78.86 ^{dA} (0.29)	79.10 ^{cA} (0.40)	79.73 ^{eA} (0.19)	80.04 ^{dA} (0.19)
Ash* (%)	1.06 ^{eA} (0.02)	1.06 ^{dA} (0.02)	0.95 ^{cB} (0.03)	0.95 ^{dB} (0.02)	0.83b ^{AB} (0.05)	0.78 ^{cB} (0.03)	0.74 ^{bB} (0.05)	0.66 ^{bB} (0.03)	0.57 ^{aB} (0.04)	0.49 ^{aAB} (0.01)
Protein* (%)	16.54 ^{dA} (0.23)	16.54 ^{aA} (0.23)	15.57 ^{bA} (0.13)	15.70 ^{cA} (0.15)	15.35 ^{bA} (0.09)	15.40 ^{bcA} (0.15)	14.80 ^{aAB} (0.15)	14.96 ^{abAB} (0.13)	14.45 ^{aA} (0.16)	14.52 ^{aA} (0.13)
Fat* (%)	7.36 ^{eB} (0.22)	7.31 ^{dB} (0.22)	6.36 ^{cAB} (0.19)	6.71 ^{dB} (0.18)	5.46 ^{bA} (0.16)	5.62 ^{cB} (0.18)	4.81 ^{aA} (0.14)	4.97 ^{bA} (0.11)	4.57 ^{aA} (0.15)	4.45 ^{aA} (0.15)

Mean values bearing different superscripts in small letters (a, b, c etc) in the columns are significantly different (p<0.05) with respect to sampling days and the values with different superscripts in Caps (A, B, C etc) in the rows are significantly different (p<0.05) with respect to the treatments.

Table.4 Changes of biochemical parameters during ice storage of FWP and FDP [Values are Mean with the S.E. in parentheses, n=3]

Parameters	0 day		2 nd day		4 th day		6 th day		8 th day	
	FWP	FDP	FWP	FDP	FWP	FDP	FWP	FDP	FWP	FDP
pH*	6.36 ^{aA} (0.04)	6.36 ^{aA} (0.04)	6.47 ^{bAB} (0.02)	6.41 ^{abA} (0.03)	6.52 ^{bcA} (0.02)	6.49 ^{bA} (0.02)	6.60 ^{cA} (0.05)	6.57 ^{cA} (0.01)	6.72 ^{dA} (0.05)	6.76 ^{dA} (0.03)
PV* (meq/kg fat)	11.99 ^{aA} (0.29)	11.99 ^{aA} (0.29)	13.51 ^{bB} (0.21)	13.12 ^{aAB} (0.34)	15.65 ^{cA} (0.14)	14.85 ^{bA} (0.26)	19.16 ^{dB} (0.29)	18.18 ^{cB} (0.33)	23.60 ^{eA} (0.68)	21.97 ^{dA} (0.76)
TVBN* (mg %)	9.36 ^{aA} (0.42)	9.36 ^{aA} (0.42)	11.99 ^{bA} (0.67)	10.27 ^{aA} (0.53)	15.30 ^{cA} (0.47)	14.93 ^{bA} (0.39)	22.43 ^{dAB} (0.63)	21.47 ^{cAB} (0.63)	27.48 ^{eB} (0.63)	25.25 ^{dAB} (0.94)
AAN	61.69 ^{aA} (3.34)	61.69 ^{aA} (3.34)	68.53 ^{bA} (4.70)	64.48 ^{aA} (5.11)	73.37 ^{bA} (3.97)	70.18b ^{AB} (3.56)	79.62 ^{cAB} (3.24)	81.05 ^{cA} (4.40)	96.65 ^{dA} (4.52)	85.95 ^{cA} (2.12)
FFA* (% oleic acid)	6.14 ^{aA} (0.14)	6.14 ^{aA} (0.14)	7.69 ^{abB} (0.44)	6.72 ^{aA} (0.21)	9.35 ^{bcA} (0.40)	9.00 ^{bA} (0.38)	11.05 ^{cdA} (0.97)	9.79 ^{bcA} (0.81)	12.15 ^{dA} (1.29)	10.68 ^{cA} (0.82)
TBA*(mgmalonaldehyde /kg)	0.65 ^{aA} (0.13)	0.65 ^{aA} (0.13)	1.03 ^{bA} (0.14)	0.76 ^{aA} (0.17)	0.98 ^{bA} (0.03)	0.84 ^{abA} (0.10)	1.16 ^{bA} (0.03)	1.14 ^{ccA} (0.03)	1.58 ^{cAB} (0.06)	1.39 ^{cA} (0.07)

Mean values bearing different superscripts in small letters (a, b, c etc) in the rows are significantly different (p<0.05) with respect to sampling days and the values with different superscripts in Caps (A, B, C etc) in the columns are significantly different (p<0.05) with respect to the treatments.

Table.5 Change in TPC (log₁₀ CFU g⁻¹) during ice storage WWP, WDP and FWP, FDP [Values are Mean with the S.E. in parentheses, n=3]

Sampling days	WWP	WDP	FWP	FDP
0	5.04 ^{aB} (0.37)	5.04 ^{aB} (0.37)	3.88 ^{aA} (0.05)	3.88 ^{aA} (0.05)
2	5.72 ^{abA} (0.25)	5.71 ^{abA} (0.25)	5.39 ^{bA} (0.12)	5.30 ^{4bA} (0.12)
4	6.15 ^{bcA} (0.19)	6.09 ^{bcA} (0.19)	5.82 ^{cA} (0.04)	5.80 ^{cA} (0.04)
6	6.65 ^{cA} (0.29)	6.74 ^{cA} (0.27)	6.57 ^{dA} (0.16)	6.49 ^{dA} (0.20)
8	7.49 ^{dA} (0.15)	6.84 ^{cA} (0.15)	7.31 ^{dA} (0.17)	6.75 ^{eA} (0.15)
Mean values bearing different superscripts in small letters (a, b, c etc) in the rows are significantly different (p<0.05) with respect to sampling days and the values with different superscripts in Caps (A, B, C etc) in the columns are significantly different (p<0.05) with respect to the treatments				

Table.6 Change in psychrophilic count (log₁₀ CFU g⁻¹) during ice storage WWP, WDP and FWP, FDP [Values are Mean with the S.E. in parentheses, n=3]

Sampling days	WWP	WDP	FWP	FDP
0	5.45 ^{aA} (0.16)	5.45 ^{aA} (0.16)	5.23 ^{aA} (0.17)	5.23 ^{aA} (0.17)
2	5.73 ^{ab} (0.14)	5.89 ^{bb} (0.10)	5.37 ^{aA} (0.07)	5.36 ^{aA} (0.07)
4	6.27 ^{ba} (0.16)	6.33 ^{ca} (0.13)	6.42 ^{ba} (0.12)	6.35 ^{ba} 0.12
6	6.82 ^{ca} (0.03)	6.74 ^{da} (0.04)	6.81 ^{ca} (0.03)	6.74 ^{ca} (0.04)
8	7.39 ^{da} (0.15)	6.91 ^{ea} (0.14)	7.44 ^{da} (0.13)	6.89 ^{ca} (0.12)
Mean values bearing different superscripts in small letters (a, b, c etc) in the rows are significantly different (p<0.05) with respect to sampling days and the values with different superscripts in Capital (A, B, C etc) in the columns are significantly different (p<0.05) with respect to the treatments				

Fig.1a&b Transversely cut muscle cells of fresh pabda, myofibril was showing closely packed & Early sign of muscle degradation after the 2nd days of storage

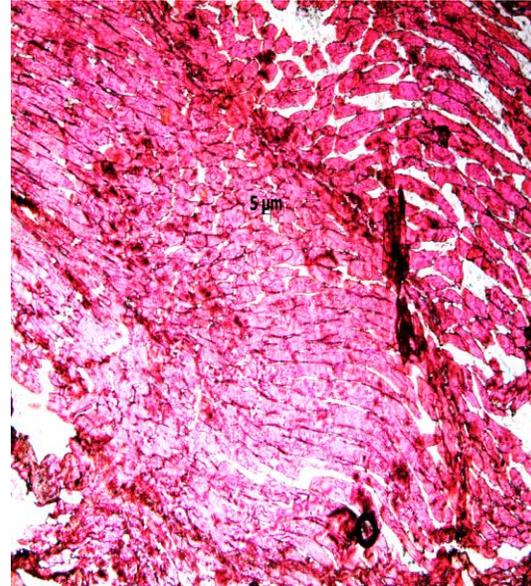
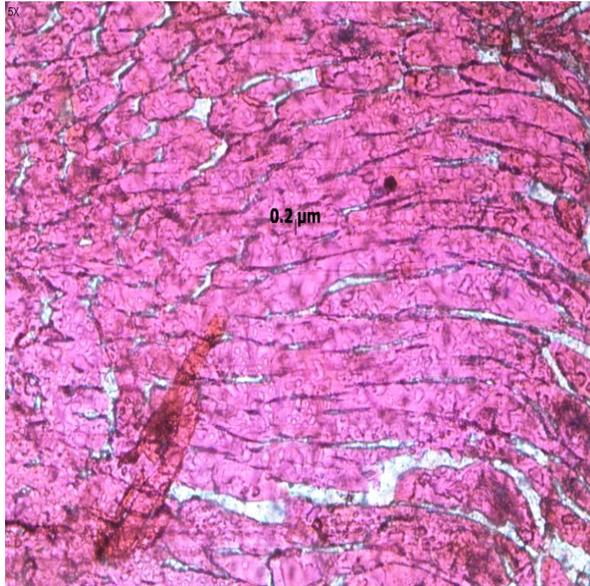


Fig.1c&d Partial and minor change in microstructure after 4th days of storage & After the 6th days of storage gapping in the muscle bundles

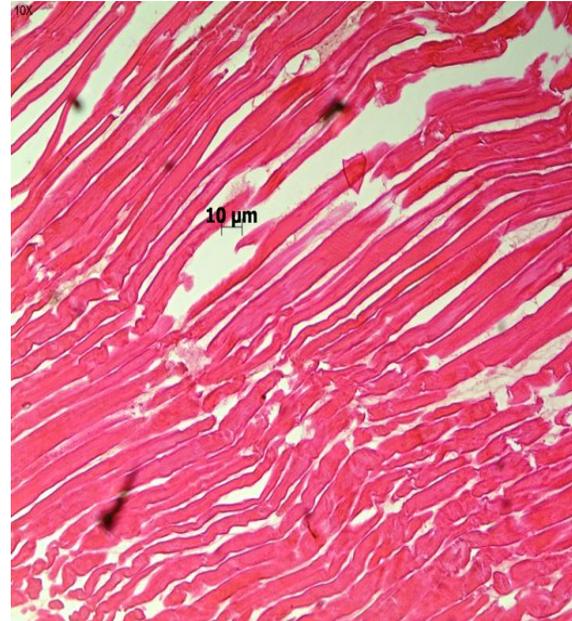
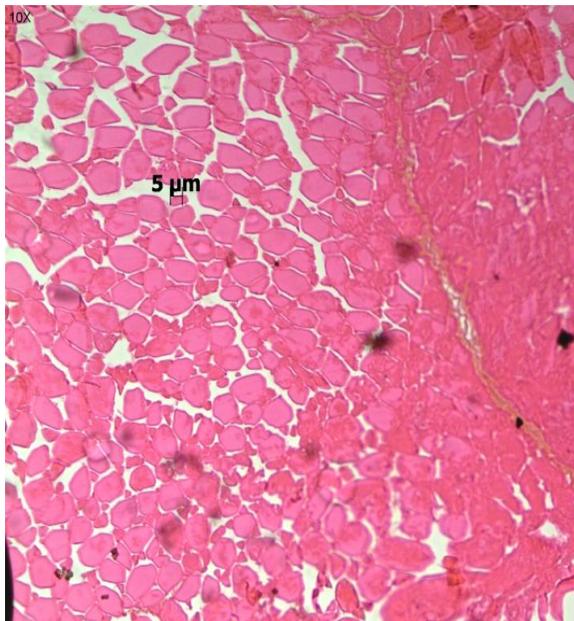
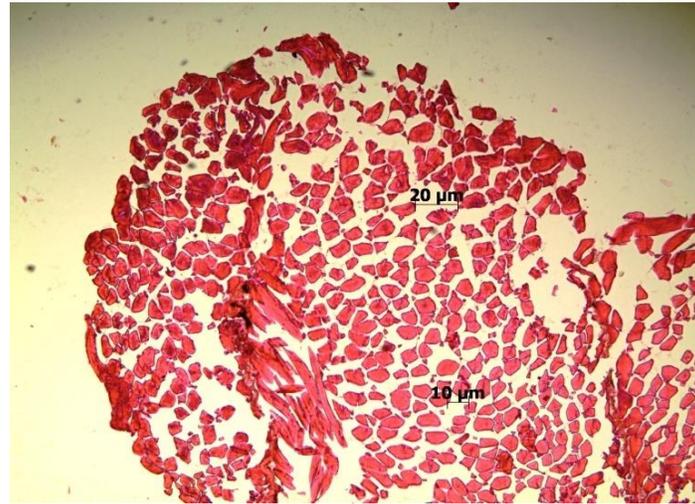


Fig.1e After the 8th days storage destructive changes in cells muscle and dislocation of muscle cells



That means the acceptable shelf life of ice stored fish was approximately 6 days as whole and 8 day as the dressed according the TPC parameter. The total psychrophilic count showed significant differences ($p < 0.05$) in all the treatments during the storage period. It was observed that the initial load of TPC was $5.45 \log \text{cfu g}^{-1}$ which approached to 7.39 in the WWP and 6.91 in WDP (Table 6). Whereas, in farmed pabda the initial load was observed as 5.23 which increased to 7.44 in FWP and 6.89 in the FDP. However, based on the microbiological acceptability limit ($7 \log \text{cfu g}^{-1}$) for fresh and marine species (ICMSF, 2002), the total psychrophilic count exceeded the above the acceptable limit in wild whole and farmed whole pabda. Oppositely, in wild dressed and farmed dressed pabda, the total count did not exceed the acceptable limit. However, it went near to the acceptable limit. The present findings agree with the findings of Bordoloi and Muzaddai (2013) in chilled *Labeo rohita*.

The changes in muscle structure

The changes in muscle structure as recorded by histological study are shown in Fig.1A to 1E. The muscle fibres were intact and

showing no gaping in the fresh fish (Fig. 1E), whereas there were visible gaping in between the fibres after 6 days of storage (Fig. 1D). The muscle structure was totally dislocated and worn out after 8 days of storage (Fig. 1E).

Fish muscle texture depends on a number of intrinsic biological factors that are related to muscle fibre density, and involving both fat and collagen content (Hernandez *et al.*, 2009). The fish death triggers autolytic and microbiological processes that make the muscle softer and less elastic (Olafsdottir *et al.*, 2004). In the same line of the present findings, earlier study by Menon and Nair (1988) showed the textural changes in iced *Labeo calbasu*. They found that the early signs of disorganization of the muscle structure were. Characterized by a loss of compactness of the fibers after seven days. Similar results have been reported for few marine fish species (Paleologos *et al.*, 2004; Poli *et al.*, 2006; Taliadourou *et al.*, 2003).

Based on the above finding it can be can conclude that the Biochemical parameters did not show significant differences during storage of whole farmed pabda and whole wild pabda under similar storage condition.

However, the dressed farmed pabda and dressed wild pabda showed significant improvement in storage shelf life compared to whole pabda. The dressed fish, whether wild or farm, remain acceptable till 6 days when stored in ice. The whole fish remained acceptable up to 3 days only. Thus, present study suggests a method of pabda preservation by minimum dressing and subsequent icing at 1:1 ratio in standard ice-box which may be economically useful for the fish retailers.

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