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Abstract

Icing and ice storage of fish is widely used for transportation and marketing of fish. This paper reports on the biochemical, sensory and textural quality changes in ice stored whole and gutted cultured milkfish (*Chanos chanos*). Moisture content decreased and fat content increased with storage period in whole fish but it was reverse in gutted fish during the ice storage. Biochemical quality parameters showed an increasing trend during iced storage but increase was greater in gutted fish compared to whole fish. Overall acceptability of whole and gutted milkfish decreased significantly over the storage ($p<0.05$). Textural quality showed deterioration with progressive storage period.

Keywords: *Chanos chanos*, ice storage, biochemical quality, texture profile, sensory quality

Introduction

Deterioration of seafood starts quickly after death of fish. The rate of spoilage of fish varies with fish species, environmental conditions, method of slaughter and post-mortem handling, storage procedures and processing conditions (Isabel et al., 2009). Post-harvest preservation is important in determining the quality of final product. Various techniques have been utilized to improve the microbial safety and extend the shelf life of fish including icing. Presently, icing and mechanical refrigeration are widely used to control the microbial and biochemical spoilage in freshly caught fish for transportation and marketing.

The texture and structure of fish muscle are important freshness quality attributes that depend on the internal cross-linking of connective tissue and the detachment of fibers (Cheng et al., 2014). Textural quality is primarily a sensory attribute that is quantified in foods by several instrumental methods. Many authors have attempted textural studies in fishes (Manju et al., 2007; Vacha et al., 2013; Viji et al., 2015).

Milkfish has a high demand, in Indian markets and is often consumed fresh. However, very little information is available regarding ice preservation aspects of cultured milkfish in ice. The present work was envisaged to evaluate quality changes in ice stored whole and gutted milkfish. Information on biochemical and sensory quality of whole and gutted cultured milkfish is of great interest to consumers as well as processors.

Materials and Methods

Farm reared milkfish (52.5 cm and 58.5 cm length and 1009 ± 74 g weight) were procured from the Narsapur fish farm of West Godavari, Andhra Pradesh, India and brought to laboratory within 10 h after harvesting in ice. All the chemicals and glasswares used were of analytical grade. The fish were de-iced and washed and divided into two batches, (a) whole and (b) gutted, of 10 nos. of fish

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each. One batch was immediately packed in insulated polystyrene box with ice (1:1). Another batch was beheaded and eviscerated. The gutted samples were packed in insulated box as described earlier. Fish to ice ratio of 1:1 was maintained by daily replacement of ice in order to maintain a temperature at 1–2°C. Samples were withdrawn at regular intervals for biochemical, sensory and textural analyses.

Proximate composition was determined by AOAC (1998) method. The sample was homogenized in distilled water (1:5 w/v) and pH was determined using digital pH meter (Systronics, India). Tri methyl amine nitrogen (TMA-N) and total volatile base nitrogen (TVB-N) content was estimated by Conway micro diffusion method using 10% tri chloro acetic acid extract (TCA) (Conway, 1950). Peroxide value (PV) was measured by iodometric titration of chloroform extract of fish samples (Yildiz et al., 2003). Free fatty acid (FFA) value was determined from chloroform extract as per AOAC (1998) to assess hydrolytic rancidity. Alpha amino nitrogen (AAN) content of sample was determined according to the method of Pope & Stevens (1939). The non-protein nitrogen (NPN) content of meat was analyzed according to the method as described by Velankar & Govindan (1958) and expressed as mgN 100 g^{-1} meat. Salt soluble nitrogen (SSN) (Ironside & Love, 1958) and water soluble nitrogen (WSN) (Winton & Winton, 1958) were estimated.

Sensory evaluation was carried out using 9-point hedonic scale by 10 trained panelists (Amerine et al., 1965). For evaluation of textural properties, anterior, belly and posterior region of fish muscle were cut into 2 cm^2 pieces. The texture of the samples was assessed objectively using Food Texture Analyser (Lloyd Instruments LRX plus, Lloyd Instruments Ltd., Hampshire, UK) using two cycle compression at 40% compression ratio using 12 mm min^{-1} test speed. Hardness, cohesiveness, springiness, chewiness and gumminess of the fish muscle were calculated as permanent of the texture analyser.

All analyses were done in triplicate. Data was subjected to ANOVA by statistical software, SPSS version 16.0 and Duncan's multiple range tests was used for post – hoc analyses at 5% level of significance.

Results and Discussion

The changes in proximate composition of whole and gutted milkfish (*Chanos chanos*) were studied during ice storage for 12 days (Table 1). Moisture and crude protein content in whole milkfish decreased during icing. Protein content of whole fish on 12th day of storage was significantly lower than other samples ($p<0.05$). Lipid content of both samples varied from 3.92 to 5.11% and 3.96 to 2.06% from 0th day to 12th day of ice storage showing significantly lower values at beginning of storage study ($p<0.05$) for whole fish and significantly higher values at beginning of the storage study for gutted fish ($p<0.05$). Ash content also showed significantly higher values on 12th day of ice storage in whole milkfish ($p<0.05$) whereas ash content of gutted milkfish showed significantly lower values on 12th day of ice storage ($p<0.05$). Similar trend was

Table 1. Changes in proximate composition of whole and gutted milkfish (*Chanos chanos*) during ice storage

Parameter	Sample	Storage period (days)			
		0	4	8	12
Moisture (%)	Whole	72.11±0.35^{a}	70.37±0.40^{b}	69.59±0.40^{c}	69.65±0.01^{c}
	Gutted	69.07±0.04^{a}	71.59±0.57^{b}	72.73±0.60^{c}	74.78±0.37^{d}
Protein (%)	Whole	20.38±0.19^{a}	20.23±0.02^{a}	20.44±0.12^{a}	19.18±0.55^{b}
	Gutted	20.84±0.20^{a}	19.13±0.81^{b}	18.27±1.08^{b}	18.50±0.28^{b}
Fat (%)	Whole	3.92±0.12^{a}	4.41±0.21^{b}	5.08±0.20^{c}	5.11±0.02^{c}
	Gutted	3.96±0.07^{a}	3.03±0.18^{b}	2.91±0.16^{b}	2.06±0.05^{c}
Ash (%)	Whole	4.02±0.08^{a}	4.37±0.20^{b}	5.25±0.10^{c}	4.24±0.07^{a}
	Gutted	4.67±0.18^{b}	5.32±0.21^{c}	5.07±0.19^{c}	4.39±0.17^{a}

Results are average of triplicate determinations, Mean ± SD; All results are on wet weight basis; Value with different superscripts in a row differ significantly ($p<0.05$)

observed by Kamal et al. (2000) for shrimp and prawns meat.

Biochemical quality parameters such as pH, TMA-N, TVB-N, PV, FFA, WSN, SSN, NPN and AAN were evaluated during ice storage of both the samples and means are presented in Table 2. The pH of fresh fish was 6.5 indicating the freshness of the fish. After 4th day of storage in ice, pH of both whole as well as gutted fish showed increasing trend. At the end of 12th day of ice storage, pH of whole and gutted milkfish was recorded as 7 and 7.4 respectively. Increase in pH during storage could be observed due to the production of amines and other volatile bases by the autolytic and microbial action on protein and other compounds. TVB-N is a product of bacterial spoilage which is used as an index to assess the keeping quality and shelf-life of seafood (Erkan et al., 2006). Fresh fish has shown a TVB-N value of 13.84 mg% and TMA-N value of 10.69 mg%. A significant increase in TVB-N and TMA-N ($p<0.05$) content was noticed in both the samples with the storage period. The increase in TVB-N during storage is a consequence of liberation of basic compounds by microbial activity on protein and non-protein nitrogenous compounds. The concentration of TVB-N in freshly caught fish is typically between 5 and 20 mgN 100 g^{-1}, whereas levels of 30–35 mgN 100 g^{-1} fish are generally regarded as the limit of acceptability for ice-stored cold water fish. In present study, the maximum TVB-N value registered for whole and gutted samples were 21.42 and 22.53 mgN 100 g^{-1} on 12th day of ice storage. Quality deterioration was relatively faster in gutted milkfish. The increase in TVB-N, and TMA-N was always higher in gutted milkfish. Similar observations were recorded by Murthy et al. (2015) for whole and gutted Pacu (*Piaractus brachypomus*).

Fish lipids are susceptible to oxidation and PV measures the amount of the primary lipid oxidation products. Initial PV values for fresh and gutted fish were 2.76 ± 0.08 and 6.26 ± 0.06 MEq O_2 kg^{-1} sample respectively which increased gradually with progressive storage period. PV of whole milkfish was

Table 2. Changes in biochemical quality attributes, lipid quality and nitrogen contents of whole and gutted milkfish (*Chanos chanos*) during ice storage

Parameter	Sample	Storage period (days)			
		0	4	8	12
TVB-N(mg%)	Whole	13.84±0.35^a	15.75±0.36^b	18.01±0.49^c	21.42±0.82^d
	Gutted	15.23±1.00^a	17.40±1.33^b	20.27±0.63^c	22.53±0.26^d
TMA-N (mg%)	Whole	10.69±0.68^a	12.03±0.24^b	14.01±0.20^c	15.52±0.22^d
	Gutted	11.94±0.54^a	13.16±0.07^b	14.99±0.54^c	15.42±0.26^c
PV (meq O_2 kg^{-1} of fat)	Whole	2.76±0.08^a	4.8±0.38^b	5.86±0.50^c	5.89±0.02^c
	Gutted	6.26±0.06^a	8.6±0.25^b	9.06±0.31^b	9.59±0.08^c
FFA (% Oleic acid)	Whole	1.83±0.20^a	3.03±0.08^b	4.18±0.99^c	4.60±0.05^c
	Gutted	4.51±0.19^a	4.77±0.07^a	5.64±0.03^b	6.20±0.01^b
pH	Whole	6.5±0^a	6.7±0^b	6.7±0^b	7.0±0^c
	Gutted	6.5±0^a	6.8±0^b	7.0±0^c	7.4±0.1^d
NPN (mg%)	Whole	576.67±5.77^a	539.67±5.77^b	512.00±1.73^c	481.33±6.35^d
	Gutted	558.67±4.62^a	531.67±2.31^b	503.33±5.77^c	461.00±10.39^d
AAN (mg%)	Whole	77.21±0.63^a	90.01±1.75^b	95.88±1.51^c	106.67±2.89^d
	Gutted	80.82±1.64^a	90.40±1.57^b	101.81±1.76^c	120.59±1.98^d
WSN (mg%)	Whole	4.72±0.19^c	4.85±0.16^c	5.47±0.15^b	3.73±0.02^a
	Gutted	4.89±0.04^b	4.11±0.11^a	5.11±0.11^c	4.21±0.14^a
SSN (mg%)	Whole	7.69±0.06^a	4.67±0.24^b	5.34±0.03^c	4.04±0.02^d
	Gutted	6.83±0.10^a	7.11±0.05^b	7.64±0.04^c	6.12±0.00^d

Results are average of triplicate determinations, Mean ± SD; Values with different superscripts in a row differ significantly ($p<0.05$)

significantly lower ($p<0.05$) for fresh fish when compared with gutted indicating faster oxidation of hydroperoxides to tertiary compounds than whole fish. Increased PV for gutted fatty fish have been reported (Erkan & Ozden, 2008) during storage. PV of samples revealed a higher primary oxidation in gutted samples when compared with whole. It could be attributed to exposure of belly area and cut surfaces to the air thereby making it more prone to oxidation. The amount of free FA (FFA) measures oxidative rancidity. Triglyceride in depot fat is cleaved by triglyceride lipase originating from the digestive tract or excreted by certain microorganisms (Viji et al., 2015). Both the samples showed an increase in FFA values as a function of storage period. Significantly higher FFA values were observed in gutted fish than whole fish at any day of storage ($p<0.05$). Similar observations for increased FFA content of gutted fish were reported by Viji et al. (2015).

NPN - fraction constitutes 9 to 18% of the nitrogen in teleost fish species (Abowei & Tawari, 2011). During ice storage, levels of NPN decreased significantly as a function of storage period ($p<0.05$). NPN contents of gutted ice stored milkfish were lower than that of whole milkfish. The decreasing values may be attributed to a leaching effect resulted from replenishment of ice during the storage period (Dileep et al., 2005). AAN, a major component of NPN in fresh milkfish was found to be 8.75 mg%. Significantly higher AAN content was observed with the progression in the storage period in both the samples ($p<0.05$) which may be a result of liberation of amino acids due to proteases on fish proteins. Salt soluble nitrogen and water soluble nitrogen exhibited decreasing trend with the progression of storage period in both the samples. Significantly lower values of SSN were observed as a function of storage period ($p<0.05$). WSN content of whole and gutted fish on 12th day of ice storage was significantly lower than that at the beginning of the ice storage. The results are in agreement with that reported by Thippeswamy et al. (2002) for ice stored whole milk fish and Rao et al. (2013) for ice stored pangasius fish.

Overall acceptability scores (mean value for appearance, colour, odour, flavour and texture) for whole and gutted milkfish indicated freshness of fish and did not show any significant difference between whole and gutted samples indicating both samples possess similar sensory quality based on overall acceptability scores (Table 3). A significant reduction in sensory scores of both samples was observed as a function of ice storage period ($p<0.05$). Putrid odour and soft slimy flesh indicated spoilage over the ice storage.

The changes in textural properties of whole and gutted milkfish samples over a storage period are given in Table 4. Hardness 1 and Hardness 2 (peak

Table 3. Sensory evaluation of whole and gutted milkfish (*Chanos chanos*) during iced storage

Parameter	Sample	Storage period (days)			
		0	4	8	12
Appearance	Whole	9 ± 0.25^a	8 ± 0.25^b	8 ± 0.25^b	7.5 ± 0.25^c
	Gutted	9 ± 0.25^a	7.5 ± 0.25^b	7 ± 0.25^c	6 ± 0.25^d
Odour	Whole	8 ± 0.35^a	7 ± 0.35^c	8 ± 0.35^a	7.5 ± 0.35^b
	Gutted	8.5 ± 0.35^a	6.5 ± 0.35^b	6.5 ± 0.35^b	6 ± 0.35^c
Taste	Whole	8 ± 0.64^a	8 ± 0.64^a	8 ± 0.64^a	7.5 ± 0.64^b
	Gutted	8 ± 0.64^a	7 ± 0.64^b	7 ± 0.64^b	6 ± 0.64^c
Colour	Whole	8 ± 0.31^a	8 ± 0.31^a	8 ± 0.31^a	7.5 ± 0.31^b
	Gutted	7.5 ± 0.31^a	7.5 ± 0.31^a	6.5 ± 0.31^b	6 ± 0.31^c
Texture	Whole	8 ± 0.43^a	7.5 ± 0.43^b	8 ± 0.43^a	7 ± 0.43^c
	Gutted	8 ± 0.43^a	7 ± 0.43^b	7 ± 0.43^b	6 ± 0.43^c
Overall	Whole	8 ± 0.25^a	8 ± 0.25^a	8 ± 0.25^a	7.5 ± 0.25^b
Acceptability	Gutted	8 ± 0.25^a	7.5 ± 0.25^b	7 ± 0.25^c	6 ± 0.25^d

Results are average of triplicate determinations, Mean ± SD; Values with different superscripts in a row differ significantly ($p<0.05$)

force during 1st and 2nd compression) decreased in both whole and gutted milkfish during ice storage ($p<0.05$). The results are in line with the observations by Viji et al. (2015) for ice stored sutchi catfish. The initial values of hardness 1 were 30.56 N and 30.42 N for whole and gutted milkfish respectively but hardness values decreased over the storage period. However, whole fish exhibited higher hardness 1 and hardness 2 than gutted fish during ice storage. Reduction in hardness values may be attributed to the weakened endomysium as part of the connective tissue and also due to degradation in the Z-line of myoûbrils (Masniyom et al., 2005) and due to increase in microbial load (Kilinc et al., 2009). Cohesiveness is the ratio of the positive force area during the second compression portion to that during the ûrst compression, excluding the areas under the decompression portion in each cycle (Manju et al., 2007). Cohesiveness slightly varied in whole and gutted fish. This indicates that there was not much change in the internal bonding of fish muscle during storage. This is in agreement with the result of Viji et al. (2015) who observed a slight reduction in cohesiveness value for ice stored sutchi catfish. Springiness is the elastic or recovering property of the fish muscle during compression. In general, a decreasing trend was observed for springiness values in whole as well as gutted fish over the storage period indicating that the fish muscle is losing its elasticity during storage. The mean values for whole and gutted fish decreased significantly over a storage period ($p<0.05$).

Table 4. Changes in textural quality of whole and gutted milkfish (*Chanos chanos*) during ice storage

Storage Period (days)	0		4		8		12	
Sample	whole	gutted	whole	gutted	whole	gutted	whole	gutted
Hardness 1 (N)								
Anterior	30.56±0.9	30.45±0.9	21.46±2.2	15.20±1.3	18.04±1.5	18.04±0.5	16.19±0.1	12.07±1.5
Belly	18.22±0.6	18.28±0.6	16.53±0.5	13.50±0.5	15.27±0.2	15.27±0.1	14.24±0.0	9.90±0.73
Posterior	20.58±0.5	20.60±0.5	18.82±0.4	16.15±1.0	13.90±0.8	13.90±0.9	12.25±0.1	11.84±0.5
Hardness 2 (N)								
Anterior	18.87±1.2	18.68±1.1	11.33±1.1	9.49±0.17	11.33±1.1	10.02±0.2	10.25±0.8	5.82±0.57
Belly	10.72±2.2	10.54±2.2	9.33±0.32	8.48±0.47	9.33±0.32	6.79±0.16	8.21±0.63	4.55±1.19
Posterior	12.79±0.4	9.05±6.42	6.70±0.83	7.97±0.11	6.70±0.83	7.33±0.85	6.01±0.94	6.98±0.52
Cohesiveness								
Anterior	0.13±0.03	0.11±0.02	0.16±0.02	0.15±0.01	0.15±0.03	0.25±0.00	0.20±0.01	0.19±0.02
Belly	0.15±0.03	0.16±0.03	0.16±0.01	0.19±0.00	0.16±0.01	0.20±0.02	0.18±0.02	0.17±0.00
Posterior	0.17±0.03	0.18±0.03	0.19±0.03	0.15±0.01	0.18±0.02	0.15±0.02	0.13±0.01	0.21±0.04
Springiness (mm)								
Anterior	2.85±1.45	2.99±1.60	1.63±0.09	2.01±0.05	2.02±0.33	2.69±0.02	1.97±0.63	2.02±0.12
Belly	1.82±0.63	1.79±0.64	2.10±0.27	2.45±0.15	1.98±0.15	1.74±0.09	1.64±0.02	1.65±0.04
Posterior	2.29±0.25	2.30±0.26	2.30±0.07	1.91±0.24	2.19±0.03	1.55±0.04	2.11±0.02	2.18±0.02
Gumminess (N)								
Anterior	3.38±0.32	3.38±0.32	3.47±0.77	2.19±0.05	2.60±0.43	3.56±0.13	3.20±0.24	2.45±0.58
Belly	2.91±0.66	2.82±0.67	2.69±0.11	2.57±0.10	2.50±0.15	2.27±0.17	2.55±0.22	1.67±0.17
Posterior	3.60±0.75	3.51±0.77	3.60±0.54	2.38±0.03	2.46±0.17	2.03±0.16	1.60±0.06	2.59±0.54
Chewiness (N.mm)								
Anterior	10.62±3.6	10.39±3.6	5.69±0.94	4.46±0.21	5.06±1.72	3.59±0.27	4.14±0.07	4.78±0.88
Belly	8.22±0.55	7.55±1.10	5.66±0.96	6.34±0.16	5.04±0.09	3.94±0.10	4.17±0.41	2.74±0.22
Posterior	8.04±0.80	7.89±0.82	8.13±1.55	4.54±0.52	5.42±0.30	3.10±0.15	3.38±0.11	5.42±1.23
Adhesiveness								
Anterior	0.05±0.04	0.05±0.04	0.03±0.01	0.06±0.02	0.06±0.01	0.04±0.00	0.04±0.00	0.04±0.00
Belly	0.04±0.03	0.04±0.03	0.03±0.01	0.02±0.01	0.04±0.01	0.02±0.01	0.03±0.00	0.03±0.00
Posterior	0.01±0.00	0.01±0.00	0.01±0.00	0.06±0.00	0.06±0.00	0.07±0.01	0.04±0.00	0.04±0.01

Results are average of triplicate determinations, Mean ± SD

Chewiness is the mouth feel sensation of laboured mastication due to sustained, elastic resistance from the fish the product of gumminess and springiness. Gumminess is the product of hardness and cohesiveness (Casas et al., 2006). A significant reduction in chewiness and gumminess values was observed for both the samples as a function of storage period ($p<0.05$). Decrease in chewiness indicates that the fish muscle becomes soft during storage. Marginal increase or decrease was observed in adhesiveness of milkfish samples during ice storage. When the hardness, cohesiveness, gumminess and springiness of anterior, belly and posterior region of milkfish were compared, belly region had lower values compared to anterior and posterior region. Chewiness and gumminess values showed marginal changes as a function of storage period. Similar trend was observed by Manju et al. (2007).

The effect of gutting on the biochemical, sensory and textural quality of cultured milkfish (*Chanos chanos*) during storage in ice has been reported. There was deterioration of biochemical quality parameters of whole as well as gutted fish as a function of storage period in ice. Deterioration was more progressive in gutted fish as compared to whole fish. Significant decrease in overall acceptability as well as textural quality of whole and gutted fish samples was observed over the storage period. As per sensory overall acceptability both guttered and whole fish samples were acceptable upto 12 days. However, whole fish scored better compared to gutted fish.

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