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Functional Properties of Ice-Stored Japanese Threadfin Bream *(Nemipterus japonicus)*

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Abstract

Changes in functional properties - emulsifying capacity, protein solubility, cook loss, relative viscosity and water-binding capacity - were observed in Japanese threadfin bream *(Nemipterus japonicus)* during 14 days storage in ice. Decreasing solu-bility of proteins profoundly influenced the functional properties. Significant correla-tions ($P<0.05$) existed among various functional properties of fish protein analyzed and with texture scores. Fish held in ice was rated "good" for up to seven days.

Introduction

Fresh fish is susceptible to rapid spoilage in tropical countries owing to the prevalence of high ambient temperature. The most important aspect in postharvest technology of fish is to prevent and retard the degradation of muscle proteins. Fish are generally kept in ice prior to processing to prevent and retard loss of freshness, especially degradation of muscle proteins which is a major reaction of the spoilage process in fish (Reddy and Srikar 1991a) and may alter functional properties, namely, emulsifying capacity (EC), water-binding capacity (WBC), relative viscosity (RV), cook loss (CL), protein solubility (PS), pH and texture. Though some information is available on the changes in functional properties of proteins in frozen fish (Colmenero and Borderias 1983) and fish mince (Reddy and Srikar 1991b), little data are available on the functional properties of fish during ice storage.

This study focuses on Japanese threadfin bream *(Nemipterus japonicus)*, known locally as pink perch, a major by-catch of the

shrimp fishery in Indian coastal waters and which contributes approximately 3.5% of the total marine landings of India (FAO 1988). The species is common throughout the Indo-Pacific region from southern China to northern Australia.

Materials and Methods

N. japonicus caught off the Mangalore coast of India was iced on board the vessel in the ratio of 1:1. Fish were washed thoroughly with chilled water and preserved in an insulated box with ice throughout the study. Samples were drawn randomly on day zero (fresh) and on the 4th, 6th, 9th, 12th and 15th day of storage, for analyses of functional properties.

Analyses

Extraction and determination of water-soluble proteins (WSP) and salt-soluble proteins (SSP) of *N. japonicus* meat were as described by Reddy and Srikar (1991b). The sum of WSP and SSP were expressed as protein solubility, calculated as per cent of total proteins (TN x 6.25). Total nitrogen (TN) in the iced fish was determined according to Srikar and Chandru (1983). EC was measured by the method of Swift et al. (1961) using refined groundnut oil. The result was expressed as ml of oil emulsified per 1.25 g of meat. RV of WSP and SSP extracts were determined according to Spinelli et al. (1973). WBC and CL were determined by the methods of Li-Chan et al. (1986) and Kondaiah et al. (1985), respectively. The pH of the meat was determined after mixing a 10-g meat sample with 50 ml distilled water.

Sensory and Statistical Analyses

Ice-stored fish was steam cooked with 2 per cent brine for 10 minutes and assessed for organoleptic qualities (color, flavor, odor and texture) by eight trained panelists using a hedonic scale ("excellent" (10.0) to "not acceptable" (0)). ANOVA and Students 't' test were employed to determine the significant differences in functional properties and texture with reference to storage period. Based on texture, shelf-life of ice-stored fish was calculated using a linear regression plot.

Results and Discussion

The effect of ice storage on PS is shown in Fig. 1a. A significant decrease ($P<0.05$) in PS from 75.74% in fresh fish to 67.32% was observed after 14 days storage. The decrease in PS could be attributed mainly to two factors: the loss of water soluble (sarcoplasmic) proteins in the melted ice and the aggregation and insolubilization of myofibrillar protein fractions through hydrophobic association by oxidized and hydrolyzed products of lipids (Reddy et al. 1990). In our study, we observed decreases in WSP content from 29.5 $mg \cdot g^{-1}$ of fresh fish meat to 20.1 $mg \cdot g^{-1}$ meat (Reddy and Srikar 1991a) and also SSP (Table 1).

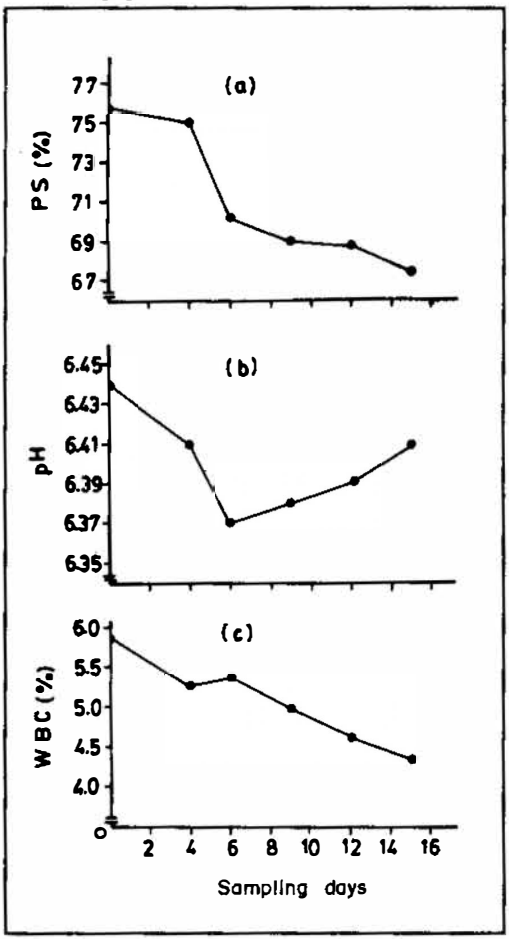

Fig. 1. Changes in protein solubility (PS), pH and water-binding capacity (WBC) in pink perch meat stored in ice.

Similarly, the decrease in EC was significant ($P<0.05$) during the same period (Table 1). A reduction in EC has been reported by Kijowski et al. (1982) during ice storage of chicken meat. The concurrent decrease in muscle PS may explain the decrease in EC, as they were significantly correlated ($P<0.01$). Further, decrease in EC as a result of low PS reflects protein denaturation during postmortem handling and storage.

Various factors such as pH, ionic strength, soluble myofibrillar protein concentration, nature of neutral salts, etc., affect the relationship between EC and PS. Among them, SSP concentration is the main factor conditioning EC, which decreased significantly

Table 1. Changes in emulsifying capacity (EC), salt-soluble proteins (SSP), cook loss (CL) and texture scores of ice-stored pink perch.

Sampling days	Parameter											
	EC* ml/1.25 g meat Mean ± SD			SSP* (g/100 g meat) Mean ± SD			CL* (%) Mean ± SD			Texture scores** Mean ± SD		
0	109.0^{a}	±	2.3	9.31^{a}	±	0.5	6.86	±	0.03	9.0^{a}	±	0.2
4	106.5^{a}	±	1.5	8.95^{ab}	±	0.4	11.03^{a}	±	0.21	8.4^{a}	±	0.3
6	101.5^{b}	±	1.0	8.71^{bc}	±	0.2	11.61^{a}	±	0.43	7.0^{b}	±	0.1
9	97.0^{c}	±	1.7	8.06^{cd}	±	0.1	15.8^{b}	±	0.37	5.9^{bc}	±	0.2
12	96.0^{c}	±	2.0	7.40^{d}	±	0.2	16.5^{b}	±	0.26	4.8^{c}	±	0.2
15	99.0^{bc}	±	1.3	8.02^{d}	±	0.1	17.12^{b}	±	0.79	2.5	±	0.2

^{abcd} Means followed by the same superscript within a column do not differ significantly ($P>0.05$)
* Average of minimum three estimates
** Mean panel scores as assessed by eight panelists

throughout the storage period ($P<0.05$) (Table 1), as a result of its denaturation and aggregation leading to insolubilization of myofibrillar protein fractions. Hence, the higher the amount of SSP in the mince, the higher was the EC of the muscle proteins. As the EC technique is accomplished by sodium chloride extraction, it is postulated that only SSP were effective in the emulsification of fat. On comparing the values of PS, SSP and EC over the storage period, changes undergone by the proteins in emulsifying fat are most nearly reflected by the trends in soluble proteins, in particular myofibrillar proteins.

The pH of the muscle obtained from ice-stored fish decreased until the 6th day (Fig. 1b) and later showed a slight increase. The observed increase in pH was similar to the observation made by Ryder et al. (1984) during ice storage of New Zealand jack mackerel. According to them, increase in pH was probably due to production of volatile base compounds.

There was a decrease in the RV of SSP and WSP extracts (Table 2). The decrease is attributed to molecular interaction and protein aggregation (Nakayama et al. 1979). Although viscosity is dependent on a number of factors such as concentration of proteins, pH, ionic strength and temperature, the primary factor affecting viscosity is protein concentration, as a direct relationship between the two exists (Kinsella 1976). In the present study, decreased solubility of proteins seemed to have a profound effect on the RV of WSP and SSP extracts since a significant direct relationship was

Table 2. Changes in the relative viscosity of salt-soluble (SSP) and water-soluble protein (WSP) extracts of ice-stored pink perch

Sampling days	Relative viscosity* in centipoise	
	SSP extract	WSP extract
0	169.4	129.7
4	158.5	130.0
6	159.0	127.1
9	151.6	126.5
12	152.3	126.7
15	152.0	126.4

* Average of five estimations

observed between the two. A similar observation was that of Crupkin et al. (1979) in Patagonian hake.

CL increased significantly ($P<0.05$) from an initial value of 6.9 to 17.2 per cent after 14 days storage in ice (Table 1). The increase in CL may be due to the decreased ability of proteins to retain moisture during the same period, as can be seen by the decreased PS. Postmortem breakdown of ATP and decrease in pH are also responsible for a drop in hydration which might have resulted in increased CL (Hamm 1960).

WBC in terms of absorbed moisture in water (AMW) decreased throughout storage (Fig. 1c). A decrease in water retention capacity after 2 hours post mortem was observed by Kijowski et al. (1982) and has been explained as due to denaturation of proteins.

The sensory quality, "texture of meat," an important attribute on which protein denaturation has profound effect, showed decreasing trend throughout the storage (Table 1). Textural changes among seafood products are associated with toughening events in myotomal tissue. This is mainly due to the decreased solubility of proteins (Rodger et al. 1980) as a result of its aggregation and denaturation. Loss in texture in southern blue whiting during ice storage has been related to gaping and loss of water (Barassi et al. 1981). Increased CL and a reduction in

Table 3. Correlation coefficient of various functional properties and texture scores.

Parameters compared	Correlation coefficient (r)
PS vs. EC	0.92**
SSP vs. EC	0.95***
PS vs. CL	-0.92**
PS vs. WBC	0.86*
PS vs. RV of SSP	0.98***
PS vs. RV of WSP	0.86*
EC vs. texture	0.80*
CL vs. texture	-0.91**
SSP vs. texture	0.81*
WBC vs. texture	0.94**
PS vs. texture	0.89**
Texture vs. storage period	-0.98***

PS = protein solubility; EC = emulsifying capacity; SSP = salt-soluble proteins; CL = cook loss; WBC = water-binding capacity; RV = relative viscosity; WSP = water-soluble proteins.

*P<0.05
** P<0.01
*** P<0.001

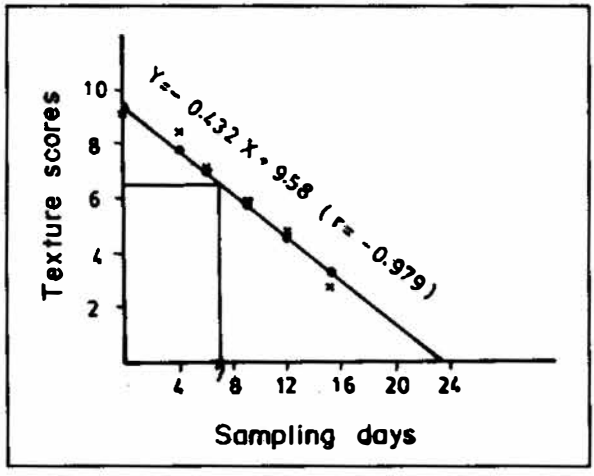

Fig. 2. Texture evaluation of ice stored pink perch. Plot of linear regression with time.

WBC appear to bear a significant relation to texture alterations in iced pink perch.

All the above functional properties were affected by loss of PS, which reflects changes in native protein structure. Significant correlations between various functional properties indicate their interdependence on changes in proteins (Table 3). The results of the present investigation reveal that determination of PS, EC, CL, WBC, RV and texture are useful in the assessment of changes occurring in proteins during ice storage. A high negative correlation (r = -0.979) was obtained on correlating the mean panel scores for texture of the product with storage period. Based on a linear regression plot (Y = -0.432X + 9.58) (Fig. 2), the product was rated fair up to seven days.

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