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Effect of super chilling on the proximate composition of Indian Mackerel (*Rastrelliger kanagartha*) stored in solar operated refrigerated fish vending unit

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Abstract

The objective of this study was to investigate the effects of super chilling on the proximate composition of commercially important fish, Indian mackerel (*Rastrelliger kanagartha*). The fish was procured from Mangalore landing centre in very fresh condition, washed in chilled water and then stored in solar operated indigenously developed refrigerated fish vending unit. The total storage period was of 12 days and the sampling was done in every alternate day during storage period. The crude protein, moisture, crude fat and ash content reached upto 15.31%, 71.21%, 3.45%, and 1.11% respectively on the 12th day. The results showed a significant decrease ($p < 0.05$) during the storage period.

Keywords: Proximate composition; super chilling; *Rastrelliger kanagartha*; solar energy; vending unit

1. Introduction

Fish is known for its high nutritional value. The chemical composition of fish regarding other food is unique taking into consideration ^[1]. Fish tissue is the main source of long chain polyunsaturated fatty acids especially omega-3 and omega-6. These fatty acids have particular importance in fish, since their consumption contributes reduction of appearance of cardiovascular diseases ^[2, 3] and improvement of learning ability ^[4]. Majority of fish species contains long muscles, and the fish flesh is easy digestible ^[5, 6, 7].

The Indian mackerel (*Rastrelliger kanagartha*) is an important fish caught along the West Coast of India and constitutes major fishery resource of this region ^[8]. Nearly 90% of the world production is constituted by India and that of 70% is obtained from West Coast of India. During the year 2015-16, about 2.49 lakh tons mackerel were caught along the entire Coast of India ^[8]. Locally fresh mackerel is consumed and exported in internal markets in the form of frozen, dried and canned. Fresh and value added Mackerel is exported to Southeast Asian countries ^[8].

The proximate composition of any fish is good indicator of quality of fish ^[29]. The chemical composition of fish varies greatly with species, sex, age, environment and season. Quality of fish, which depends on the nature of fish species and on the handling and storage conditions ^[9, 10], changes after catch due to chemical reaction and microbiological spoilage ^[11]. During handling and storage, quality deterioration of fresh fish occurs rapidly and limits the shelf life of the product.

Solar powered refrigeration have been very attractive during the last twenty years, since the availability of sunshine and the need for refrigeration both reach a maximum levels in the same season ^[12]. Super chilling is the practice of chilling food to a temperature just below the freezing point of the aqueous phase of a particular product, and then storing it at that temperature. This is generally around -1.5 °C to -2 °C. Super chilling, on a practical level, offers a simple method of extending the shelf life of a chilled product by several days. The quality of foods is heavily dependent on the length of storage. In particular, perishable fish and shellfish can quickly lose the extreme freshness they need to be suitable for human consumption ^[31]. To help preserve their freshness, such fresh-foods must be stored at low temperatures. Traditionally, seafood has been kept in cold storage or in freezers, but in recent years, an additional storage technique based on the Japanese concept of "Hyo-on" (super chilling) has attracted much interest ^[13]. Super chilling means a temperature range in which foods remain in a non-frozen condition despite being in sub-zero temperatures ^[31]. The present study was done to investigate the changes in the proximate composition of *Rastrelliger kanagartha* stored in solar driven unit maintained at the super chilled temperature (-3 °C) conditions.

2. Materials and Methods

2.1 Sample preparation

Fresh Indian mackerel (*Rastrelliger kanagurta*), fatty marine fish was used for this study. The fish was procured in fresh condition from Mangalore fish landing centre during the month of November in year 2015, washed in chilled water before keeping in the vending unit. The average total length and total weight observed was 27.95±0.96 cm and 204.75±2.56 g respectively.

2.2 Chemical analysis

2.2.1 Moisture content

The moisture content estimation was done following the method AOAC [14]. 5 g of fish meat was taken in triplicate in a pre-weighed petriplate and dried in hot air oven by keeping petriplate open without lid. The temperature of the oven was maintained at 100±5 °C and the samples were kept for overnight drying (16 h). The samples were cooled to room temperature in a desiccator containing silica gel. Drying and cooling was done repeatedly till constant weight was obtained. Total moisture content was estimated with the formula given below:

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,

W₁ = Empty weight of petriplate

W₂ = Sample and petriplate weight before drying

W₃ = Sample and petriplate weight after drying

2.2.2 Crude protein content

The crude protein content of the samples was determined by estimating total nitrogen by Kjeldhal method AOAC [14]. About 1 g of sample was digested with 10 ml of concentrated sulphuric acid and a pinch of digestion mixture [K₂SO₄ (10): CuSO₄ (1): SeO₂ (0.25)] in a 250 ml digestion flask. Few glass beads were added to the digestion flask to avoid bumping. The contents in the digestion flask were heated in the digestion chamber. Digestion was continued till a colourless solution was obtained. After cooling the volume was made by adding distilled water in 100 ml volumetric flask. 2 ml of aliquot was taken and distilled in the Kjeldhal distillation unit with 10 ml of 40% sodium hydroxide solution. The liberated ammonia was absorbed in 10 ml of 2% boric acid solution containing mixed indicator (0.1% methyl red and 0.1 % bromocresol green in 1:1 ratio dissolved in 95 % ethyl alcohol till the colour of boric acid solution turned to green. This was titrated against 0.02 N standard sulphuric acid until the pink colour was developed. Crude protein content was calculated by multiplying total nitrogen content by 6.25 and expressed as percentage weight of meat.

$$\text{Total nitrogen (\%)} = \frac{14 \times N \times X \times 250 \times 100}{1000 \times V \times W}$$

Where,

N = Normality of H₂SO₄

X = ml of standard H₂SO₄ required for titration of sample

V = Aliquot (ml) of digested extract taken for distillation

W = Weight (g) of sample

Since average nitrogen content of fish protein is 16 %, so 1g nitrogen = 100/16=6.25g protein Hence, crude protein %= total nitrogen %×6.25 (conversion factor)

2.2.3 Crude fat content

The crude fat of the sample was determined by Soxhlet extraction method AOAC [14]. About 1 g of moisture free sample was kept inside the whatman thimble. The thimble was plugged with cotton loosely and placed in a soxhlet extraction unit. Petroleum ether AR grade (40-60 °C) was used as solvent. Heating was achieved by thermostatically controlled mantle. The temperature was set to 500-600 °C and extraction was continued for 16 h. After the extraction, the pre-weighed receiver flask containing the extracted fat was dried initially on a water bath at 98-100 °C and then using an oven 60 ± 5 °C. The flask was cooled in desiccators were repeated till constant weight was obtained. The fat content of samples was calculated by using following formula:

$$\text{Fat content (\%)} = \frac{W_2 - W_1}{S} \times 100$$

Where,

W₁ = Weight of empty flask

W₂ = Weight of flask after evaporation

S = Weight of sample

2.2.4 Ash content

Ash content of the samples was determined by method as described in AOAC [14]. 1 g of moisture free sample was taken in a pre-weighed silica crucible. Preliminary charring was done by slow heating on flame without burning. After the charring the sample was incinerated in the muffle furnace at 550±10 °C for 5-6 h. The crucibles were removed and cooled in desiccator and weighed. Ash content was calculated from the weight difference of crucible and expressed as the ash content in percentage on dry weight basis by using following formula:

$$\text{Ash content} = \frac{W_2 - W}{W_1 - W} \times 100$$

Where,

W₁ = Weight of crucible with sample

W₂ = Weight of crucible with ash

W = Weight of crucible

2.3 Statistical analysis

The data obtained from moisture content, crude protein content, crude fat and ash content analysis was further analyzed by using Statistical Package for Social Science (SPSS, version 21.00). Analysis of variance (One way-ANOVA) was performed in order to compare the changes in mackerel muscle during the super-chilled storage study. Significance of difference was defined at $p < 0.05$.

3. Results and Discussion

3.1 Changes in moisture content

The moisture content during storage days of mackerel is presented in the Fig. 1. There was significant difference ($p < 0.05$) in the moisture content during the storage period. The initial moisture content recorded was 74.77% and was found to be decreased during storage period and reached 71.21% on the 12 day of storage. Similar results were reported in horse mackerel [15]. According to [16] changes in horse mackerel (*Trachurus trachurus*) in slurry ice varies from 75 to 79%. The findings by Tawfik MS were also in corroboration with present study. [18, 19] also reported similar results for changes in stored mackerel.

3.2. Changes in crude protein content

The crude protein content is represented in the Fig. 2. The

crude protein content decreased significantly ($p < 0.05$) with the increase in the storage days. The initial crude protein content at 0 d was 19.46%, at the end of super-chilled storage the protein content recorded was 15.31%. The results of present study were in agreement with the findings of [20, 21, 22, 23]. A crude protein content of 20.20% in muscle tissue was reported by Tawfik MS. [24] Reported crude protein in mackerel varied from 16.65% to 20.09% [25] also reported that protein content in sardine and mackerel ranged between 17.04 - 28.01%.

3.3 Changes in crude fat content

The crude fat content in the muscle tissue of mackerel is represented in the Fig. 3. The crude fat content decreased significantly ($p < 0.05$) with the increase in storage days. At the fresh sample (0 d) the crude fat content observed was 5.75%, it decreased with the increase in storage days and the value recorded on 12 d was 3.45%. According to [26] the fat content

varies with sex, age and season. Tawfik MS, reported 4.10% of the crude fat content in muscle tissues of stored fish sample. Spanish mackerel contains higher amount of fat and has an inverse relation b/w fat and moisture content [27].

3.4 Changes in ash content

The ash content of the stored mackerel is presented in the Fig. 4. It showed the significant difference ($p < 0.05$) during the storage period, with the increase in storage days the ash content decreased progressively in fish muscle samples. The initial ash content recorded was 1.96%, it decreased progressively and reached 1.11% on 12 d of the super-chilled storage. Ash content findings of present study were in agreement with the findings of [28], Similar results were reported by [29] for changes in proximate composition of Indian mackerel along Ratnagiri coast. A similar pattern of changes in ash content were presented by [30] in chilled mackerel muscles stored in an insulated box.

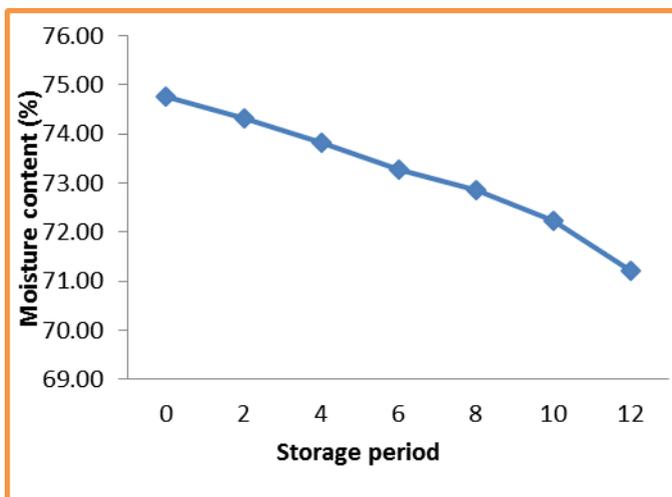


Fig 1: Changes in the moisture content of Mackerel during super chilled storage.

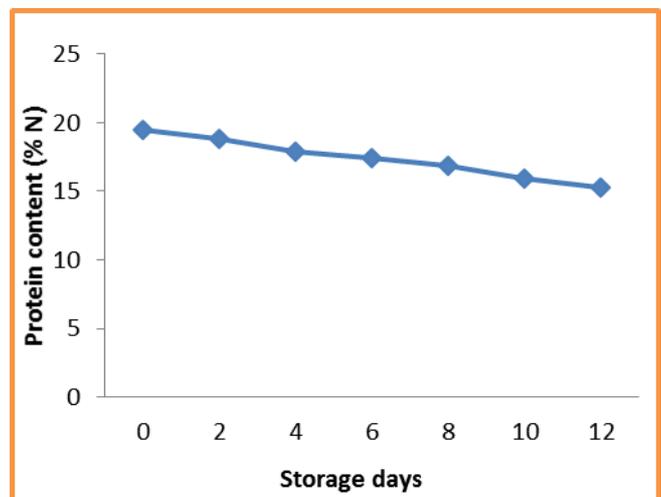


Fig 2: Changes in the protein content of Mackerel during super chilled storage.

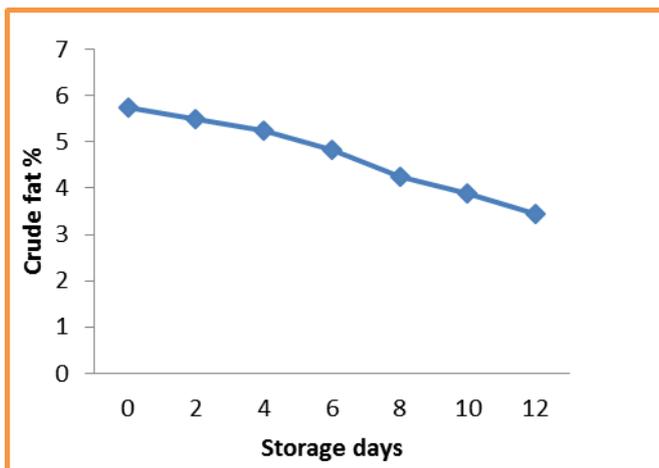


Fig 3: Changes in the crude fat content of Mackerel during super chilled storage.

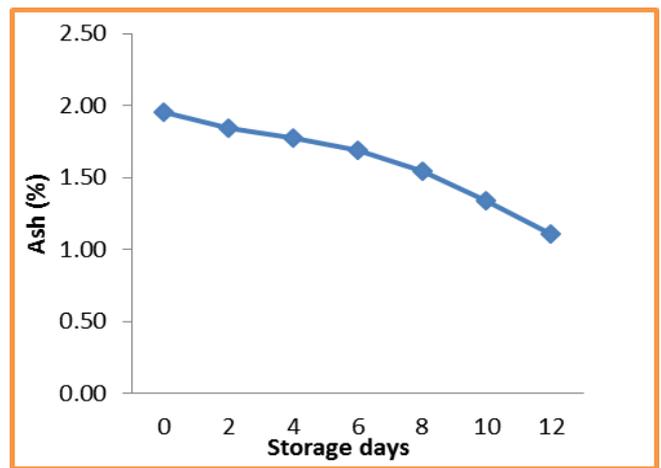


Fig 4: Changes in the ash content of Mackerel during super chilled storage.

4. Conclusion

The present study was conducted to estimate the changes in the proximate composition in muscle tissues of mackerel during the super-chilled condition in the indigenously developed unit, and the results obtained were far better than the conventional methods. The stored Mackerel was acceptable upto the 12 days of storage in contrary to the other

chilling methods where the shelf life is for 4-6 days only. It can be concluded with the present study that Mackerel is a cheap source of protein, rich in source of fat content and availability of different fatty acids which are considered as beneficial to human health.

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