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Effect of turmeric and *Spatoglossum asperum* on shelf life extension of marine finfish *Sillago sihama* in chilled storage condition

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The effect of turmeric and seaweed powder (*Spatoglossum asperum*) on shelf life extension of *Sillago sihama* in chilled storage condition was determined by sensory, pH, biochemical and bacteriological analysis. The experimental setup was divided into six groups, undeveined, deveined, undeveined coated with 5 % *S. asperum* powder, deveined coated with 5 % *S. asperum* powder, undeveined coated with 5 % turmeric and deveined coated with 5 % turmeric, all the group of fishes were stored in chilled conditions with 1:1 (fish:ice) ratio. Deveined *S. sihama* coated with 5 % turmeric demonstrated a longer shelf life of 14 days and between the groups significant differences ($P < 0.05$) were found in the sensorial, pH, biochemical and bacteriological values. Nevertheless, the validity of group one and two were found to be acceptable up to 8 and 10 days, respectively. In conclusion, deveined *S. sihama* coated with 5 % turmeric and stored in chilled conditions retain the shelf-life up to 14 days.

[Keywords: Indian white fish, Sensory analysis, *Spatoglossum asperum*, Turmeric]

Introduction

Seafood is a natural component of a balanced diet and contains high levels of various vital nutrients, thus assists us to maintain a good nutritional status, important for our health[1]. FAO forecasted a net increase in World seafood demand by 2025 due to increase in population growth and per-capita seafood consumption[2]. The export market distributes the fish as live, fresh, chilled, frozen, heat-treated, fermented, dried, smoked, salted, pickled, boiled, fried, freeze dried, minced, powdered or combination of two or more of these forms. Approximately 40 % of world fish market supply fish as live, fresh and chilled form[2]. Since, the public always needs reassurance about the quality of the most perishable commodities, it must be necessary to ameliorate the caliber of seafood which has been transported long distances. Short shelf-life is a defining element of the perishable product (sea food) that bears upon the quality distribution. There are numerous factors which affect the fish quality such as improper handling during fishing, lack of adequate infrastructure facilities at landing centre, shortage of continuous power supply, insufficient road connectivity, smaller number of ice plants, awareness on hygiene during storage, handling of stored raw materials, inadequate number of cold storage facilities, and refrigerated transporting systems. Among these, improper handling induces degradation of protein, carbohydrate, lipid, minerals and organic substances due to several biochemical and enzymatic changes[3]. In addition to the above factors, microbes play a significant role in spoiling the fish quality[4]. These factors result in a high proportion of post harvest losses and quality deterioration of fish with subsequent risk to the health of consumers.

Sillago sihama (Kilangan), Indian white fish is the most dominant species among Sillaginidae family. It is considered a highly esteemed food fish from Indian waters[5]. It is one of the most important fish among Indian consumers commanding high price in different states of the country[6]. A number of research works have been carried out by various authors addressing the issues related to handling, processing and preservation techniques of seafood. Spices are widely

used agents in a variety of food products to improve the quality. Many spices including cinnamon, black pepper, turmeric, ginger, garlic and onions inhibit microbial growth in foods[7]. It has been reported that turmeric has admirable biological activities such as antibacterial, antiviral, anticancer etc., due to the presence various bioactive components[8]. Moreover, turmeric is one of the major ingredients in Indian cooking recipe, hence can be accepted by the consumers. On the other hand, especially brown seaweeds possess a variety of bioactive compounds that include alginic acids, laminarans, tocopherol, fucosterol, isoaromadendrene epoxide and sulfated polysaccharides, hence it is also considered as a medicinal plant[9]. Previous studies reported that the bioactive potential macromolecules (fucoidan/sulfated polysaccharide) present in the brown seaweeds demonstrated strong antibacterial activity against various bacterial pathogens such as *Vibrio* spp, *Staphylococcus* sp., *Escherichia coli*, *Aeromonas hydrophila*, *Enterobacter* sp., *Pseudomonas aeruginosa*, etc.[10,11]. Though, limited studies have been carried out in India regarding chilled fish shelf life improvement with natural preservatives, hence in the present study, we made an attempt to investigate the effect of turmeric and seaweed powder on shelf life extension of *S. sihama* in chilled storage condition.

Materials and Methods

Sample collection and storage

Fresh Indian white fish, *S. sihama* (Kilangan) with an average body weight of 80 ± 2.1 to 120 ± 2.4 g and length of 8 ± 0.15 to 9 ± 0.20 cm was collected from the Kattumavadi landing centre (Latitude: N 10°9.0174'; Longitude: E 79°5.5076') Southeast coast of India. The collected fish were washed with clean running water and packed in insulated boxes with fish and an ice at the ratio of 1:1. Then the fish were transported to the laboratory within 4 to 6 hrs. The fish samples were stored in chilled conditions (1 kg ice: 1 kg fish) using six thermo-cool boxes (each box 15 kg capacity). The temperature of the fish was maintained at 0 to 1 °C by re-icing for every 12 hrs. Once in two days, 750 g of fish from each group were randomly sampled to assess the sensory, biochemical and bacteriological analysis to ensure its validity for a period of 14th day.

Turmeric and seaweed collection

Turmeric was purchased from the grocery shop and the brown seaweeds *Spatoglossum asperum* was collected from the Gulf of Mannar region, Tamil Nadu, India and identified with the help of the Marine botanist, Centre for Advanced Studies in Marine Biology, Parangipettai, India. To remove the debris, seaweed was washed with running water followed by the distilled water. After that, the seaweed was allowed to shade dried at room temperature, then blended, sieved and stored in airtight containers.

Experimental setup

Fish were grouped into six different categories and each group was packed individually in the food grade polythene bags to avoid direct contact with ice and leaching of coated materials. Group one: control (whole fish without any application), group two: deveined fish (gill and gut removed), group three: undeveined fish coated with 5 % of seaweed powder (1 kg fish/ 50 g *S. asperum*), group four: deveined fish coated with 5 % seaweed powder (1 kg fish/ 50 g *S. asperum*), group five: undeveined fish coated with 5 % turmeric (1 kg fish/ 50 g turmeric), group six: deveined fish coated with 5 % turmeric (1 kg fish/ 50 g turmeric).

Sensory analysis

During the experimental period the sensory evaluation was performed once in two days for fresh and cooked fish (100 °C for 10 min in microwave oven) to examine the degree of freshness and quality. The sensory evaluation of chilled fish for different experimental group was evaluated by eye clarity, colour, stiffness, gill colour, texture, odour and mucus. Similarly, after cooking, the fish colour, odour, taste and texture were examined. The sensory characteristics were judged by a trained panel consisting of five experts with the help of modified sensory score sheet (Table 1 and 2). The sensory characteristics and overall acceptability of fish was assessed on the basis of 10-point scale[12]. Seven categories were ranked; highly acceptable (8.5-10), acceptable (6.5-8.4) moderately acceptable (4.5-6.4), just acceptable (3.6-4.4), just unacceptable (2.6-3.5), unacceptable (1.5-2.5) and rejected (0-1.4). The scores of different panelists were averaged.

Physical, biochemical and bacteriological analysis

pH and temperature

The pH was measured using pH meter (EuTech instruments). 10 g of fish muscle was homogenized with 50 ml of distilled water by using a blender and the pH was measured after half an hour. The core temperature of the fish was measured using a digital

Table 1 — Modified sensory evaluation score for raw fish

S. No	Appearance	Eye clarity shape	Colour	Stiffness	Gill colour	Texture	Odour	Mucus	Marks
1	Natural and bright	Bright and transparent convex cornea	Natural	Pre-rigor	Dark red	Hard	Fresh natural and fishy	Fresh and natural	8-10
2	Bright	Convex; slightly sunken	Moderate	Rigor	Red	Moderate Hard	Fishy	Slight fresh	5-7
3	Slightly bright	Flat; opalescent cornea	Slight Moderate	Post-rigor	Brown	Hard less flesh	Stale	Moderate	3-4
4	Loss of bright	Concave; milky cornea	Slight darkening	Slightly Post-rigor	Dark brown	Slightly Hard	Slight spoil odour	Slightly darken	0-2

Table 2 — Modified sensory evaluation score for cooked fish

S. No	Colour	Odour	Taste	Texture	Marks
1	Natural	Fresh fishy odour	Sweet and natural	Firm and good elasticity	8-10
2	Moderate	Moderate	Moderate and sea weedy	Moderate firm and elasticity	7-8
3	Slight	Slight moderate	Slight moderate	Slight firm loss of elasticity	6-5
4	Light pink or reddish	Moderate ammonical dour	Tasteless and moderate sour and bitterness	Slightly chewy and total loss of firmness	4-2
5	Total colour change	Extremely off odour and ammonia smell	Off flavour and bitterness	Soft and mushy	1-0

thermometer temperature range from -40 to 250 °C (METRAVI-DTM 902).

Biochemical analysis

Total protein, carbohydrate and lipid were estimated in the fish tissue sample followed by a standard method [13-15], respectively.

Bacteriological analysis

The bacterial density on the fish tissue was enumerated by following the procedures recommended by American Public Health Association[13]. All the media were purchased from Himedia Laboratories Pvt Ltd, Mumbai, India. The enumeration of total plate count (TPC), proteolytic bacteria, *Vibrio*, *Pseudomonas*, *Aeromonas*, *Salmonella* and *Escherichia coli* were carried out by using nutrient agar, skimmed milk agar, thiosulphate citrate bile salt sucrose agar (TCBS), Kings Medium A base, *Aeromonas* isolation agar, XLD agar and MacConkey agar respectively. Ten gram (10 g) of fish tissue samples from each group were homogenized with 90 ml of sterilized saline water serially diluted and seeded on the plates containing respective media and incubated at 37 °C for 24 hrs. The colonies developed on the plates were counted, calculated log value and expressed as log CFU/g.

Statistical analysis

Data are shown in graphical representation as mean ± SD. One-way ANOVA was performed to find a significant difference at the level of $P < 0.05$ on various parameters between different groups.

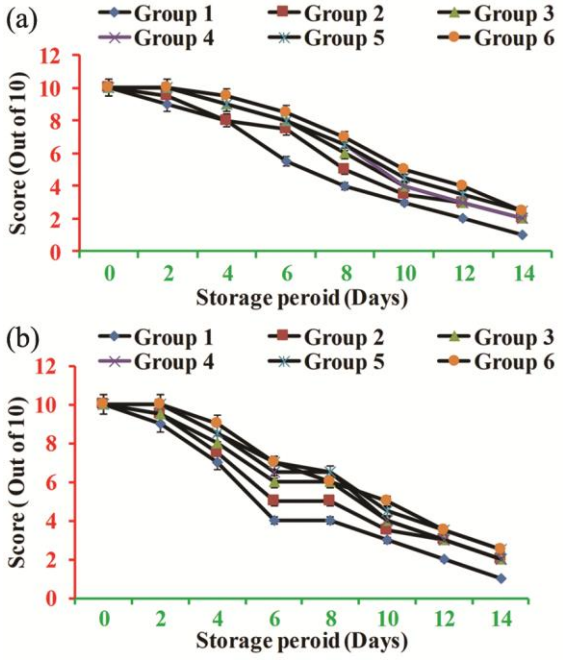

Fig. 1 — Sensory evaluation and Overall acceptability of raw and cooked fish: (a) Raw fish (b) Cooked fish. Significant difference ($P < 0.05$) found in the overall acceptability of all the groups for both fresh and cooked fish.

Results

Sensory analysis

The overall sensory score (organoleptic score) of fish stored in chilled condition and cooked fish for different groups were significantly differed ($P < 0.05$) from 0 – 14th day (Fig. 1a and b). The sensory scores for deveined

fish coated with 5 % turmeric (group 6) were recorded with a highest score of 3.6 ± 0.06 scales (just acceptable) on the 14th day. Group 3 undeviened coated with 5 % *S. asperum* powder, group 4 deveined coated with 5 % *S. asperum* powder and group 5 undeveined coated with 5 % turmeric were just acceptable on the 12th day, whereas group 2 (only deveined) and group 1 (without any application) were just acceptable on the 10th and 8th day, respectively (Fig. 2). All the groups were rejected by the panelists after 14th day because of strong fishy to sour odours and soft texture except group 6 (just acceptable). Cooked fish samples for all the groups produced sour and ammonia odour with mushy texture and bitter flavor at the end of the storage period day 14 (Fig. 3).

Physical, biochemical and bacteriological analysis

pH

The pH values of all the six groups varied from 6.6 ± 0.1 to 6.8 ± 0.03 on the 0th day. The pH values

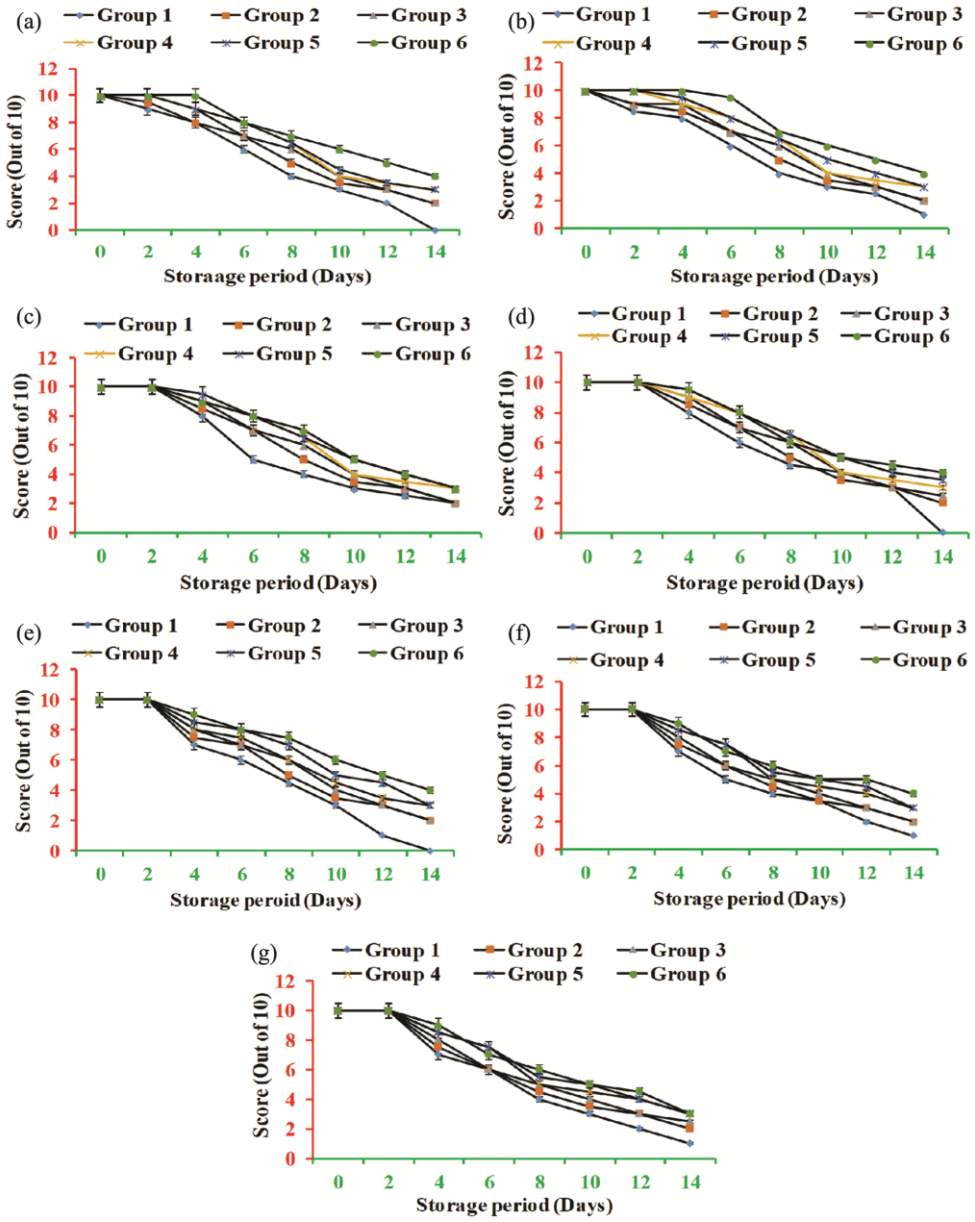

Fig. 2 — Organoleptic score for appearance, skin colour, stiffness, eye clarity, mucus, smell and body colour of raw fish stored in ice for 14 days: (a) Eye clarity (b) Colour (c) Stiffness (d) Gill colour (e) texture (f) Odour and (g) Mucus. Values are expressed as mean ± SD. Significant difference ($P < 0.05$) found in all the organoleptic parameters among the groups.

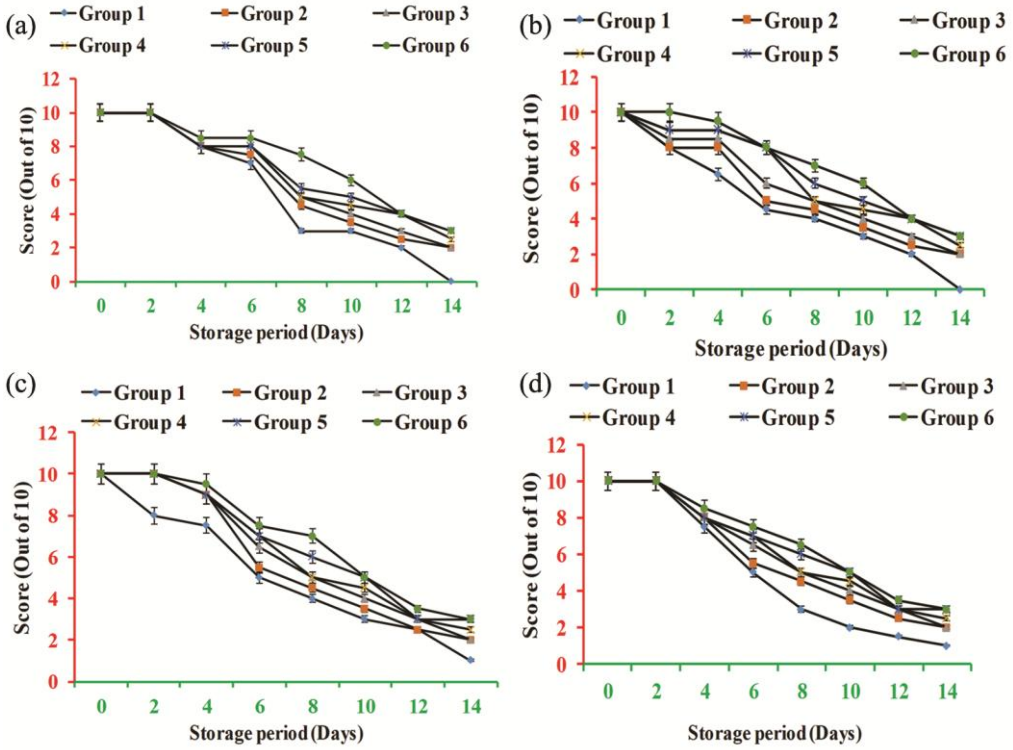

Fig. 3 — Organoleptic score for (a) Colour (b) Odour (c) Taste and (d) Texture of cooked fish stored in ice for 14 days. Values are expressed as mean ± SD. Significant difference (P < 0.05) found in all the organoleptic parameters among the groups.

gradually increased when the storage days increased and there was a significant difference (*P < 0.05*) between the groups. At the end of the storage period (14th day), pH value raised to 7.7 ± 0.09 in the group 1 (fish without any application) and in group 6, pH value reached up to 7.2 ± 0.15 (Fig. 4a). The pH value was significantly lower in group 6, deveined fish coated with 5 % turmeric when compared to group 1 (7.7 ± 0.13), 2 (7.5 ± 0.18) and 3 (7.4 ± 0.1). However, on the 14th day, there was no much difference in the pH values among the group 4 (7.3 ± 0.15), 5 (7.3 ± 0.017) and 6 (7.2 ± 0.07).

Biochemical analysis

Figure 4b demonstrates the protein level of fish in different experimental groups. The total protein value was varied between 16.5 ± 0.4 and 16.7 ± 0.13 % in all the six groups on 0th day and the level were reduced significantly when the storage days increased. At the end of the experiment, on the 14th day, the lowest level of total protein content of 8.6 ± 0.07 % was observed in group 1 and the highest protein level of 12.6 ± 0.03 % was recorded in group 6. Subsequently, on the 14th day, group 2, 3, 4 and 5 showed a moderate level of 9.3 ± 0.17, 9.3 ± 0.15, 9.7 ± 0.04 and 9.7 ± 0.02 % in the total protein value respectively. Similarly, on the 0th day for all the six groups the carbohydrate level was ranged from 0.91 ± 0.91 to 0.93 ± 0.02 % and the level was gradually decreased from 0.36 ± 0.01 to 0.52 ± 0.02 % when the storage period increased (Fig. 4c). The highest reduction of carbohydrate 0.57 ± 0.01 % was observed in group 1 (0.93 ± 0.02 to 0.36 ± 0.03 %) and low of 0.39 ± 0.01 % (0.91 ± 0.01 to 0.52 ± 0.01 %) was observed in group 6. In group 2, 3, 4 and 5 showed the reduction of carbohydrate 0.52 ± 0.01 %, 0.47 ± 0.01 %, 0.43 ± 0.01 % and 0.43 ± 0.01 %, respectively. In the same way, in the entire group the lipid content was reduced from 0 to 14th day. In group 6 the lipid content was reduced from 2.2 ± 0.08 to 1.7 ± 0.06 % (0.5 %), however, in group 1 the lipid level was reduced from 2 ± 0.25 to 1.2 ± 0.1 % (0.8 %). There was no significant difference in lipid value among the group 4 (0.5 %), five (0.5 %) and 6 (0.5 %) (Fig. 4d). Overall, there was a significant difference (*P < 0.05*) in protein, carbohydrate and lipid level between the groups in chilled storage conditions from 0 – 14th days. The biochemical analysis of the fish muscle of the deveined fish group coated with 5 %

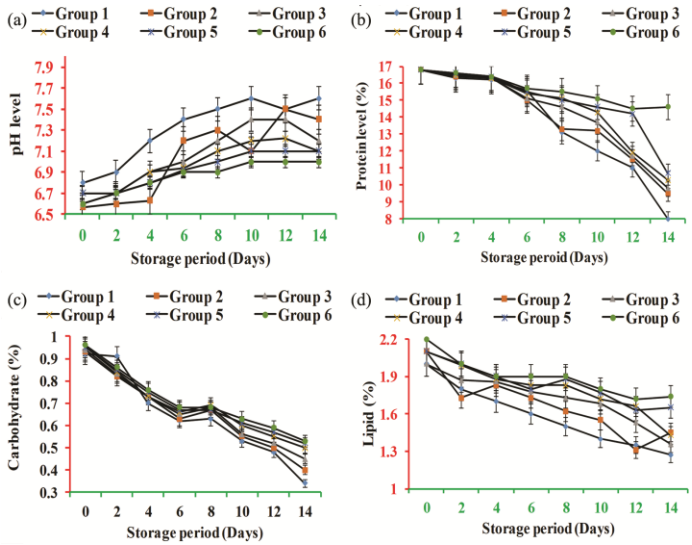

Fig. 4 — pH, protein, carbohydrate and lipid analysis of raw fish stored in ice for 14 days: (a) pH, (b) Protein (c) Carbohydrate and (d) Lipid. Values are expressed as mean ± SD. Significant difference ($P < 0.05$) in the level of pH, protein, carbohydrate and lipid was found among the groups.

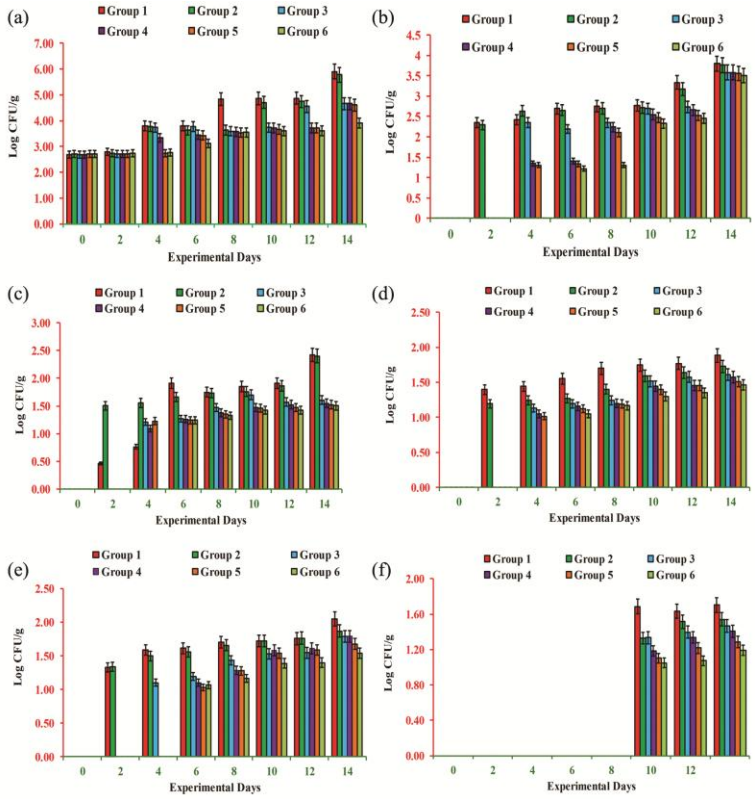

Fig. 5 — Bacteriological analysis of fish *Sillago sihama* during ice storage for 14 days: (a) TPC (b) *Proteolytic bacteria* (c) *Vibrio* (d) *Pseudomonas* (e) *Aeromonas* and (f) *E. coli.* Values are expressed as mean ± SD. Colony forming unit was significantly different ($P < 0.05$) among the group for all the bacteria. CFU-Colony forming unit.

turmeric showed less reduction in total protein, carbohydrate and lipid from the 0^{th} day to 14^{th} day when compared to other groups.

Bacteriological analysis

The effect of turmeric and *S. asperum* powder on the bacterial population in the chilled fish was

expressed as log CFU g^{-1} (Fig 5). No *Salmonella* growth was observed in any of the groups. Group six showed no bacterial growth till the 4th day in any of the selective media plates except TPC. All other groups showed bacterial growth on the specific media from the second and fourth day onwards. The highest log CFU g^{-1} of TPC (5.9 ± 0.07), proteolytic bacteria (3.79 ± 0.14), *Vibrio* (2.42 ± 0.01), *Pseudomonas* (1.88 ± 0.09), *Aeromonas* (2.05 ± 0.02) and *E. coli* (1.70 ± 0.06) in group 1, whereas, least log CFU g^{-1} value of 3.9 ± 0.03, 3.5 ± 0.02, 1.5 ± 0.03, 1.46 ± 0.02, 1.54 ± 0 and 1.19 ± 0.04 were observed in group six on the 14th day, respectively (Fig. 5). The group four fish coated with 5 % of seaweed also demonstrates low log CFU g^{-1} of TPC (4.66 ± 0.02), proteolytic bacteria (3.58 ± 0.02), *Vibrio* (1.55 ± 0.03), *Pseudomonas* (1.57 ± 0.04), *Aeromonas* (1.79 ± 0.02) and *E. coli* (1.41 ± 0.03) than the group one however the value was higher than the group six on the 14th day. The bacteriological study result showed significant difference ($P < 0.05$) between the groups.

Discussion

Shelf-life of the fish from harvest to human consumption is very important criteria for the processor or retailer to plan the time length of the product and market control. Fishing area, method of fishing, handling practices, ice ratio during storage, storage time, type of fish and microbial flora of the fish could affect the quality and shelf-life[16,17]. The rate of deterioration during packing depends on the biochemical composition of substrate and metabolites in the fish tissue, microbial contamination and the condition of ice ratio. There is a lack in hygienic handling practices, improper refrigeration and awareness of seafood safety and wholesomeness in the Indian seafood market. The present study was carried out to find out the possibility of the extending shelf life of the capture fish by improving the storage condition and applying traditional preservative to support the local seafood suppliers and retailers for quality distribution to Indian consumers. In the present study the effect of turmeric and seaweed *S. asperum* powder on shelf-life extension of the Indian white fish *Sillago sihama* in a chilled condition was performed based on the sensory analysis, pH, total protein, carbohydrate, lipid and bacterial population to find out the possibilities of shelf-life extension.

Chilling is an important temporary method to protect seafood against the deteriorating effect. Ice reduces the temperature to about 0 °C which lowers the growth rate of spoiling and pathogenic microorganisms[18]. In our study, 1:1 fish and ice ratio were maintained to retain the temperature. In general, turmeric was used as a disinfectant in traditional medicine to overcome the many microbial infections and recently very few studies reported that turmeric effectively minimizes the deterioration of sea food[19]. Further, brown seaweed contains a large number of cell-wall polysaccharides and it has been reported that these compounds possess antibacterial, antioxidant and other biological activities. The major deteriorating process that affects the texture, colour and flavor of the fish are microbial spoilage and autolysis process. Hence, in this study, the fish skin surface was coated with turmeric (5 %) and *S. asperum* powder (5 %) separately to inhibit the bacterial invasion. In addition, gut and gills were removed in group 2, 4 and 6 to minimize widening of the microbial contamination.

According to the sensory evaluation, good quality was retained only for 8 days in group 1 (undeveined and without application) stored in chilled conditions (1:1), whereas the deveined fish coated with 5 % turmeric (group 6) showed long shelf-life, just accepted up to 14 days than the group 1. The *S. asperum* powder (5 %) applied group demonstrates shelf-life of 12 days. The significant difference ($P < 0.05$) found in the sensory score between the experimental groups of fresh and cooked fish. This indicates the application of 5 % turmeric support the extension of shelf-life in stored fish up to 14 days and application of 5 % *S. asperum* powder extended the shelf-life up to 12 days. The shelf-life of fish stored in chilled ice without any preservatives was extended up to 8 days. This observation was in agreement with previously published studies were extended shelf-life of 8 days was observed during an ice storage condition[20-22]. The sardines retained good quality for five days and acceptable up to 15 days when stored in slurry ice alone. However, in the present study, deveined fish (remove gill and gut) stored in chilled condition extend the shelf life up to 10th day, it shows that removal of gill and gut reduce the deterioration of fish and improves the shelf-life.

The pH of the live fish muscle is close to the value of 7.0 ± 0.08, however, after death the pH may vary from 6.0 ± 0.05 to 7.1 ± 0.20 depending on season, species and another component. In the case of fish *S. sihama* stored in ice at the ratio of 1:1, pH increased significantly with storage time and reached the value of 7.7 ± 0.09 on the 14th day. This is because

of significant growth of alkalinizing bacteria in this batch, including accumulation of ammonia with the concomitant deleterious effects on sensory quality. Likewise, slight increases in pH level from initial values of 5.9 ± 0.06 to a final pH of 6.2 ± 0.1 have been reported in other fishes, including sardines[23]. In the present study, in group 1 the initial pH value was 6.8 ± 0.21 and increased to 7.7 ± 0.09 at the end of the experiment. The fish without gill, gut and coated with 5 % turmeric showed the lowest pH value of 7.2 ± 0.15 at the end of the experiment (14^{th} day), this confirms that significant inhibition of alkalinizing microbial flora. The pH results in all the six groups differs significantly ($P < 0.05$). Furthermore, this pH result correlated with other nutritional and microbial parameters.

The chemical composition of any edible organisms during storage condition is extremely important, since the nutritive values are reflected in its biochemical contents. The total protein content retained till the 8^{th} day for all the groups and it was gradually reduced ($P < 0.05$) when the day extended. This result coincides with the report of rainbow trout muscle hydrolyzed during chill storage for five days showed loss of function of proteins[20]. In group 6, the total protein content was high due to deveining (removal of gill and gut) and application of 5 % turmeric. Deveining and application of turmeric slowdowns the denaturation process of the protein in the fish muscle by reducing the enzymatic and microbial activity. Carbohydrate is the principal and immediate source of energy for organisms, immediately after the death of fish, the cells start breakdown the stored glycogen (glycolysis) and degrade the energy rich carbohydrate[24]. Hence, in this study very less content of carbohydrate was observed in all the experimental groups. Group six showed low reduction of carbohydrate percentage than the other groups due to deveining (removal of gill and gut) and application of 5 % turmeric slowing down the degradation process of carbohydrate in fish muscle.

Generally, during fish storage a considerable amount of free fatty acid appears, it is more profound in ungutted fish (undeveined) than the gutted fish (deveined) due to the involvement of digestive enzyme[25]. In group 6, the fish gill and gut was removed immediately and coated with 5 % turmeric that reduces the enzymatic activity, denaturation process i.e lipid oxidation. This may be the reason for the high content of lipid in group six than other groups. Lipid oxidation generates low molecular weight carbonyl and alcohol compounds by the breakdown of hydroperoxides, lead to the changes in fish quality which affects the colour, texture, flavor and odour[26]. Thiansilakul *et al.*[5] reported that off-odour development in sea bass and red tilapia correlated with lipid oxidation during 15^{th} days of storage in a chilled condition. In the present study, in all the experimental group shows gradual decrease in total protein, carbohydrate and lipid content and the level was significantly differed between the groups ($P < 0.05$). However, the highest reduction was observed in group 1, fish stored in ice only, whereas in group 6, nutritive values retained to some extent. Interestingly, the results of the biochemical values were significantly correlated with pH, sensory evolution and bacterial load. This proves that removal of gill and gut and application of turmeric 5 % delay the denaturation process of protein, carbohydrate and lipid content in the fish muscle.

Immediately after the death of fish, microorganism invaded into fish flesh and react with the complex mixture of natural substance present in the fish tissue which provides an ideal growth medium for bacteria[27]. In the present study, all the bacterial groups showed a notable increase in their count when the days increased. In group 1 (Undeveined without any application) stored in ice shows a steady increase ($P < 0.05$) in the bacterial population than other groups. However, bacteria *Vibrio*, *Pseudomonas*, *Aeromonas*, *E. coli* growth was significantly lower ($P < 0.05$) in group six when compared to the other groups. Thus, the result confirms that the deveined and application of 5 % turmeric in chilled storage condition may indirectly support to maintain the bacterial load in *S. sihama.* In general *Pseudomonas*, *E. coli*, *Salmonella*, proteolytic and lipolytic bacteria are responsible for bacterial spoilage of fresh fish after capture[28]. The presence of the higher bacterial count in the fish skin sample than other organs may be due to the improper handling during harvest and processing. Majeed and MacRae[29], observed that most of the bacterial flora associated with spoilage in fish were gram negative. In the present study, TPC log value 5.9 ± 0.07 CFU g^{-1} was observed on the 14^{th} day for the group one, whereas for the deveined fish coated with 5 % turmeric, group 6 was 3.9 ± 0.03 CFU g^{-1}. Similarly, group 4 deveined fish coated with 5% seaweed powder shows Log CFU g^{-1} of 4.66 ± 0.02 CFU g^{-1}. It is generally accepted that fish with bacterial load of 10^6 CFU g^{-1} is likely to be at the stage being unacceptable from the microbial point of

view and unfit for the human consumption[16]. Besides, the count of pathogenic bacteria was higher in group one on 14th day, whereas it observed normal in group coated with turmeric and *S. asperum* powder. The bacteriological study results suggested that the fish stored in chill condition (1:1) with the deveined and application of 5 % turmeric and 5 % seaweed powder reduce the spoilage and thereby extend the quality of chilled fish.

In conclusion storage of Indian white fish, *S. Sihama* in ice (1:1) deveined with 5 % turmeric allowed a remarkably good maintenance of sensory, pH, biochemical and bacteriological quality involving an extension of its shelf life up to 14 days when compared with other groups. On the basis of results obtained from the present study, proper handling, ice storage condition (1:1), deveined and application of 5 % turmeric might help the processor and retail marketer to maintain the quality, thereby extend the shelf life of Indian white fish, *S. sihama* in chilled storage condition.

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Conflict of Interest

The authors declares that there is no conflict of interest.

Author Contributions

PR, MV, AM and RA: Conceptualization, Methodology, Investigation, Writing-Original Draft. SP: Formal analysis, Writing-Review and Editing. KK and EK: Writing-Review and Editing. NMP: Methodology, Supervision and Writing-Review and Editing.

References

1 Jag Pal, Shukla B N, Maurya A K, Verma H O, Pandey G, *et al*., A review on role of fish in human nutrition with special emphasis to essential fatty acid, *Int Fish Aquc Stu*, 6 (2) (2018) 427-430.

2 FAO, EAF-Net. About the EAF Toolbox. FAO Fisheries and Aquaculture Department, Rome, (2012).

3 Pereira H M, Leadley P W, Proenca V, Scharlemann P W, Fernandez J F, *et al*., Scenarios for global biodiversity in the 21st century, *Science*, 330 (2010) 1496-1501.

4 Gram L & Huss H H, Fish and shellfish products In: *The microbiological safety and quality of foods*, edited by B M Lund, T C Baird Parker and G W Gould, (Aspen Publishers Inc., Gaithersberg, Maryland, USA) 2000, 472-506.

5 Thiansilakul Y, Benjakul S & Shahidi F, Compositions, functional properties and antioxidative activity of protein hydrolysates prepared from round scad (*Decapterus maruadsi*), *Food Chem*, 103 (4) (2007) 1385-1394.

6 Yeragi S S & Yeragi S G, Food and feeding of an economically important estuarine fish, *Sillago sihama* (forsskal), *Int J of Life Sciences*, 3 (2) (2015) 147-151.

7 Amrita V, Sonal D & Rai S, Antibacterial Effect of Herbs and Spices Extract on *Escherichia coli*, *Elec J Biology*, 5 (2) (2009) 40-44.

8 Augustine A, Anitha P, Gopi S & Gopi S, Biological activities of curcuminoids, other biomolecules from turmeric and their derivatives – A review, *J Tradit Complement Med*, 7 (2) (2017) 205–233.

9 Nasrin M, Hossein N, Jaleh B, Solmaz E & Amir Hossein M, Chemical Constituent and Biological Activities of *Spatoglossum asperum* J. Agardh from Oman Sea, *Lett Drug Des Discov*, 15 (3) (2018) 263-269.

10 Maruthupandi T & Ajith kumar T T, Antibacterial effect of fucoidan from *Sargassum wightii* against the chosen human pathogen, *J Pharm Pharm Sc*, 2 (2013) 156-158.

11 Subramanian P, Manoharan V, Thangapandi M, Periyannan R & Prabhu N M, In vitro antioxidant and antibacterial activity of sulphated polysaccharides isolated from *Spatoglossum asperum*, *Carbo Poly*, 170 (2017) 296–304.

12 De Silva M P K S K, Senaarachchi W A R K & Liyanage N P P, Evaluation of sensory and proximate properties of reservoir grown tilapia (*Oreochromis niloticus*) and cage cultured genetically improved farmed tilapia (gift), *Int J Fish Aqua Stu*, 2 (2015) 10-13.

13 Lowry O H, Rosebrough N J, Farr A L & Randall R J, Protein measurement with the folin phenol reagent, *Int J Biol Chem*, 193 (1951) pp. 265.

14 Folch J, Lees M & Sloane Stanely G H, A simple method for the isolation and purification of total lipids from animal tissues, *Int J Biol* Chem, 226 (1957) 497-507.

15 Roe J H, The determination of sugar in blood and spinal fluid with anthrone reagent, *J Biol Chem*, 212 (1995) 335-343.

16 Apha, *Compendium of methods for the microbial examination of food*, 3rd edn. (American Public Health Association, Washington DC, USA) 2002, pp.183-198.

17 Connell J J, Control of Fish Quality-Proposed limit of acceptability for Marine Species, *Fishing News Ltd*, Surrey, England, (1995) pp. 179.

18 Gram L & Huss H H, Microbiological spoilage of fish and fish products, *Int J Food Microbiol*, 33 (1996) 121-137.

19 Huss H H, Quality & Quality changes in fresh fish, *FAO Fisheries Technical Paper 348*, FAO, Rome, Italy, vol. 195 (1995).

20 Shamima A, Abu T & Md Abdul K, Studies on the Performance of turmeric with salt as a preservative for the curing of two lean fishes in laboratory condition, *Bangladesh J Zool*, 35 (1) (2007) 49-60.

21 Marrakch E L, Bouchrit N, Bennour Hamama A & Koufaka A, The bacteriology of Moroccan Sardine (*Sardina pilchardus*) stored in ice: Nature of the bacterial flora, *Microbiology, Aliments, Nutrition,*10 (1992) 61-68.

22 Ababouch L H, Souibri L, Rhaliby K, Ouahdi O, Battal M, *et al*., Quality changes in sardines (*Sardina pilchardus*) stored in ice and at ambient temperature, *Food Microbi*, 13 (2) (1996) 123-132.

23 Campos C, Rodriguez O, Losada V, Aubourg S & Barros-Velazquez J, Effects of storage in ozonised slurry ice on the sensory and microbial quality of sardine (*Sardina pilchardus*), *Int J Food Microbiol*, 103 (2005) 121-130.

24 Nunes M, Batista I & Morao R D C, Physical, chemical and sensory analysis of sardine (*Sardina pilchardus*) stored in ice, *J Sci Food Agric*, 59 (1992) 37-43.

25 Mahapatra B K, Subhendu D, Pailan G H, Pardar P & Manilkumar S, Training manual on fish processing & value added fish product, Central Institute of fisheries Education, 3rd edn, (2013).

26 Bahri P, Ayse G I, Gulsum O & Irfan I, Microbiological and chemical qualities of salted grey mullet, *Int J Sci Techno*, 2 (2006) 91-98.

27 Al-reza S, Karmaker S, Roy S, Hoque R & Rahman N, Effect of traditional fish processing methods on the proximate and microbiological characteristics of *Laubuka dadiburjori* during storage at room temperature, *J Fish Aquat Sci*, 10 (2015) 232-243.

28 Cai L, Wu X, Li X, Zhong K, Li Y, *et al.*, Effects of different freezing treatments on physicochemical responses and microbial characteristic of Japanese sea bass (*Lateolabrax japonicas*) fillets during refrigerated storage, *LWT-Food Sci Technol*, 59 (2014) 122–129.

29 Majeed K N & MacRae I C, Experimental evidence of toxin production by *Aeromonas hydrophila* and *Aeromonas sobria* in meat extract at low temperature, *Int J Food Microbiol*, 12 (1991) 181-188.