Effect of turmeric on shrimp (*Penaeus semisulcatus)* shelf life extension in chilled storage conditions

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Abstract

The present investigation aimed to evaluate the effect of turmeric on shelf life extension of shrimp *Penaeus semisulcatus* under chilled storage conditions by sensory (organoleptic parameters), pH, proximate and bacterial analysis. The experimental setup was grouped into six, head on (group I), head on coated with turmeric (group II), headless (group III), headless coated with turmeric (group IV), peeled (group V) and peeled and coated with turmeric (group VI) groups. Peeled shrimps coated with turmeric group retained their quality and their shelf life was extended up to 8 days of storage in ice (1:1). Significant differences (p<0.05) were found in the overall acceptability among the experimental groups of fresh and cooked shrimp. The level of pH, protein and carbohydrate varied (p<0.05) among the experimental groups. However no significant difference was found in the lipid and bacterial level in peeled shrimp coated with turmeric on the 8th day compared to other groups including the control. The sensory analysis, pH, protein, carbohydrate, lipid and bacteriological results of the present study proved that the application of turmeric in peeled shrimp stored in ice (1:1 ratio) extended its shelf-life up to 8 days.

Keywords: Shrimp, Shelf life, Turmeric, Chilled storage, Sensory analysis, Sea food

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Introduction

Marine shrimps are one of the most traded seafood commodities worldwide with trade volume and value reaching new heights and expected to carry on rising. Over the last decades worldwide production of shrimp has increased exponentially and accounts for 16 % of global seafood exports (FAO, 2014). In India shrimp export generated the value of 8833.29 crores from an export Quantum of 2.09 lakh tones during the year 2012-13 (MPEDA, 2013). Shrimps are distributed as live, fresh, chilled, frozen, cooked and ready-to-eat products or a combination of two or more of these forms for export market. The Indian shrimp export and local consumption was contributed by five major species i.e. *P. monodon, P. indicus, P. vannemi, P. semisulcatus* and *P. merguiensis*. Out of these, two of them were from capture fisheries namely *P. semisulcatus* and *P. merguiensis,* and the remaining species were from aquaculture production.

Shrimps are also sold in chilled condition in the Indian market because of consumer preference. In the last two decades, improvements in the packing system, innovations in refrigeration, ice making and transportation have also supported the distribution of shrimps in fresh condition. Shrimps need timely harvest, immediate transportation with appropriate storage conditions. Use of quality ice and hygienic packaging are mandatory to maintain the quality of shrimps (Otwell *et al*., 2001). Proper storage and transport will extend the shelf life of shrimp, which also control both the enzymatic and microbiological deterioration of the shrimp. Loss of quality in seafood has been considered hazardous to consumers due to the proliferation and colonization of pathogenic bacteria such as *Salmonella* and *Vibrio* species with accumulation of unpleasant metabolites (Connell and Shewan 1990; Palumbo *et al.* 1992; FDA, 2001; Otsuka *et al.*, 2007).

The rate of deterioration in shrimp is highly temperature dependent and inhibited by reducing the storage temperature (Sivertsvik *et al*., 2002). The most prevalent method of retarding spoilage of seafood is icing (Surendran *et al*., 1989). Immediately after death, several biochemical and enzymatic changes occur in muscles of seafood especially with improper handling which may quicken degradation activities (Pereira *et al*, 2010). Turmeric has been used in Indian traditional medicine to prevent bacterial and fungal growth and it offers more than 600 health benefits. Moreover, turmeric has been used as an ingredient in Indian food recipes. Therefore, the present study aimed to evaluate the effect of turmeric on shelf life extension of shrimp *Penaeus semisulcatus* in chilled storage conditions from the catching point.

Materials and methods

Shrimp collection and storage

Live *P. semisulcatus* shrimps with an average body weight of 10 g were collected from fishermen, Kattumavadi landing centre (latitude: N 10° 9.0174', longitude: E 79° 5.5076') located in the East Coast of India, Gulf of Mannar region. Live shrimps were chill killed in ice slurry and then packed in ice in clean insulated boxes at a ratio of 1:1 (ice: shrimp) and transported to the laboratory within three hours. Shrimps were divided into six different groups and packed in individual groups in the polythene bags (food grade) to avoid direct contact with ice. Commercially available food grade turmeric powder was mixed with sterile distilled water and made into turmeric paste. This paste was applied over the shrimps (coating the shrimps) and packed in polythene bags. Shrimp groups were kept in two thermo cool boxes lined with polythene sheets (10 kg capacity each). Ice was replaced once in every 12 hours to maintain the temperature of the shrimp. Shrimp samples (500 g) were drawn from each group once in two days to evaluate their quality through sensory, pH, proximate and bacterial analysis.

Experimental setup

Group I	Head-on
Group II	Head-on coated with 0.5% of turmeric paste
Group III	Headless
Group IV	Headless coated with 0.5% of turmeric paste
Group V	Peeled (removal of head and shells of the shrimps)
Group VI	Peeled and coated with 0.5% turmeric paste

Sensory analysis

Six experts examined organoleptic or sensory attributes of raw and cooked shrimp to determine the quality characteristics. Starting from day 0, 500 gm from each group was randomly sampled and evaluated for their sensory characters. Ice stored shrimps were thawed and steam cooked (5 min) for flavor analysis. Panelists were asked to examine the appearance, odor, texture, taste and overall acceptability of raw and cooked shrimps. Ratings were assigned separately for each parameter on a 1 – 9 scale. With the help of the taste panel, sensory assessment was done by modified sensory score sheets and overall acceptability ranking was tabulated (Tables 1, 2). Seven categories were ranked as; highly acceptable (10-8.5), acceptable (8.4-6.5) moderately acceptable (6.4-4.5), just acceptable (4.4-3.5), just unacceptable (3.4-2.5), unacceptable (2.4-1.5) and rejected (1.4-0). Different panelists scores were averaged and recorded.

Table 1: Modified organoleptic score chart for fresh shrimp.

S. No	Shell	Color	Tail	Texture	Odor	Marks
1	Natural and bright	Greenish and natural	Natural	Hard	Fresh natural and fishy	8-10
2	Moderate Natural	Moderate green	Moderate	Slightly hard	Slight fresh	7- 8
3	Slightly loss and of brightness	Slight greenish	Slight	Moderate hard	Moderate	6-7
4	Loss of brightness and opaque	Slight darkening	Losing the shape	Slightly hard	Sweaty odor Slight spoil odor	4-6
5	Slightly reddish shell become lose	Moderate Darkening	Dark patches	Soft and loss of elasticity	Moderate Spoil odor	2-4
6	Shell total lose and darkening	Darken	Total color change	Very soft Loss of elasticity	Extremely off odor	0-2

Table 2: Modified organoleptic score chart for cooked shrimp.

S.No	Color	Odor	Taste	Texture	Marks
1	Natural	Fresh fishy odor	Sweet and natural seaweedy	Firm and good elasticity	8-10
2	Moderate	Moderate	Moderate and seaweedy	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 Odor	Tasteless and moderate sour and bitterness	Slightly chewy and total loss of firmness	4-2
5	Total colour change	Extremely off odor and ammonia smell	Off flavor and bitterness	Soft and mushy	1-0

Physical and biochemical analysis

pH

The pH was measured by means of a glass electrode pH meter (EuTech instruments). Before each reading, the electrode was rinsed with distilled water. 10g of shrimp muscle sample were homogenized with 50 mL of sterile distilled water and the pH was measured in each group after ten minutes.

Biochemical analysis

The total protein, lipid and carbohydrates concentration of the shrimp tissue was estimated by following the methods described by Lowry *et al*. (1951), Folch *et al*. (1957) and Roe (1955), respectively.

Bacteriological analysis

Bacteriological analysis was performed with homogenized samples of shrimp meat (10 g) with 90 mL of normal saline. Samples were serially diluted up to 10^{-6} and subjected to plating on nutrient agar, skimmed milk agar (10%), TCBS, Kings medium A base, Aeromonas isolation agar, XLD agar and MacConkey agar for the detection of Total plate count (TPC), proteolytic bacteria, *Vibrio*, *Pseudomonas*, *Aeromonas*, *Salmonella* and *E. coli* respectively. The bacterial colonies developed on the plates were counted (CFU gm^{-1}) after 24 to 48 hours of incubation at 37°C. Further, biochemical characterizations of the bacterial isolates were carried out by adopting the procedure described by Jolt *et al*. (1994), Oyeleke and Manga (2008).

Statistical analysis

Data are expressed in graphical representation as mean±SD. Statistical analysis using two-way ANOVA was performed to find significant difference at the level of $p<0.05$ on various parameters among the different groups of storage conditions. All the statistical analysis was carried out using SPSS (version 11) soft ware package.

Results

Organoleptic analysis

The sensory or organoleptic evaluation was carried out immediately after chill killing and an average score was 10 (Figs. 1 and 2). The overall acceptability score was highly acceptable (10–8.5) for all the groups of stored raw shrimp for about two days (Fig. 3a). However, the score was gradually decreased over the days and reached unacceptable condition on 8th day in group one and two. Headless and peeled shrimps coated with turmeric (group three and five), were just unacceptable on 8th day of storage, whereas group four and six retained just acceptable and acceptable condition up to 8 days of storage respectively. Likewise, group one, two and three of cooked shrimps were unacceptable (1.5–2.4) on the 8th day of storage (Fig. 3b). Cooked shrimp of group four and six, coated with turmeric, retained acceptable condition (8.4-6.5) till 6th day. All the taste panelists confirmed that sweet and fishy odor become bland, tasteless and ammonical on the 6th day for group one and three. Significant differences ($p<0.05$) were recorded among the overall acceptability of all the groups of cooked fish.

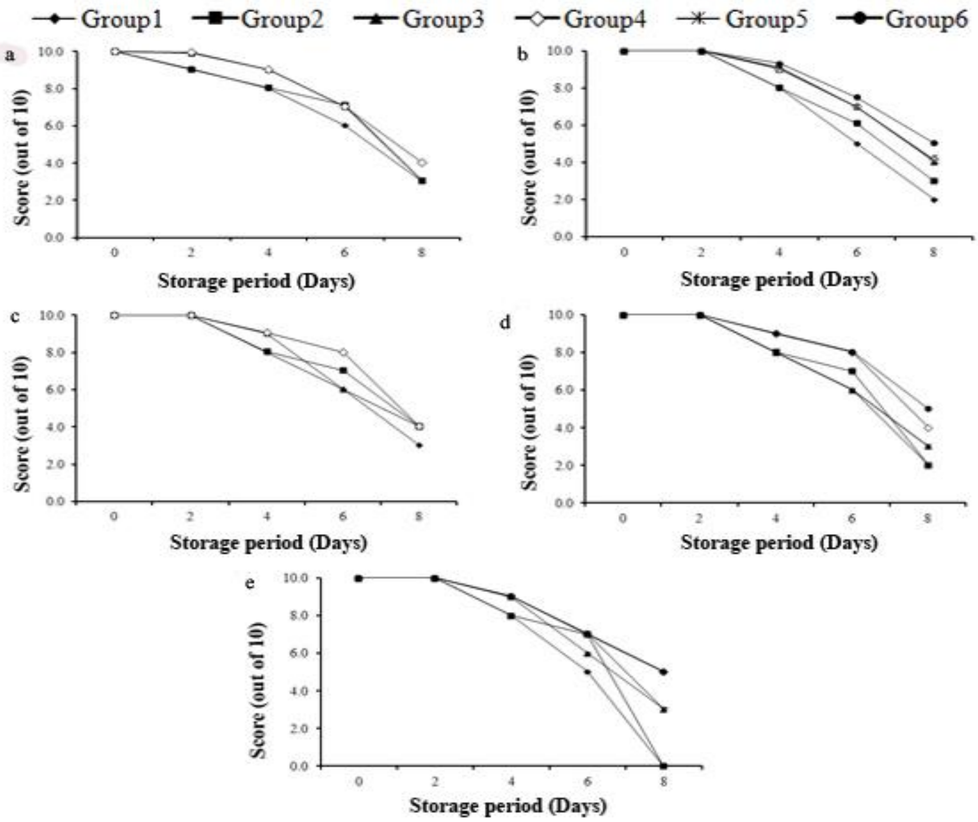

Figure 1: Organoleptic score for shell, colour, tail, texture and odour of the shrimp stored in ice for 8 days.

a-Shell, b-Colour, c-Tail, d-Texture, e-Odour. Values are expressed as mean±SD. Parameters of shell and tail are not scored for the group 5 and 6 as those were peeled shrimps. Significant difference (*p*<0.05) found in all the organoleptic parameters among the groups except tail between group 5 and 6.

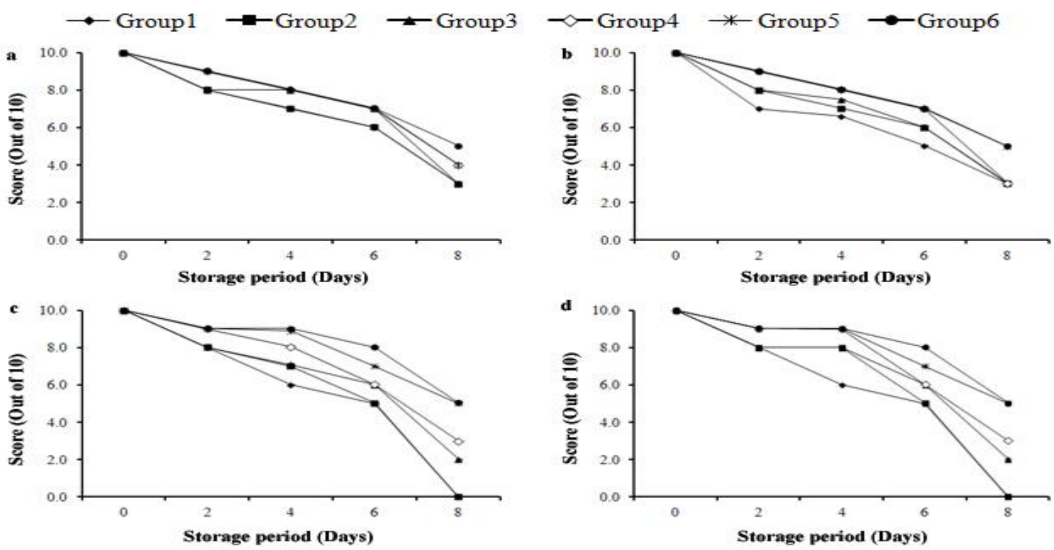

Figure 2: Organoleptic score for colour, odour, taste and texture of cooked shrimp stored in ice for 8 days.

a- Colour, b- Odour, c-Taste, d-Texture. Values are expressed as mean±SD. Significant difference (*p*<0.05) found in the organoleptic parameters among the groups.

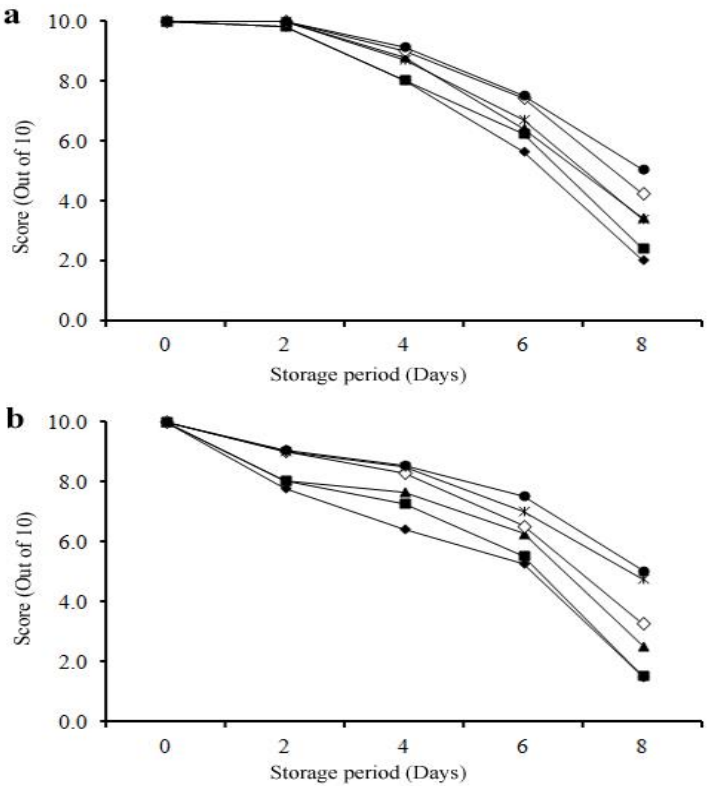

Figure 3: Overall acceptability of raw and cooked shrimp stored in ice for 14 days.
a-OAA of raw shrimp, b-OAA of cooked shrimp significant diference (*p*<0.05) found in the overall acceptibility of all the groups for both fresh and cooked shrimp.

Physical and biochemical analysis

pH

The pH of the shrimp increased steadily throughout the study period from an initial pH of 6.5 to 7.9. Significant pH difference ($p<0.05$) was noticed in group one (7.9) and six (6.9) on the 8th day of storage (Fig. 4a).

Biochemical analysis

The total protein values of all the six groups varied between 16.3 and 16.7% on day 0 of storage. The level of protein was greatly reduced in group one on the 6th day, whereas group six showed no much difference in the protein value from day 0 (16.7%) to day 6 (11.3%) of storage (Fig. 4b). Significant variation ($p<0.05$) in carbohydrate content was observed in all the groups of stored shrimp. The carbohydrate concentration was recorded as 0.52 and 0.53% in group one and two respectively, whereas it was 0.65 and 0.61% in group four and five respectively (Fig. 4c). However, group six recorded 0.73% of carbohydrate on the 8th day of storage. The lipid value for the six groups varied from 0.12–0.13% on the day 0 of the experiment (Fig. 4d). No significant differences ($p<0.05$) in lipid content were found among the groups during 8 days of storage.

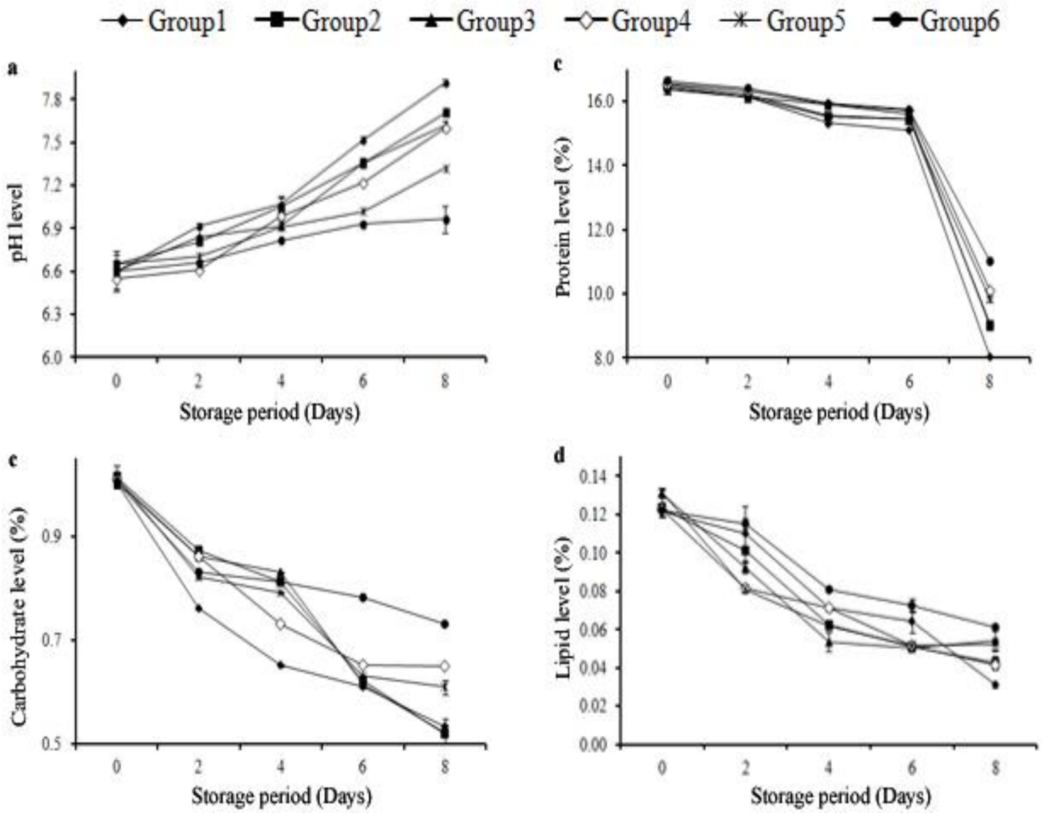

Figure 4: pH, protein, carbohydrate and lipid analysis of raw shrimp stored in ice for 8 days. a- pH level, b-Protein level, c-Carbohydrate level, d-Lipid level. Values are expressed as mean±SD. Significant difference (*p*<0.05) found in pH, protein and carbohydrate level among the groups. No difference (*p*<0.05) found in lipid level.

Bacteriological analysis

Significant differences ($p<0.05$) were observed in bacterial density among the experimental groups. There was an increase in the TPC when the storage time increased and reached 10^5 on the 8th day in all the groups (Fig. 5). Group three, four five and six were devoid of *Aeromonas* and *Salmonella* until the 8th day of storage. Shrimp group coated with turmeric (group six) registered very low level of bacterial count (10^4CFU/g) in all the selective media tested. However, head-on shrimps (group one) showed the highest bacterial load (TPC 10^5, proteolytic bacteria 10^5, *Vibrio* 10^5, *Pseudomonas* 10^5, *Aeromonas* 10^4, *Salmonella* 10^4 and *E. coli* 10^5) on the 6th day of storage. Shrimp group consisting of headless, peeled and coated with turmeric registered low bacterial count (10^3 and 10^4 CFU/g) even at the end of experiment.

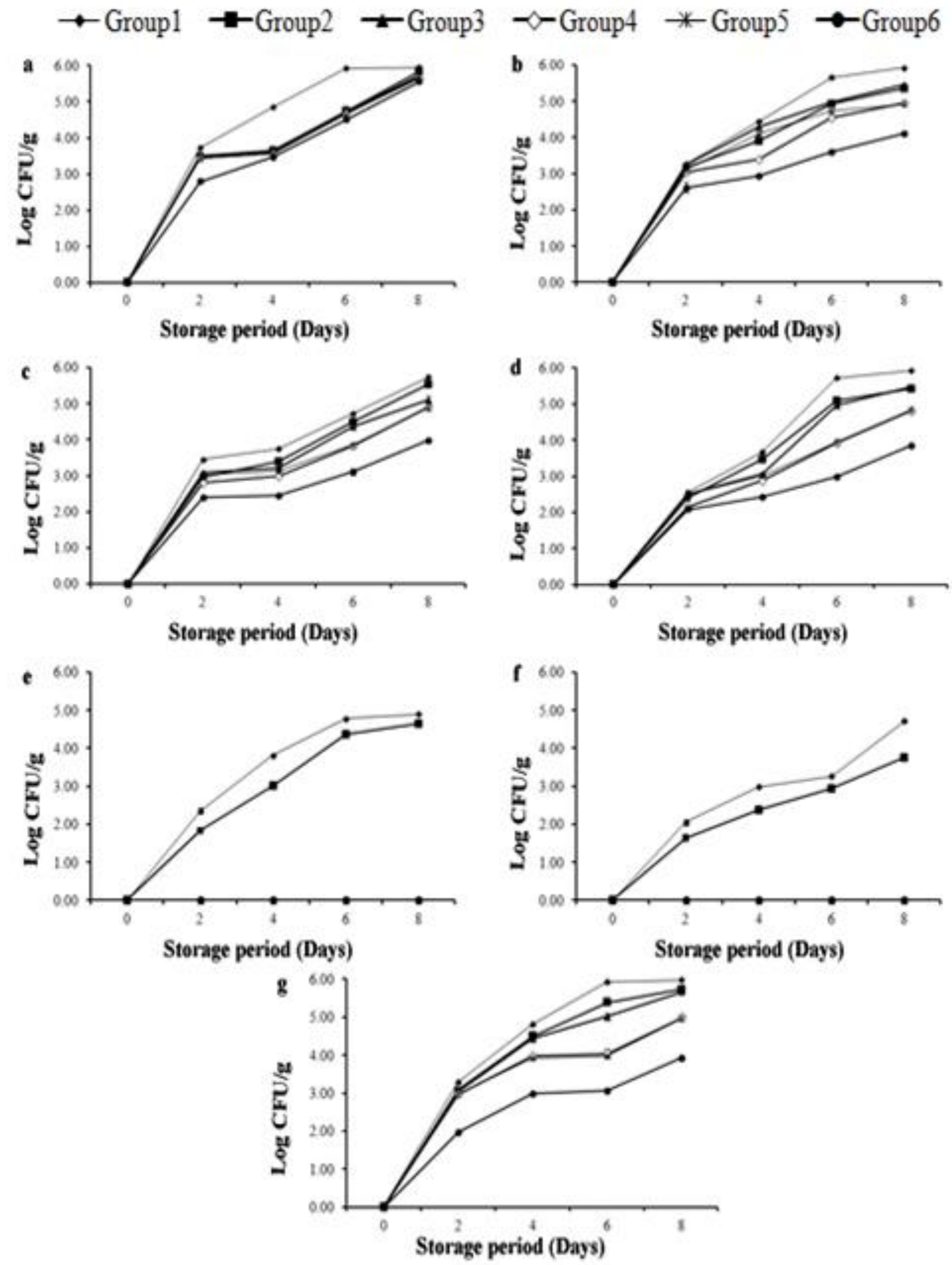

Figure 5: Bacteriological analysis of shrimp stored in ice for 8 days.
a-TPC, b-Proteolytic bacteria, c-*Vibrio*, d- *Pseudomonas*, f-*Salmonella*, g-*E.coli*. Values are expressed mean±SD. Significant difference (*p*<0.05) found among the groups for all the bacteria.

Discussion

Shrimp is the most important seafood trade worldwide (Oosterveer, 2006), and it has got a huge market value and is a promising income generator of the country. The distribution of fresh or chilled shrimp is a difficult task because it takes nearly two to four days (from catching point to selling point) to reach the interior part of the country from coastal regions. The quality of shrimp arriving at the processing plant and local market shows wide variations in due to indifferent usage of the raw material during capture, storage and transportation. Shortage in the above lead to rapid deterioration of stored shrimp and failed to retain the quality until it reached the consumer far away from the coastal area. The protein rich shrimps must be supplied to the consumer without losing their freshness. Hence, there is a need to improve storage condition of chilled shrimp. Therefore, the present study evaluated the six different approaches to extend shelf-life of shrimps and its quality by organoleptic scoring, pH, biochemical and bacteriological analysis.

There was a gradual decrease in the organoleptic parameters of shrimp observed up to eight days of storage. Both raw (9.1) and cooked (8.5) shrimp of headless and peeled group coated with turmeric scored highly acceptable until the fourth day of storage like freshly caught shrimp. Shrimps of group two, four and six were still edible at the end of six days and spoilage started after day eight. In the course of eight days, head-on shrimp underwent noticeable changes including progressive black discoloration of the head and tail due to melanosis, whereas headless shrimp documented minimum discoloration in telson region. Farooqui *et al*. (1978) reported that shrimp in ice maintained good quality for 0 - 2 days as judged by organoleptic parameters and acceptable up to 7 days and rejected after the 8th day. The results of the present study differed from the report of Shamshad *et al*. (1990), where *P. merguiensis* had a shelf-life of 13 and 9 days when they stored at 0°C and 5°C, respectively. This may be due to the species difference, capture area and maintenance of shrimp from the catching point to the landing centre.

The pH of the sample groups increased gradually, probably due to the formation of alkaline compounds like amines by deamination of amino acids (Huss, 1988). Though the pH of head-on (7.9) shrimp and headless (7.6), peeled (7.3) shrimp coated with turmeric did not how remarkable variations, it stayed behind the critical margin of pH 7.8 for acceptability (Chung and Lain, 1979). Protein value reduced from 16.45 (day 0) to 8.04% (8th day) in head-on shrimp stored in ice, whereas it was 10.12 and 11.03% (8th day) for headless and peeled shrimp coated with turmeric. The maximum protein content (15.7%) was retained until the 6th day for headless and peeled shrimp coated with turmeric. Crawford (1981) reported that shrimp collagen is more susceptible to hydrolysis by proteinase than fish collagen. This might be the major reason for faster deterioration of shrimp than finfishes. Likewise, the headless shrimp coated with turmeric retained the maximum content of carbohydrate (0.73%) until the 8th day when compared to rest of the groups where it ranged from 0.52 to 0.65%. Level of lipid content for all the groups lay between 0.16 and 0.04%, showing that the application of turmeric does not have any notable effect on retaining the lipid content of shrimp.

Total plate count (TPC) is the common method to determine the microbial spoilage of food products. Significant differences ($p<0.05$) were found in the growth of bacteria among the shrimp groups at different storage conditions. The ice stored head-on shrimp allowed the maximum growth of bacterial population than the other groups. *Aeromonas* and *Salmonella* growth was not observed in all the groups except in head-on and headless without turmeric from the 2nd and 4th day of storage, respectively. Previous investigations reported that the *Vibrio*, *Pseudomonas*, *E. coli*, proteolytic bacteria, *Aeromonas* and *Salmonella* may spoil the meat quality (Majeed and MacRae 1991; Gram and Huss, 2001). Thus, in the present study, shrimp peeled and coated with turmeric (Group 6) showing *Vibrio*, *Pseudomonas*, *E. coli*, proteolytic bacteria, *Aeromonas* and *Salmonella* ranging between 0 and 10^3 CFU/g, may have had the rate of spoilage reduced Counts reported from tropical countries also ranged from 10^3 to 10^6 CFU/g (Surendran *et al*., 1985). De Silva (1985) reported the maximum count of 10^8 CFU/gm. The results of the present investigation proved that the freshness of ice stored shrimp can meet the existing standard plate count which is 10^6 CFU /g (ICMSF, 1988).

Crustaceans and other shell fish spoil more rapidly compared with other fishes because they are small and their guts are not removed immediately after harvest which can activate autolytic spoilage. Moreover, the biological and chemical composition of the tissue supports rapid spoilage (Early and Stroud, 1982). In addition, rate of deterioration of seafood is highly temperature dependent and inhibited by maintaining low storage temperature (Sivertsvik *et al*., 2002). The shrimps used in this study were bought live from fishermen under adequate storage conditions and hygienic handling. Hence, the shelf life of shrimp stored in air-tight containers with sufficient ice (1:1) was extended because of reduced oxygen concentration which may limit chemical oxidation and reduce the growth of aerobic microorganisms. Besides, the application of turmeric has great positive impact on the storage of shrimp in ice as it retained the organoleptic characteristics, protein level and reduced bacterial growth to some extent. From practices followed and subsequent results obtained in the study suggest that proper handling and conditioned storage with sufficient ice (1:1) and turmeric might help the processors and retail market to reduce the microbial contamination and retain the nutritive value, and thereby extend shelf-life of stored shrimp.

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