

Original Research Article

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Quality Changes of White Shrimp (*Litopenaeus vannamei*) Treated with Potassium Sorbate and Sodium Metabisulphite: A Comparative Study

A. Jeyakumari*, Jesmi Debbarma, S. Remya, C.N. Ravishankar,
A.A. Zynudheen, George Ninan and K.V. Lalitha

ICAR- Central Institute of Fisheries Technology, Cochin- 682 029, India

*Corresponding author

ABSTRACT

Keywords

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The present study evaluated the quality changes of potassium sorbate (PS-1.5%), sodium metabisulphite (SMB-1.25%) dip treated white shrimps (*Litopenaeus vannamei*) stored under ice. White shrimp had a protein content of 18.8%. Fatty acid composition of shrimp meat revealed that, white shrimp had higher polyunsaturated fatty acids (PUFA) content (44.73%) followed by saturated fatty acids (35.45%) and monounsaturated fatty acids (19.65%). Biochemical quality indices such as pH, total volatile base, trimethylamine content and thiobarbituric acid value showed an increased trend during storage. The texture profile analysis showed decreased trend in hardness of shrimp meat during storage. Sensory analysis showed that PS and SMB treated sample had higher score for overall acceptability than control. Microbial analysis revealed that quality of white shrimps under ice storage had a shelf life up to 9, 12, 15days, respectively for control, SMB and PS treated samples.

Introduction

Shrimps are rich in protein, low fat and calories (Chen *et al.*, 2013). *Litopenaeus vannamei* is generally referred as pacific white shrimp or white leg shrimp. It has become more popular species of shrimp cultured in India and worldwide. Moreover, it occupies nearly 90% in the global aquaculture shrimp

production. In India, the marine product exports reached USD 7.08 billion during the year 2017-2018. Frozen shrimp had higher contribution of 68.46%. Among this 76.45% from the cultured shrimp in the total shrimp exported. It may be due to the adoption of *Litopenaeus vannamei* culture in India. The export of *L. vannamei* was 4, 02, 374 MT during 2017-18 (MPEDA, 2018). Shrimps are

highly perishable due the presence of higher amount of free amino-acids and other soluble non-nitrogenous substances which results in limited shelf life (Zeng *et al.*, 2005). Chilling or icing is the most common preservative method used worldwide to preserve the food products which retains the taste and nutritional value (Campanone *et al.*, 2002). However, quality and shelf life of shrimp during iced or refrigerated storage is limited due to microbiological enzymatic activity and melanosis. Due to increasing demand for fresh and processed shrimp, both industry and researchers are focusing to extend the shelf life of shrimp and shrimp products. Several studies have been conducted for shelf life extension of fish and shell fish with a range of natural and synthetic preservatives. However, the seafood processors are still using sodium metabisulphite dip treatment for preserving the quality of shrimp. It has been reported that sulphites and their derivatives are widely used as polyphenol oxidase inhibitors for controlling melanosis in shrimps (Montero *et al.*, 2001). Manju *et al.*, (2007) observed extended shelf life of potassium sorbate / sodium acetate treated fish than control. Thomas (2000) reported that potassium sorbate is known to inhibit a wide range of bacteria and have numerous advantages as food preservatives and also its greater solubility extends the usage of sorbate as a solution suitable for dipping and spraying. Based on the above information, the present work was undertaken to study the effect of potassium sorbate (PS)/sodium metabisulphite (SMB) dip treatment on the quality and shelf life of white shrimp under iced storage.

Materials and Methods

Sample preparation

Fresh pacific white shrimp (*Litopenaeus vannamei*) with the average weight of 30 ± 2.0 g and length 18 ± 1.0 cm were purchased from

an Aqua farm at Kokilamedu, Chennai, India and are divided into three lots. First and second lots were dip treated with potassium sorbate (PS), sodium metabisulphite (SMB) solution at the concentrations of 1.5% and 1.25%, respectively for 3 minutes. Third lot which was kept as control (C- without treated). All the samples were kept in an insulated ice box and brought to laboratory for the further analysis with iced condition (1:1, shrimp/ice). All the sample boxes kept at chill room (2° - 3° C) to avoid rapid melting of ice and required ice were replaced to compensate the melted ice. The samples were analysed up to 15 days at known interval periods.

Biochemical, microbiological and sensory analysis

Proximate composition of shrimp meat was analyzed according to AOAC, (2005). For fatty acid analysis, the fat was extracted from fresh shrimp meat by Folch *et al.*, (1957) and fatty acid composition analysis was performed using Gas Chromatography (Varian, CP-3800). pH of shrimp meat was determined by using calibrated glass electrode pH meter (Cyberscan 510; Eutech Instruments, Singapore). Total volatile base nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N) contents were determined by the method of Conway, (1950). Non-protein nitrogen was determined according to AOAC, (2005) method. Thiobarbituric acid (TBA) value was estimated according to Tarladgis *et al.*, (1960). Texture attributes of shrimps were evaluated using texture analyser (Lloyd instruments LRX plus, UK) according to the method followed by Anderson *et al.*, (1994). Sensory evaluation of whole head- on- shrimp was assessed by six trained panelist according to the method followed by Jeyakumari *et al.*, (2015) for shrimps. The mean of the scores given by the panel represented the overall acceptability of the shrimps. The score of below 4 was considered as unacceptable.

Aerobic plate count (APC) and *Staphylococcus aureus* were determined by the method of FAO, (1992). *Escherichia coli* and Enterobacteriaceae were determined according to BAM, (2002). Enterococci were determined according to the method followed by Koutsoumanis and Nychas (1999).

Statistical analysis

One way Analysis of Variance (ANOVA) was performed using Statistical Package for Social Science (SPSS) software version 16.0.(SPSS Inc, Chicago, Llinois, USA) for the obtained results. The data were analyzed at the significance level of 95% ($p < 0.05$) by using Tukey multiple range test.

Results and Discussion

Proximate and fatty acid composition of white shrimp

In the present study white shrimp had moisture, protein, fat and ash content of $78.45 \pm 0.18\%$, $18.8 \pm 0.23\%$, $1.28 \pm 0.09\%$, 1.2% , respectively. Results are agreement with earlier researchers reported for shrimp (Gokoglu *et al.*, 2008; Jeyakumari *et al.*, 2015). Fatty acid composition revealed that, white shrimp had higher polyunsaturated fatty acids (PUFA) content (44.73%) followed by saturated fatty acids (35.45%) and monounsaturated fatty acids (19.65%). Lin *et al.*, (2003) also observed similar results in white shrimp.

Moisture, pH and Non Protein Nitrogen Content (NPN)

In the present study, moisture content showed increased trend in white shrimp during ice storage (Fig. 1). Jeyakumari *et al.*, (2015) also observed similar results for white shrimp which was iced at various time intervals and explained that increasing moisture content

during progressive storage may be due to the loss of proteins and other soluble substances. pH of shrimp meat showed increased trend in pH during storage (Fig. 2). Dileep *et al.*, (2005) reported that increase pH in muscle foods is associated with the accumulation of basic compounds, mainly resulted from microbial action. However, PS and SMB treated sample showed less pH than control. Nirmal and Benjakul (2009) also observed similar results for ferulic acid treated white shrimp and reported that it may be due to during treatment, some of the basic decomposed compounds might be leached out to some extent. In the present study, NPN content showed decreasing trend (610-602 mg %) during chilled storage in the control (Fig. 3). Jeyakumari *et al.*, (2015) also observed decreasing NPN content in shrimp stored under ice and reported that the changes may be due to the leaching of soluble compounds in the muscle. However, PS and SMB treated sample showed a significant ($P < 0.05$) increase in NPN content during storage. Sikorski *et al.*, (1990) found that the contribution of higher NPN content in seafood could arise from free amino acids, low molecular weight peptide, urea and trimethylamine oxide.

Total Volatile Base Nitrogen (TVB-N) and Trimethylamine Nitrogen (TMA-N)

Initial TVB-N content of shrimp meat was 2.8mg N/100g. In the present study, total volatile basic nitrogen content in shrimp meat showed increasing trend during ice storage (Table 1). Control sample had a TVB-N value of 25.85 mg of TVB-N/100g at the end of 15th day. However, shrimp treated with PS/SMB had a TVB-N value of 20.15mg of TVB-N/100g, 23.15mg of TVB-N/100g, respectively on day 15. The TVB value of < 30 mg N/100 g sample is acceptable for consumption the shrimps (Lopez-Caballero *et al.*, 2007). Accordingly, the entire sample had a TVB-N value within the acceptable limit

during storage. It was observed that TMA content in control sample was absent till 3rd day and there after it exhibited 2.70mgN/100g during 6th day and further increased to 7.5mgN/100g on 15thday. However, PS and SMB treated sample had a TMA content of 6.50, 6.93 mg N/100g respectively (Table 1). The TMA value of 10–15 mg/100g is recommended for the consumption in fish and shell fish product (Connell, 1995). Accordingly, the entire sample is does not crossed the acceptable limit.

Thiobarbituric acid (TBA)

TBA index is commonly used as a biochemical quality indicator which measures the level of malanaldehyde (MDA) content, a secondary lipid degradation product (Benjakul *et al.*, 2005). Fresh shrimp meat had TBA value of 0.05mg of MDA/kg of sample. In general, TBA value showed increased trend during storage (Fig. 4). In case of control, TBA value reached 0.21mg of MDA/kg on day 15. However, PS, SMB showed lower TBA values of 0.15mg of MDA/kg, 0.18mg of malanaldehyde/kg, respectively on 15thday. The TBA value of 1-2mg of MDA/kg is generally considered as the limit for acceptability of seafoods for human consumption (Connell, 1995). Accordingly, entire sample had an acceptable limit of TBA values.

Textural quality

Texture is one of the important properties of fish and shell fish whether it is raw or processed because it influences the consumer acceptability. In general, there is significant ($p<0.05$) decrease in textural properties were observed in all samples during storage (Table 2). Initially, the hardness of shrimp showed 36.95N and it was reduced to 28.40 N, 26.35N, 26.80N, respectively for control, PS,

SMB treated sample at the end of storage. Jeyakumari *et al.*, (2015) reported that decrease trend in textural attributes during progressive storage is due to the proteolysis of meat which is caused by endogenous and microbial enzyme. Cohesiveness of the shrimp meat does not showed significant ($p>0.05$) difference in both control and treated samples during storage which indicates that shrimp meat is not undergone any internal structural changes during storage. Springiness or elasticity of shrimp meat decreased significantly ($p<0.05$) which indicates the shrimp meat gets reducing its elasticity during storage. In the present study, chewiness values showed significant ($p<0.05$) decrease in both control and treated sample during storage. It may be due to muscle softening and degradation.

Microbial quality

Total aerobic mesophilic bacterial counts of newly caught farmed white shrimp (*L. vannamei*) was close to or lower ($4.3\log_{10}$) than the value recommended ($5.0*10^5$ cfu/g) for raw fish and shell fish (ICMSF, 1998). Lalitha and Surendran (2006) also observed similar results for cultured *Pennaeus monodon* and *Macrobrachium rosenbergii*. White shrimps treated with PS showed reduced total aerobic bacterial count on day 3, there after it showed significant ($p<0.05$) reduction on 6th day and then, gradually increased. Lakshmanan *et al.*, (2003) reported that initial reduction of microbial count might be due to bacterial species are not able to grow or at low temperatures. Gradual increase in total bacterial counts during storage may be due to the adaption of some of the bacterial species to chill temperatures (Lalitha and Surendran, 2006). Ninan *et al.*, (2003) also observed similar results for cultured prawn kept under chilled storage.

Table.1 Changes in TVB-N and TMA-N of white shrimp (*Litopenaeus vannamei*) during ice storage

Sample/Days	0	3	6	9	12
TVB-N (mg%)					
T _C	2.8 ± 0.02	6.78±0.01	11.13±0.15	16.23±0.02	21.74±0.03
T _P	2.8 ± 0.02	8.29±0.03	13.49±0.10	15.87±0.03	18.23±0.03
T _S	2.8 ± 0.02	8.36±0.02	17.20±0.08	18.43±0.02	19.52 ± 0.01
TMA (mg%)					
T _C	Nil	Nil	2.7±0.01	2.7±0.02	6.9±0.05
T _P	Nil	2.7± 0.02	3.4 ±0.02	4.62±0.14	6.52 ± 0.02
T _S	Nil	2.7±0.01	4.2 ±0.00	5.5 ±0.10	6.0 ±0.04

Results are mean ± SD, n=3; T_C- Control; T_P- Potassium sorbate treated; T_S- Sodium metabisulphite treated

Table.2 Changes in texture of white shrimp (*Litopenaeus vannamei*) during ice storage

Storage days	Sample/Parameter	Hardness 1 (N)	Hardness 2 (N)	Cohesiveness	Springiness (mm)	Chewiness (kgf.mm)
0	T _C	38.95±0.25	29.85 ± 0.10	0.18± 0.12	2.89 ± 0.20	2.52 ± 0.25
	T _P	36.11±0.10	30.45±0.33	0.15±0.04	2.43±0.05	1.65±0.18
	T _S	36.75±0.20	24.68±0.25	0.12±0.20	2.42 ±0.14	1.72±0.25
3	T _C	38.93 ±0.15	29.85 ±0.10	0.18 ±0.12	2.62 ±0.32	2.35±0.12
	T _P	36.11±0.10	27.79±0.15	0.15±0.05	2.43±0.05	1.35±0.23
	T _S	32.22±0.20	22.68±0.18	0.12±0.08	2.42 ±0.14	1.75±0.10
6	T _C	38.80 ±0.32	26.47 ±0.30	0.18 ±0.10	2.55±0.22	1.79±0.18
	T _P	31.96±0.10	22.79±0.20	0.16±0.05	2.46±0.05	1.35±0.10
	T _S	29.35±0.20	19.69±0.35	0.14±0.02	2.15±0.05	1.30±0.15
9	T _C	35.35±0.25	24.18±0.45	0.20±0.02	2.20 ±0.14	1.62 ±0.40
	T _P	30.85±0.20	25.45±0.15	0.17±0.04	2.55±0.15	1.30±0.02
	T _S	26.75±0.35	19.71±0.25	0.15±0.00	2.15±0.18	1.25±0.05
12	T _C	31.45 ±0.28	22.10 ±0.42	0.18 ±0.02	2.30 ±0.10	1.43 ±0.32
	T _P	24.98±0.25	18.82±0.20	0.23±0.00	2.40±0.20	1.25±0.25
	T _S	24.53±0.35	18.18±0.15	0.23±0.02	2.10±0.35	1.20±0.15

Fig.1 Changes in moisture content of white shrimp (*Litopenaeus vannamei*) during chilled storage

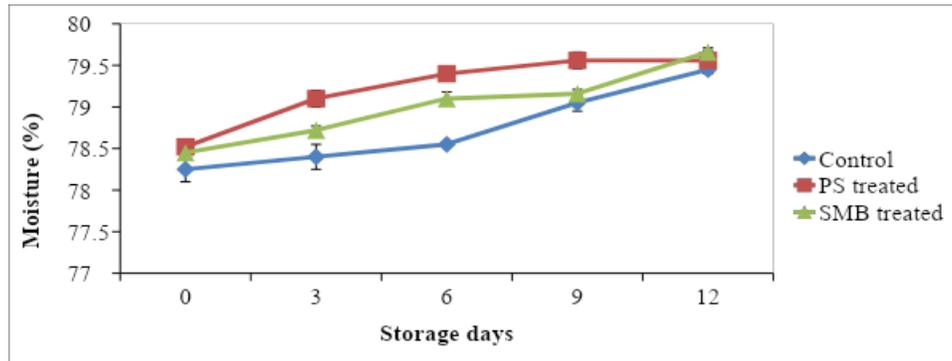


Fig.2 Changes in pH values of white shrimp (*Litopenaeus vannamei*) during chilled storage

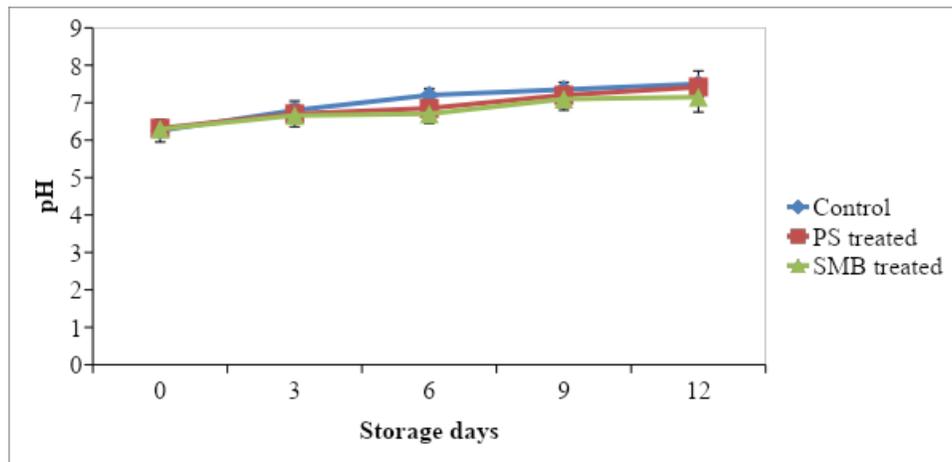


Fig.3 Changes in Non protein nitrogen (NPN) values of white shrimp (*Litopenaeus vannamei*) during chilled storage

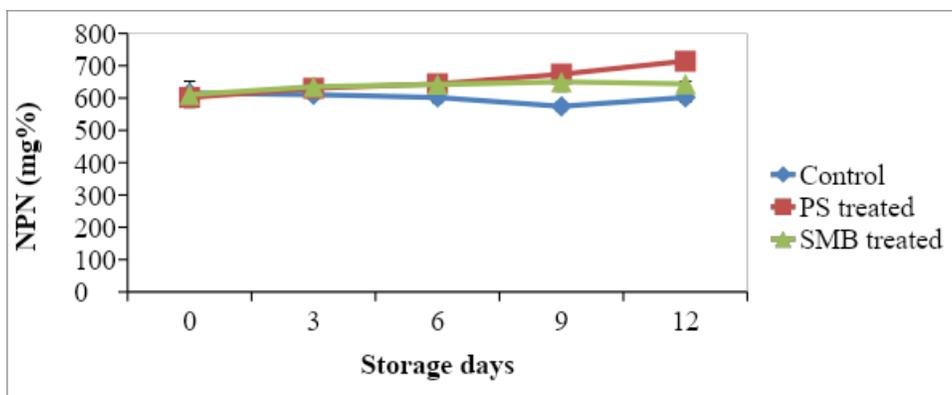


Fig.4 Changes in thiobarbituric acid (TBA) values of white shrimp (*Litopenaeus vannamei*) during chilled storage

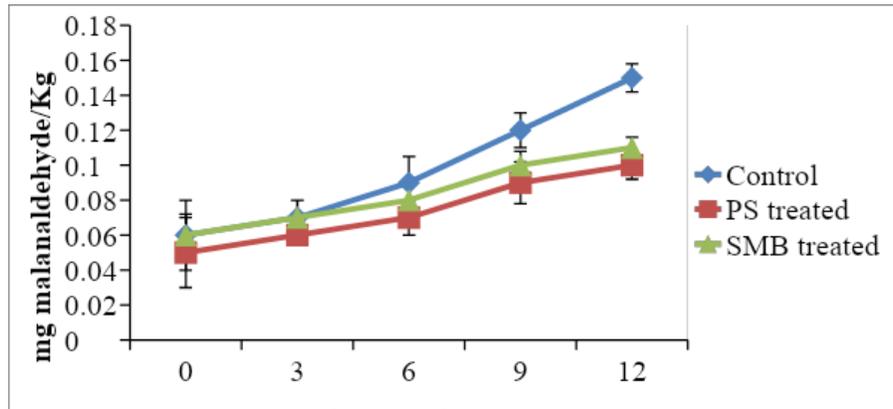
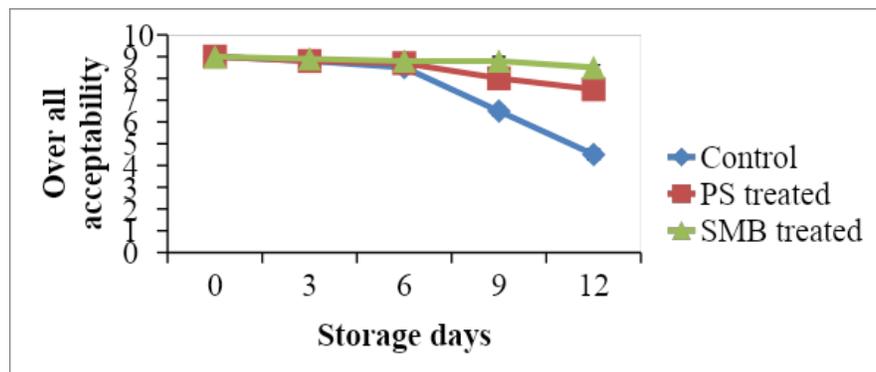


Fig.5 Changes in overall acceptability of white shrimp (*Litopenaeus vannamei*) during chilled storage



Results showed that aerobic counts gradually increased to 5.2 log₁₀ on 12th day for control sample (Fig. 3). In case of PS, SMB treated sample, TPC reached 4.4 log₁₀, 4.9 log₁₀, respectively on day 12. Moreover, both PS, SMB treated sample total bacterial count reached 5.1 log₁₀, 5.5 log₁₀, respectively on day 15. Results from the study indicate that among the two treatments, PS was effective in reducing the bacterial count under ice storage.

Overall Acceptability

Fresh shrimp had natural characteristics of odor, bright colour and excellent textural properties with a score of 9.0. There is no significant (p<0.05) changes in over all acceptability till 6th day. After 6th day, control

sample lost its freshness and fetch the score of 6.5, 4.5 on 9th and 12th day respectively (Fig. 5). Basavakumar *et al.*, (1998) observed similar results for *Penaeus monodon* stored under ice. In case of PS treated sample exhibited slightly black colour and loose head on day 12 with score of 6.5. Thereafter slight yellowness on the shell and complete loosening of head was observed and rejected on 15th day with the score of 4.5. It was observed that over all acceptability of SMB treated sample had higher score of 6.5 till 15th day. However, the samples were rejected based on the microbial quality.

It can be concluded that biochemical quality indices such as total volatile base nitrogen, trimethylamine, and thiobarbituric acid

content were within acceptable limit in the white shrimp under ice storage. Microbial and sensory analysis revealed that control sample had a shelf life of 9th day. In case of potassium sorbate, sodium metabisulphite treated samples remains acceptable up to 12th day. Results indicated that use of potassium sorbate and sodium metabisulphite could extend the shelf-life of white shrimp to three more days than control under ice storage.

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