International Journal of Fisheries and Aquatic Studies 2019; 7(5): 296-299

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2019; 7(5): 296-299

www.fisheriesjournal.com
Received: 12-07-2019
Accepted: 17-08-2019

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Physical, chemical and sensorial quality evaluation of phosphate treated and non-treated PUD shrimp (*Litopenaeus vannamei*) samples

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Abstract
The present study was conducted to assess the effects of food grade sodium tripolyphosphate (STPP) ($Na_5P_3O_{10}$) or water dip (control) treatments on the physical, chemical and sensorial quality attributes of decapitated Pacific white shrimp (*Litopenaeus vannamei*) during frozen storage at -35 °C for 10 days. Results indicated that control shrimp samples have been shown to lose texture, and gradual deterioration in quality attributes with frozen storage. The rate of these deteriorations are increased as the time of storage progressed. On the other hand, phosphate (STPP) treated shrimp samples exhibited significantly ($p< 0.05$) higher moisture retention, tenderness and bound water at any given time of frozen storage as compared with control samples. The present work also demonstrated significantly ($p< 0.05$) lower values of drip loss, TVB-N and TMA-N, recorded in STPP-treated samples. Results indicated that economic, physical, chemical and sensorial quality advantages have been resulted from soaking Pacific white shrimp in cold 5% Sodium tripolyphosphate solution for 5 minutes prior to freezing. With these results, we can suggest that 5% STPP treatment would be an alternative way to improve the quality of decapitated Pacific white shrimp during frozen storage.

Keywords: *Litopenaeus vannamei*, phosphate treated shrimp, quality deterioration, seafood, sodium tri polyphosphate

1. Introduction

Shrimp is one of the highly demanded crustacean in the domestic and international Markey due to its high nutritional value. In India earlier giant tiger shrimp (*Penaeus monodon*) is the single most important species produced through aquaculture practices. But recently, pacific white shrimp (*Litopenaeus vannamei*) has attracted the farmer attention because of its fast growth, diseases resistance, availability of SPF strains & culture feasibility in wide salinity range. On the other hand, seafood are highly susceptible to both chemical and microbiological deterioration due to its high water content, neutral pH, large quantities of free amino acids, and naturally presence of autolytic enzymes [1]. Once after harvesting a series of complex reactions takes place inside the seafood leading to deterioration of quality and ultimately spoils the seafood [2]. Therefore, shrimp should be immediately frozen to restrict microbial and enzymatic activity which causes deterioration. Freezing and frozen storage is able to prevent microbial spoilage effectively [4]. This will ultimately leads to seafood products of high quality, best appearance and little weight loss [3].

The quality deterioration in frozen shrimp is mainly due to lipid oxidation, protein denaturation, and dehydration [5]. These changes can result in the development of off-flavors, toughening and reduced water-holding capacity [6]. Industry is therefore vitally interested in factors controlling these problems because reduced product quality results in reduced consumer acceptance [7]. Dehydration occurs during frozen storage and can lead to weight loss which directly translates to loss of value. In addition, recrystallization of ice during frozen storage leads to higher drip losses which can cause increased dehydration, and result in tougher seafood [8, 9].

Phosphates are present normally in all living things and are therefore present in almost all food. They are multi-purpose, generally recognized as safe (GRAS), and legally permitted additives to improve the quality of many foods, particularly that of meat and fish products [10].

Sodium tripolyphosphate (STPP) is an inorganic compound produced on a large scale because it forms a major component of many domestic and industrial products. STPP acts as a preservative for seafood, meats poultry and animal feeds [20]. Thus the aim of this study was to determine the yield (%) and quality difference between sodium tripolyphosphate treated and non-treated peeled undeveined (PUD) shrimp samples.

2. Materials and Methods

2.1 Sample preparation

The present study was conducted at College of Fisheries Science, Junagadh Agricultural University, Veraval, Gujarat, India in the year 2018. Initially, 2 Kg large size (25-30 g/shrimp) Pacific white shrimp (*Litopenaeus vannamei*) was purchased from aquaculture farm located near Chorwad, Gujarat, India. Then it was washed, hand peeled and again washed with the tap water for several times, then divided into two equal groups (each contains 0.5 kg of PUD shrimp) and immediately cooled on ice before being treated in STPP solution. Shrimps were divided into 2 groups, one group of sample was soaked in cold 5% and 10% sodium tripolyphosphate (STPP) solution for 5 min. From this, six samples of 50 g each were prepared in which three samples were treated with 5% STPP (5g/100ml) and three samples were treated with 10% STPP (10g/100ml) solution. Then shrimp samples were packed in petri plates, with 5 shrimp pieces in each plate (phosphate treated samples) and second group of samples were soaked in cold distilled water for 5 min, drained, subdivided and packed as pervious group (control and water dip samples). Control and STPP treated shrimp samples were subjected to freezing at -35 °C for different intervals of time up to 10 days. Samples of control, 5% and 10% were analyzed at 3 days interval for examination.

2.2 Analytical methods

Pacific white shrimp samples were analyzed before freezing (zero time), after 5 days and 10 days of frozen storage at -35 °C for their chemical composition, physical properties & organoleptic evaluation. At each time of interval, the shrimp samples were thawed at room temperature prior to analysis. Moisture content was determined using moisture analyzer MAC instrument, pH by using pH testing paper. Yield (%) was calculated by analyzing weight differences observed in the samples before and after frozen storage. Sensory quality was analyzed based on the organoleptic test by scoring appearance, odor, texture, and overall acceptability of treated and non-treated PUD shrimp samples. TMA and TVB-N values were calculated using Conway micro-diffusion method [11]. The evaluation of shrimp samples were used a 9-point hedonic scale when 1, extremely dislike; 2, very much dislike; 3, moderately dislike; 4, slightly dislike; 5, neither like nor dislike; 6, slightly like; 7, moderately like; 8, very much like; 9, extremely like [12].

2.3 Calculation

TVB-N (mg/100g) = (Vs-Vb) × N(HCL) × 14 × Volume of extract ×100/Weight of sample (g)

TMA (mg/100g) = (Vs-Vb) × N(HCL) × 14 × Volume of extract ×100/Weight of sample(g)

$$\text{Drip loss (\%)} = (W1 - W2) \times 100 / W1$$

Where

Vb = Titrate volume of 0.01 N NaOH for the blank (ml)

Vs = Titrate volume of 0.01 N NaOH for the sample (ml)

2.4 Statistical analysis

Statistical analysis with ANOVA was performed using IBM SPSS statistics 21 software (IBM Corporation, USA). Completely Randomized Block Design (RCBD) was used for sensory data. Duncan's new multiple range test was used to test for the differences between means. The significance level was at $p < 0.05$.

3. Results and Discussion

3.1 pH, TVB-N and TMA

Moisture percentage was varied from 71.42±0.10 to 74.11±0.05 during the storage condition. The pH of samples varied between 6.07±0.13 and 6.65±0.01. After 4 days of frozen storage, pH value of treated samples were significantly ($p < 0.05$) higher than control sample due to affecting of phosphate solution. At the 7 days of frozen storage, the pH values of control and STPP immersed samples slightly increased, which may be associated with the increasing of the volatile base nitrogen as obtained also in previous studies [13, 14]. The pH values of sample slightly decreased during the 10th day of frozen storage, which was probably caused by increasing concentration of substances in unfrozen remaining water that modified the acid-base equilibrium. This may have made the fish muscle more acid [15, 16].

TVB-N and TMA, both the indices are well documented as freshness indexes. Their increase is related to the activity of spoilage bacteria and endogenous enzymes, which impart the characteristic unpleasant odor [17]. As shown in Table 1, the TVB-N and TMA-N contents were initially significantly ($p < 0.05$) higher in control shrimp as compared to STPP-treated shrimp, because of the effect of phosphate treatment. During frozen storage both indices increased steadily with a higher rate in control samples than in phosphate-treated samples (Table 1).

As can be noticed from the same results of table 1, samples pre-treated with phosphate exhibit less protein deterioration as evident from lower TVB-N and TMA-N contents than control shrimp throughout the storage and the significantly ($p < 0.05$) least TVB-N and TMA values were found in 5% STPP treated group. This could be explained on the basis that phosphate-protein film formed on the surface of treated samples protects shrimp meat proteins from the action of enzymes [18, 3]. However, it is worth mentioning that a level of 30 and 5 mg N/100g flesh for TVBN and TMAN; respectively are usually regarded as the limit beyond which seafood will develop an objectionable odor/taste [19].

3.2 Drip loss

Referring to Table 2, it could be observed that at any given time of frozen storage phosphate-treated shrimps showed lower drip loss as compared with control samples. Concerning drip loss, it is worth mentioning that drip results from the inability of the thawed muscle to reabsorb all of the separated water, which had been previously frozen. Formation of drip brings about the loss of weight, nutrient and flavor components, an unpleasant appearance of seafood, and a tough texture. Therefore, the more drip loss the lower the biological value and palatability properties of shrimp samples and this will lead to weight loss which will have negative impact on financial value [5]. Also, 5% STPP-treated shrimp samples showed the significant ($p < 0.05$) least drip loss than control and 10% STPP-treated samples.

3.3 Sensory Evaluation
Organoleptic evaluations for the raw shrimp samples (at zero time) were rated as excellent (≥ 9), at that time the samples had fresh seaweedy odor; white color of shrimp flesh; bright shining appearance and firm and elastic texture. Throughout the storage period, there were decreases and significant ($p<$ 0.05) changes in all sensorial criteria (appearance, odor, taste and overall acceptability). However, at the end of frozen storage time overall acceptability scores indicated that control samples were organoleptically acceptable, they rated as "fair" quality, when there was some loss of neutral odor with slight discoloration. During frozen storage, the sensory qualities decreased because the major cellular components of fish were gradually deteriorated and the leaching of pigments along with drip water resulted a gradual loss of brightness of fish muscle [14] (Table 3).

The degree of freshness of the shrimp having treated with STPP was higher than those treated in water containing no phosphate (Control) (Table 3). STPP-treated shrimp samples organoleptically were in "good" condition up to 10 days, at that time, the samples had neutral odor and natural flesh color; the texture became less firm and there was some loss of brightness. However, the sample treated with 5% STPP showed the significantly (<0.05) higher acceptability than control and 10% STPP treated samples.

Table 1: Chemical analysis of control (C) and phosphate treated (5% & 10% STPP) shrimp samples

Storage (days)	**4 Days**			**7 Days**			**10 Days**		
Components	Con trol	5% STPP	10% STPP	Con trol	5% STPP	10% STPP	Con trol	5% STPP	10% STPP
Moisture (%)	73.21 ± 0.05^{b}	72.31 ± 0.06^{a}	73.07 ± 0.03^{b}	72.70 ± 0.12^{b}	71.42 ± 0.10^{a}	72.88 ± 0.05^{b}	73.52 ± 0.08^{a}	74.11 ± 0.05^{b}	73.71 ± 0.07^{a}
pH	6.07 ± 0.13^{a}	6.33 ± 0.09^{ab}	6.60 ± 0.06^{b}	6.10 ± 0.06^{a}	6.35 ± 0.03^{b}	6.70 ± 0.05^{c}	6.09 ± 0.02^{a}	6.34 ± 0.03^{b}	6.65 ± 0.01^{c}
TVB-N (mg N/100g)	13.30 ± 0.10^{a}	11.90 ± 0.06^{b}	12.60 ± 0.06^{c}	15.40 ± 0.06^{c}	13.30 ± 0.06^{a}	14.00 ± 0.25^{b}	16.10 ± 0.26^{c}	14.00 ± 0.15^{a}	14.70 ± 0.35^{a}
TMA (mg N/100g)	2.10 ± 0.06^{c}	1.40 ± 0.06^{b}	0.70 ± 0.03^{a}	3.50 ± 0.06^{a}	2.10 ± 0.23^{b}	1.40 ± 0.15^{a}	4.20 ± 0.06^{b}	2.80 ± 0.21^{a}	2.80 ± 0.32^{a}

Table 2: Physical analysis includes the yield (%) or drip loss of control and STPP-treated Pacific white shrimp samples.

Shrimp samples	**Control**	**5% STPP**	**10% STPP**
Weight before frozen storage (W1)	51.00 ± 0.58^{a}	49.67 ± 0.33^{a}	50.67 ± 0.33^{a}
Weight after frozen storage (4 days) (W2)	46.83 ± 1.74^{a}	48.77 ± 0.15^{a}	48.67 ± 0.33^{a}
Drip loss (%)	8.22 ± 2.37^{b}	1.81 ± 0.41^{a}	3.93 ± 1.12^{ab}

Table 3: Sensory panel scores of control (C) and STPP-treated (5% & 10%) shrimp samples during frozen storage at -35 °C.

Storage (days)	**4 days**			**7 days**			**10 days**		
Components	**Control**	**5% STPP**	**10% STPP**	**Control**	**5% STPP**	**10% STPP**	**Control**	**5% STPP**	**10% STPP**
Appearance	7.12 ± 0.05^{a}	7.43 ± 0.06^{b}	7.36 ± 0.09^{ab}	6.63 ± 0.13^{a}	7.27 ± 0.10^{b}	6.92 ± 0.16^{ab}	5.76 ± 0.07^{a}	7.13 ± 0.10^{c}	6.61 ± 0.13^{b}
Color	7.36 ± 0.12^{a}	8.24 ± 0.15^{b}	7.79 ± 0.09^{a}	6.83 ± 0.20^{a}	7.95 ± 0.14^{b}	6.95 ± 0.13^{a}	6.47 ± 0.14^{a}	7.74 ± 0.16^{b}	6.72 ± 0.08^{a}
Odor	7.68 ± 0.17^{a}	8.49 ± 0.23^{b}	8.26 ± 0.09^{ab}	6.89 ± 0.16^{a}	8.27 ± 0.19^{b}	7.86 ± 0.33^{b}	6.56 ± 0.15^{a}	8.01 ± 0.05^{b}	6.97 ± 0.18^{a}
Overall Acceptability	7.42 ± 0.22^{a}	8.76 ± 0.10^{b}	7.93 ± 0.24^{a}	7.25 ± 0.35^{a}	8.58 ± 0.31^{b}	7.75 ± 0.25^{ab}	6.89 ± 0.18^{a}	8.37 ± 0.17^{c}	7.52 ± 0.19^{b}

4. Conclusion
From the results it is apparent that STPP is an indispensable additive for the maintenance of the functional properties of the seafood proteins which helps the preservation of the muscle integrity, inhibits the drip loss and helps to prevent the economic loss during the thawing. Phosphates dip treatments were effective in inhibition of flavor, color and lipid oxidation and thereby enhancing tenderness of seafood by restricting protein denaturation; and reduces other deterioration of shrimp quality during frozen storage. So 5% STPP could be suggested to improve the physical, chemical and sensorial quality of shrimp in frozen storage condition.

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