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Research Article

Effects of Tea Polyphenols on the Quality and Shelf Life of Shrimp during Cold Storage

[1]Zhuanzhuan Zhang, [2]Wangsong Shang and [3]Xianjun Dai
[1]College of Life Science,
[2]Key Laboratory of Marine Food Quality and Hazard Controlling Technology, Zhejiang Province, Hangzhou, China

Abstract: The effects of tea polyphenols on quality of shrimp during refrigerated storage were investigated. Shrimps were respectively treated through soaking in the distilled water and aqueous solution of 0.2% tea polyphenols for 10 min and then stored at 0°C for 20 days. The control and treated shrimp samples were assessed periodically for microbiological (total viable count), chemical (pH, TVB-N) and sensory characteristics (TPA texture properties) during 5, 10, 15 and 20 days, respectively. The results indicated that the shelf life was increased at the storage of 0°C under the tea polyphenols treatment. In the same cold storage, the shrimps that were treated with aqueous solution of 0.2% tea polyphenols was better than that were treated with distilled water. At the end of shelf life (15 days), the pH value was 6.92 and 6.97 the total viable count was 6.43 log 10 CFU/g and 8.13 log 10 CFU/g, the TVB-N was 16.6 and 20.3 mg/100 g. Therefore, tea polyphenols showed a significant inhibition effects on the propagation of bacteria and production of TVB-N, thus prolonged the preservation time of shrimp.

Keywords: Quality, shrimp, tea polyphenols

INTRODUCTION

Litopenaeus vannamei, a kind of shrimp, has been one of the most valuable species all over the world and are widely appreciated by Chinese consumers in consideration of their high contents of protein, minerals and Highly Unsaturated Fatty Acids (HUFA) in the meat. In China, the shrimphas been extensively cultured and the product volume was 1,240,000 tons every year, corresponding to 39.2% of the harvesting of global output (Hong *et al*., 2008).

The shrimps are generally processed as fresh, cooked or as value-added products before they are frozen and exported. However, quality deterioration, such as texture, flavor and color, often occurs during the storage due to bacteriological activity leading to loss of quality and subsequent spoilage (Sriket *et al*., 2007). The rate of deterioration is associated with many factors such as species, size, lipid content, microbial load and storage temperature (Hultmann and Rustad, 2004). Cold storage is an efficient way of reducing the rate of the deterioration of shrimp and of extending the shelf life of shrimp at the same time. However, the quality of shrimp meat would be deteriorated during cold storage as the shrimp contains abundant proteins and unsaturated fatty acid. Endogenous proteases, which are able to hydrolyze different proteins in the shrimp muscle, are important early in the deterioration process (Fan *et al*., 2008). It is worthwhile that some measures are taken to delay the decline of shrimp quality and extend the preservation life of shrimp during cold storage. Tea Polyphenols (TP), a natural and efficient bioactive substance, which play an important role in protein precipitation and enzyme inhibition, have beneficial anti-bacterial and anti-oxidative activities (Fan *et al*., 2008; Shi *et al*., 1994). TP could demonstrate potential as the preservatives and anti-oxidants in food industry, especially in the field of the preservation of fresh produce. Li *et al*. (2009) reported that TP dip treatment could effectively extend the shelf life of the mei fish during 0°C storage. Fan *et al*. (2008) reported that TP dip treatment could improve the quality of silver carp during ice storage. However, there have been few studies on the use of TP dip to extend the shelf life of shrimp at 0°C storage. Therefore, the objective of this study was to evaluate the effect of a TP dip treatment on the quality and shelf life of *Litopenaeus vannamei* during ice storage.

MATERIALS AND METHODS

Shrimp sample preparation: The live shrimps of similar size were obtained from the local supermarket. After the shell and head of the shrimp samples were stripped, the meat samples were divided into two groups. The shrimp meats were given a dip treatment in 0.2% (w/v) TP solution (0°C) (treated group) and distilled water (0°C) (control group), respectively for

Corresponding Author: Xianjun Dai, College of Life Sciences, China Jiliang University, Xueyuan Street No. 258, Xiasha High Education Area, Hangzhou 310018, Zhejiang Province, P.R. China
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10 min, then drained well. The shrimp samples were packed into small plastic bags and kept in a refrigerator at 0°C for 20 day. Partial samples were randomly taken out every 5 days to examine the texture, pH value, Total Volatile Base Nitrogen (TVB-N) and bacteriological volume.

Texture analysis: Texture profile analysis was performed using aTMS-Pro Texture analyzer with a load cell of 50 N. The crosshead velocity was used at the condition of 40% double compression and 300 mm/min normal stress. Results were analyzed with the Texture Expert program for calculating hardness, elasticity and cohesiveness.

Determination of pH: The pH values were measured according to the GB/T of the Chinese standard (GB/T 5009.45-2003). The 20.0 g sample of shrimp meats were mixed with 200 mL of distilled water for 30 min and the mixture was filtered. The pH value of the filtrate was measured using a digital pH meter.

Determination of TVB-N: TVB-N was determined by the KDY-9820 Kjeldahl apparatus. After the shrimp meat was homogenized with MgO, the mixture was distillated by xx. The distillate was collected in a flask containing a 3% aqueous solution of boric acid and amixed indicator which produced from dissolution of 0.1 g of methyl red and 0.1 g of methylene blue to 100 mL of ethanol. Afterward, the boric acid solution was titrated with a 0.01 Mhydrochloric acid (HCl) solution. The TVB-N value (mg N per 100 g of shrimp) was determined according to the consumption of hydrochloric acid.

Bacteriological analysis: The 5 g samples were put into 45 mL of 0.85% NaCl solution and homogenized with a mortar. Total Viable Counts (TVC) were determined by counting the number of colony-forming units after incubation at 30°C for 2 days. All counts were expressed as log10 cfu/g and performed in duplicate (Arashisara *et al*., 2004; Sallam, 2007).

Data analysis: Statistical analysis was carried out using SPSS statistic program for Window. All data were subjected to Analysis of Variance (ANOVA). The Least Significant Difference (LSD) procedure was used to test for difference between means (significance was defined at $p<0.05$).

RESULTS AND DISCUSSION

Texture: The meat texture of shrimp depends on intrinsic biological factors, such as the concentration of fat and collagen and the microbiological and autolytic processes caused by the death of the shrimp, which induce degradation of myofibrillar protein integration and eventual softening of the muscle (Hultmann and Rustad, 2004). Texture Analyzer texture profile analysis (Texture Profile Analysis, TPA) is a kind of test that attempts to imitate the conditions in the mouth by an instrument. The force against compression is recorded when a probe is pressed into a sample for the given distance. After a specified time, the compression is repeated at the same position, which can simulate to reflect the parameters, such as hardness, adhesion, elasticity, chewing, gum, cohesive strength, resilience and fragility (Liu and Li, 2010). In the experiment, the hardness and springiness changes of the shrimp samples were shown in Fig. 1 and 2. Overall in the storage process, the hardness of shrimp increased at first and then decreased gradually, but the springiness value continuously decreased during the storage time. At the 5th day, the shrimp hardness of control group and treated group reached the highest value. After the 5th day, the hardness values of experimental shrimps began to decrease and that of control group decreased more rapidly than treat group. The hardness values of experimental shrimps basically kept no significant variance from the 10 to 20 day. The shrimp springiness value of control group was lower than that of treat group from 5th to 20th day. The change of chewiness and adhesive index showed irregular in the experiment.

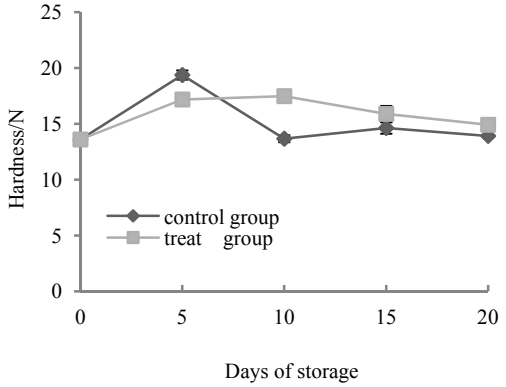

Fig. 1: Changes in hardness of shrimp during the cold storage

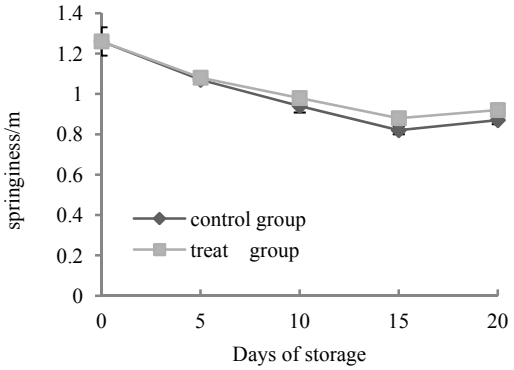

Fig. 2: Changes in springiness of shrimp during the cold storage

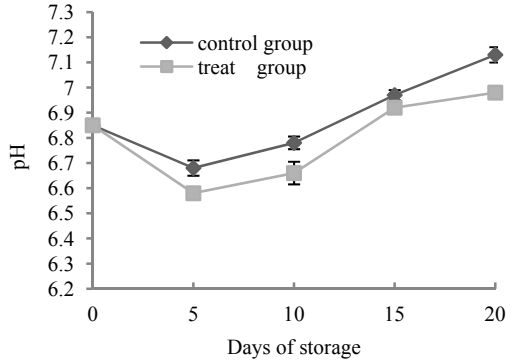

Fig. 3: Changes in pH of shrimp sample during cold storage

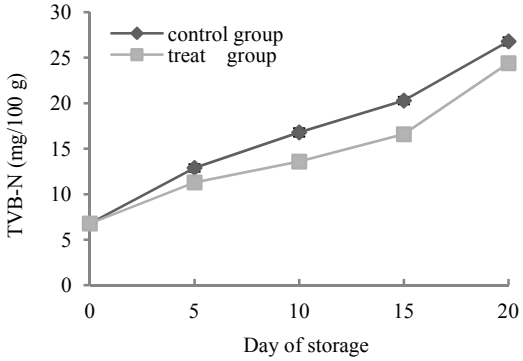

Fig. 4: Changes in TVB-N values of shrimp sample during cold storage

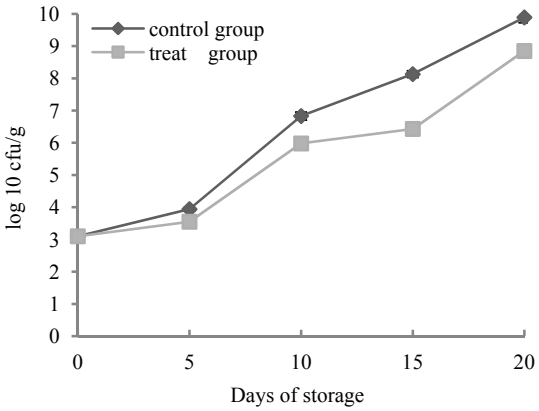

Fig. 5: Changes in Total Viable Counts (TVC) of shrimp during cold storage

From the results of hardness and elastic index, the hardness and springiness value of treat group was better than that of control group.

pH: The change of pH value is an important feature of aquatic changes in quality during storage. Variations of pH values in shrimp samples were depicted in Fig. 3 during the cold storage. The initial pH value of shrimp samples was 6.85. During storage, the pH values decreased in the early stages and then gradually increased. The possible reason was that the glycolysis of shrimp meat would occur in the kept process, which led to accumulation of lactic acid and decrease of pH value. Another reason might be attributed to the dissolution of CO_2 in the shrimp samples. With the extension of time, the increase of pH value might be caused by the growth of spoilage bacteria leading to the accumulation of alkaline components (e.g., ammonia and trimethylamine) (Manat *et al*., 2005; Ruiz-Capillas and Moral, 2001). Similar results were reported in other reference (Manju *et al*., 2007; Fan *et al*., 2009).

The data revealed that variations in values of pH in the treat group sample had the same trend as those in control group. However, the uptrend of the control group are obviously, which pH value was 7.13 at the 20^{th} day. The uptrend of the experimental group, which were treated with aqueous solution of 0.2% tea polyphenols, rose slowly and were significantly lower than the control group ($p<0.05$). The possible reasons were that polyphenol molecules containing a phenolic hydroxyl group, could release the H^+ which could reduce the pH value of shrimp. On the other hand, TP could inhibit the activity of lipoxygenase and cyclooxygenase in shrimp to delay the hydrolysis of protein.

TVB-N value: The TVB-N value is one of the most widely used indicators of sea food deterioration. It is a general term which includes the calculation of trimethylamine (produced by spoilage bacteria), dimethylamine (produced by autolytic enzymes during chilled preservation), ammonia (produced by the deamination of amino acids and nucleotide catabolites) as well as other volatile basic nitrogenous compounds correlated with seafood spoilage (Ruiz-Capillas and Moral, 2005; Fan *et al*., 2009). Changes in TVB-N value were shown in Fig. 4 about the experiment. As the results showed, the TVB-N values increased gradually in treated sample and controlled sample during the cold storage. The TVB-N of treated sample increased rapidly, while the TVB-N value of controlled sample was not obvious. According to SC/T3032-2007 standard, TVB-N was less than 25 mg/100 g and belonged to first grade of freshness. TVB-N concentrations increased from an initial value of 6.78 to 26.8 mg/100 g in treated samples, to 24.4 mg/100 g in control group. This increase was significantly lower in treated samples than in controlled samples ($p<0.05$). The difference of TNB-N value was more obvious with microbial spoilage at the later storage.

In the present study, the TVB-N concentration was also significantly lower ($p<0.05$) in samples treated with aqueous solution of 0.2% TP than in samples treated with distilled water. This could be attributed to either a more rapidly reduced bacterial population or decreased capacity of bacteria for oxidative de-amination of non-protein nitrogen compounds or both (Fan *et al*., 2008).

Bacteriological analysis: The total number of colonies in food refers to the total number of bacteria, which can predict the shelf life of food. The inhibition mechanism of TP is related to permeability of bacterial cell membrane, which could damage the membrane structure and lead to increased permeability of bacterial membrane, there by affecting the cell metabolism.

Variations in the value of total numbers of colony were presented in Fig. 5 during the cold storage. Initial total numbers of colony in shrimp samples was 3.11 log 10 CFU/g. Total numbers of colony of controlled samples rose continuously and reached about 6.85 log 10 CFU/g on the 10^{th} day and 9.89 log 10 CFU/g on the 20^{th} day during the cold storage, which was no obvious stagnation period. Total numbers of colony of treated samples (with aqueous solution of 0.2% tea polyphenols) grew slowly during the first 5 days and attained 6.43 log 10 CFU/g on the 15^{th} day and 8.98 log 10 CFU/g on the 20^{th} day. The numbers of colony in treat group were significantly lower than that of control group ($p<0.05$). The significant reduction in total numbers of colony observed in treated samples could be attributed to the inhibitory effect of TP on spoilage bacteria. The above result also indicated that dip treatment with 0.2% TP was equally effective in inhibiting spoilage bacteria growth and extending the iced storage life of shrimp samples to 20 days compared to 15 days for dip treatment with distilled water.

CONCLUSION

On the basis of the above results, the hardness and springiness values was better in samples treated with aqueous solution of 0.2% TP than in samples treated with distilled water. TP treatment on shrimp could effectively inhibit bacterial reproduction, reduce fat oxidation and delay the spoilage. TP dip treatment on shrimp kept the good quality characteristics for the extension of the shelf life during iced storage.

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