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Research Article

Quality changes of *Fenneropenaeus indicus* shrimp treated with *Arthrospira platensis* extract over five-months storage

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Abstract

In this study, the effect of glazing with *Arthrospira* (*Spirulina*) *platensis* extract (SPE) were evaluated on the quality characteristics of *Fenneropenaeus* (*Penaeus*) *indicus* at frozen temperature. Three different concentrations of SPE (0.3, 1.0, and 1.3%) were used and compared with water glazing (WG) and unglazing conditions (UG). Shrimp quality was measured by pH, peroxide value (PV), total volatile basic nitrogen (TVB-N), thiobarbituric acid (TBA), textural properties (hardness and cohesiveness), and sensory characteristics for five months of frozen storage. Results illustrated that the glazing treatment reduced the quality loss of shrimp in the course of frozen storage, compared to the unglazed control sample. Variation range of pH, PV, TVB-N, and TBA after 150 days increased to 7.68–7.79, 2.70–2.74 meq per kg O_2 lipid, 28.12–30.08 mg/100g, 2.53–2.88 mg per kg MDA, respectively. The values of cohesiveness, hardness and sensory of all groups decreased after 150 days. As regards the glazed samples, those treated with SPE showed lower TVB-N, PV, TBA, and higher textural and sensory properties. However, further research is necessary to optimize the use of SPE in the glazing system.

Keywords: Shrimp, Glazing, Textural, Frozen storage, TVB-N, PV, TBA

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Introduction

The consumption of seafood has been steadily increasing over the last decades due to its nutritional characteristics and benefits to the consumer's health (FAO, 2022). However, they are susceptible to spoilage, which leads to decreases in their shelf-life, consumer acceptability, nutritional value, and safety (Messina *et al*., 2015).

One of the earliest techniques used to preserve the quality of seafood such as fish has been freezing. Glazing is another method to control deteriorating conditions during frozen storage. Glazing is defined as a layer of ice on the surface of frozen products (Trigo *et al*., 2019). The ice layer can act as a barrier to control moisture shift and oxygen uptake on the surface of frozen food packages (Solval *et al*., 2014). Applying glazing finally led to inhibiting lipid oxidation and microbial activity (Ezquerra-Brauer *et al*., 2018).

In recent years, consumer preference has shifted to minimally process and products without chemical preservatives. For this purpose, natural compounds are considered safe alternatives to synthetic preservatives (Karre *et al.*, 2013). Natural compounds can be extracted from terrestrial and marine sources. Among marine resources, algae is a rich source of diverse bioactive compounds. Spirulina contains both enzymatic (superoxide dismutase, glutathione peroxidase, catalase and ascorbate peroxidase) and non-enzymatic (carotenoids, ascorbic acid, tocopherols, and chlorophyll derivatives) as antioxidant protection system (Abd El-Baky *et al*., 2007). These compounds demonstrated various biological activities such as antioxidant, antibacterial, anticoagulant, anticancer, antiviral, anti-inflammatory and others (Mohamed *et al*., 2012). On this basis, these compounds can be used in different industries including the food industry in order to minimize spoilage and also for efficient food preparations.

Arthrospira (*Spirulina*) *Spirulina platensis* is a species of blue-green algae which contains high protein content (55-70%), essential vitamins (B1, B2, B12, E, and provitamin A), pigments (phycocyanin, chlorophylls and carotenoids), minerals (iron, magnesium, selenium, and zinc) and essential fatty acids (da Silva *et al*., 2019). Moreover, previous studies documented that the *Spirulina* extracts showed antioxidant and antimicrobial activities (Okpala, 2015; Parashideh *et al*., 2014). Based on this, up to now *Spirulina* was used in different food products such as yogurt, pasta, bread, cheese, and ice-cream (da Silva *et al*., 2019). However, its efficacy in the glazing systems for controlling the change in the quality of shrimp during frozen storage has not been reported yet.

In this study, *S. platensis* extract (SPE) was used as glazing materials for frozen *Fenneropenaeus indicus*. The objective of current study is to evaluate the effects of glazing with SPE on chemical, textural and sensory changes of frozen *F. indicus* during frozen storage.

Materials and methods

Preparation of glazing solution containing Spirulina extract

S. platensis powder was purchased from Barij Essential Pharmaceutical Company (Kashan, Iran). For the preparation of SPE, 2.5 g of *Spirulina* powder was weighed and added to 200 mL of water. The mixture was heated (100°C) cautiously until the volume was reduced to 50 mL. The hot solution was filtered twice using double filter paper. The filters were concentrated using rotary evaporator at 60°C and finally dried using freeze-dryer.

Shrimp preparation and treatment

The fresh *F. indicus* shrimps were purchased from a local market in the *Persian Gulf*, Bandar Abbas (Hormozgan, Iran). Shrimps were then transported frozen for six hours by an airline to the central Laboratory of Iran Veterinary Organization. In the laboratory, the shrimps were washed, cleaned, and deveined by hand and finally divided into five groups as follows:

Group 1: unglazed shrimps (UG)

Group 2: water glazed shrimps (WG)

Group 3, 4, and 5: *Spirulina* solution (0.3, 1.0 and 1.3%) glazed shrimps (SG)

For the glazing process, the samples were first immersed in water and *Spirulina* solution for 30 seconds and then allowed to drip for 5 seconds. After glazing, the samples were stored at –18°C for 150 days and chemical, textural and sensory evaluations were performed every 30 days (Shi *et al*., 2019).

Chemical analyses

pH determination

5 g of homogenized shrimp samples were mixed with 45 mL of distilled water and then the pH was measured using a pH meter (CRISON Instruments, Barcelona, Spain) at ambient temperatures. Three sample measurements were performed for each treatment.

TVB-N determination

TVB-N content of shrimp samples was determined using the method reported by Goudlas and Kontaminas (2005) by the application of a Kejeldahl apparatus. The TVB-N value was expressed as mg N/100 g shrimp flesh. Three measurements of samples were performed for each treatment.

PV determination

PV of shrimp samples was measured as described by the AOAC official method (2005). A volume of 25 mL of acetic acid: chloroform solution (3:2 v/v) was added to 5 g of minced shrimp meat and mixed in saturated potassium, iodide starch solution, and distilled water in volumes of 0.5, 0.5, and 30 mL, respectively. Titration of released iodine with 0.01 N sodium thiosulphate was held until the intense blue color disappeared. PV was calculated using a previously reported formula. Three measurements of samples were performed for each treatment.

TBA determination

The distillation method reported by Namulema *et al*. (1999) was used to determine the degree of lipid oxidation in shrimp samples. Lipid oxidation was measured using thiobarbituric acid (TBA values), which is expressed as mg per kg malonaldehyde shrimp meat. Three measurements of samples were performed for each treatment.

Textural properties

The analysis of the texture profile of the shrimp samples was performed using a TA-XT2i texture analyzer. Shrimp samples were compressed twice with a cylindrical probe of 25 mm diameter, at 1 mm/s speed, and with 50% compression of the original height between the flat plates. Six sample measurements were performed for each treatment.

Sensory evaluation

Sensory properties of control and treated shrimps were evaluated based on the method reported by Simeonidou *et al.* (1997). For this, ten experienced panelists (5 men and 5 women between ranges 25–45 years) were chosen to evaluate the quality of the samples. After thawing, shrimp samples were evaluated with three parameters (aroma, texture, and appearance). Sensory properties were scored based on a 5-point hedonic scale (5: very good, 1: very bad).

Statistical Analysis

Results were presented as mean±standard division (SD). One-way analysis of variance (ANOVA) and Duncan were used to detect significant differences between different treatments.

Results

pH determination

Figure 1 shows the pH values of UG, WG, and SG shrimp samples during frozen storage. On day zero the range of pH of different groups were 6.22–6.56 and then increased up to 7.68–7.79 on day 150.

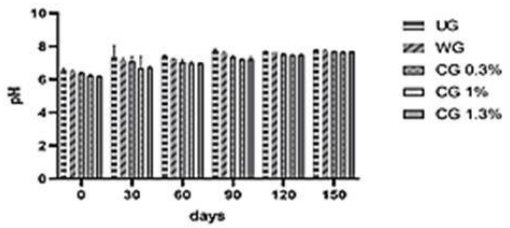

Figure 1: pH changes of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) F. indicus during frozen storage.

TVB-N determination

TVB-N is one of the important seafood quality indicators and it is associated with spoilage by bacteria and the activity of endogenous enzymes (Shi *et al.*, 2019). The changes to TVB-N in UG, WG, and SG shrimp samples during frozen storage are illustrated in Fig. 2. The range of TVB-N on day zero of different groups was 12.05-12.70 mg/100g and then increased up to 28.12-30.08 mg/100g on day 150.

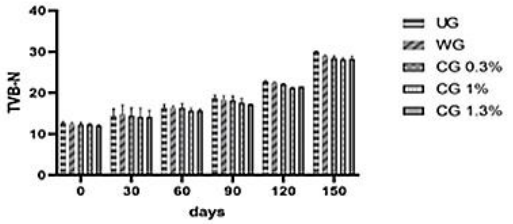

Figure 2: Changes in TVB-N of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

PV determination

The PV was used to measure the formation of primary lipid oxidation products that govern the extent of lipid oxidation at the initial stages of oxidation. Figure 3 shows the PV values of UG, WG, and SG shrimp samples during frozen storage. The range of PV on day zero of different groups was 1.07–1.31 meq per kg O_2 lipid and then increased up to 2.70–2.74 meq per kg O_2 lipid on day 150.

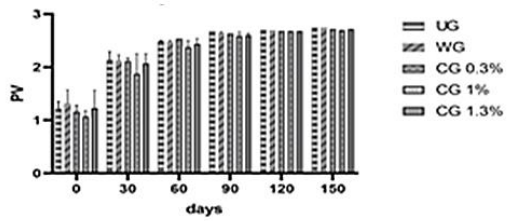

Figure 3: PV changes of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

TBA determination

TBA is a valuable tool for measuring the secondary oxidation products of lipid oxidation. The changes of TBA in UG, WG, and SG shrimp samples during the frozen storage stage are shown in Figure 4. The range of TBA on day zero of different groups was 0.42–0.56 mg per kg MDA and then increased up to 2.53–2.88 mg per kg MDA on day 150. The acceptability limit of TBA for seafood is 7–8 mg per kg MDA.

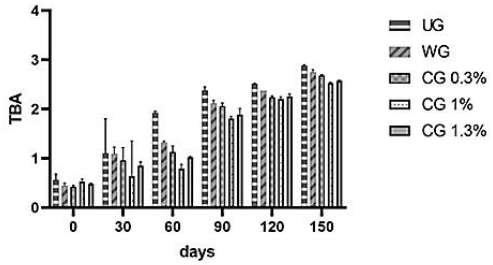

Figure 4: Variations of TBA unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

Textural properties

Figures 5 and 6 show the textural properties (cohesiveness and hardness) of UG, WG and SG shrimp samples during frozen storage stage. The cohesiveness range on day zero of different groups was 1500.5–1580.5 and then decreased up to 299.5–390.5 on day 150. The hardness on day zero was 0.39–0.69 and then decreased up to 0.25–0.33 on day 150. The lowest cohesiveness and hardness were observed in the UG shrimps at the end of storage time.

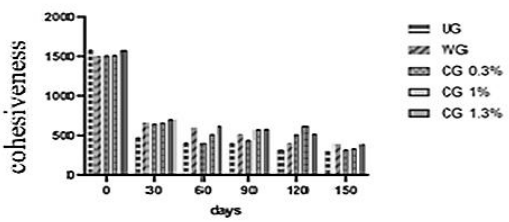

Figure 5: Textural properties (cohesiveness) of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

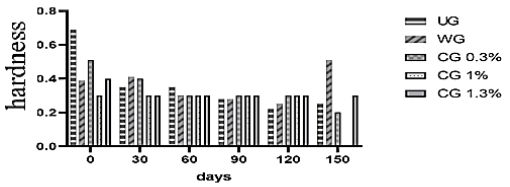

Figure 6: Textural properties (hardness) of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

Sensory evaluation

The sensory properties of UG, WG, and SG shrimp samples during frozen storage were obtained (Figs. 7 to 9). On day 120 of storage, there were no significant differences among all shrimp samples. After 150 days, an obvious sensory decline in the shrimp was observed for all samples and the differences between individual groups were found to be statistically significant (p<0.001). The shrimp were considered unsuited for human consumption when the total score of sensory evaluation is <15 (Shi *et al.*, 2019). Unglazed and water-glazed shrimp samples were admissible after up to 120 days, and *Spirulina*-glazed shrimp sample was acceptable until the end of the studied storage stage.

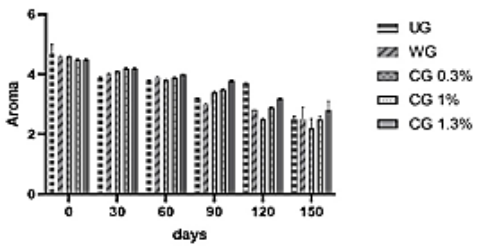

Figure 7: Sensory properties (Aroma) of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

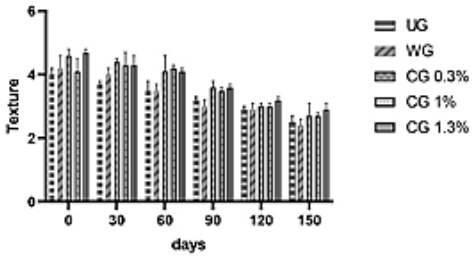

Figure 8: Sensory properties (Texture) of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

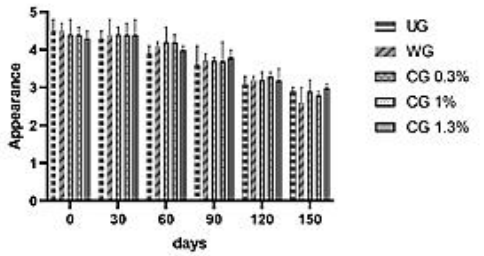

Figure 9: Sensory properties (appearance) of unglazed (UG), water-glazed (WG), and *Spirulina*-glazed (SG, 0.3, 1.0, and 1.3%) *F. indicus* during frozen storage.

These results indicated that the glazed sample with *Spirulina* could retain the shrimp quality in terms of sensory assessment during frozen storage, followed by the water-glazed sample.

Discussion

The present study was conducted to investigate the effect of SPE as a glazing material on the quality of *F. indicus* shrimp during frozen storage. SG group showed lower pH values compared to other groups. Similarly, green tea extract-glazed shrimps had slightly lower pH values than unglazed samples during frozen storage of *Litopenaeus setiferus* (Sundararajan *et al.*, 2011). The TVB-N value of ≤20 mg N/100 g sample was considered

fresh, ≤30 mg N/100 g sample as acceptable and >40 mg N/100 g sample was not suitable for consumption (Goncalves and Junior, 2009). Based on these criteria, all of the studied groups were within the acceptable range. SG group (1%) showed lower TVB-N values compared to other groups (28.12 mg/100g). Shi *et al*. (2019) reported that the initial TVB-N value of *Solenocera melantho* was 7.84 mg/100 g and after 24 weeks of frozen storage increased to 28.48, 24.08 and 19.23 mg/100 g in unglazed, water-glazed and rosemary-glazed shrimp, respectively. In the present study, lower TVB-N values in SG groups can be traced to the antimicrobial activity of *Spirulina* extract which controlled the bacteria growth and finally decreased the TVB-N. Furthermore, Shi *et al.* (2019) also reported that using natural extract could inhibit the degradation of macromolecular components containing nitrogen. The increase in PV was in all likelihood due to the faster rate of peroxides formation compared to degradation rate of peroxides into secondary oxidation products. As can be seen in Figure 3, the PV values slightly decreased in SG glazed shrimps compared to WG and UG, however, no significant differences were observed between different groups during the storage phase. Shi *et al*. (2019) reported that rosemary glazing treatment could effectively slow down the primary oxidation process in mud shrimp (*S. melantho*) during the frozen storage stage.

In accordance with the results, the TBA values of all groups were below the acceptable set limit throughout the storage period. The highest and lowest TBA were measured in the NG and SG glazed shrimps, respectively. This indicated that SPE was more effective in decreasing lipid oxidation than WG and UG. The lower TBA value in SG glazed groups may be explained by the antioxidant activity of phenolic substances found in *Spirulina* extract. Sundararajan *et al.* (2011) reported that glazing with green tea extract decreased the TBA values in *L. setiferus* compared to unglazed or water-glazed samples during frozen storage. They also reported that the shrimps treated with 5% green tea extract had a significantly lower TBA value than other groups. Also 1.3% SG glazed shrimps showed the highest cohesiveness values compared to other groups. A similar trend was also observed for hardness values. He and Xiao (2016) investigated the effect of tangerine peel (*Citri reticulatae pericarpium*) essential oils (TPEOs) as a glazing layer on freshness preservation of bream (*Megalobrama amblycephala*) during super chilling storage. Their results showed that the glazing layers of TPEO can effectively slow down the degradation process of fish samples and the textural characteristics (hardness, springiness, and cohesiveness) of treated samples were higher than the control group.

Results showed that the unglazed *F. indicus* shrimp exhibited significant quality decline after 150 days of frozen

storage. Glazing treatment significantly reduced the quality loss of shrimp during the 5 months of frozen storage compared to the unglazed control sample. Glazing with SPE was more effective in controlling quality changes in frozen *F. indicus* shrimp. Based on these, SPE-glazed shrimp exhibited lower chemical and higher textural and sensory properties compared to the WG and UG shrimps.

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