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IMMEDIATE EFFECT OF DIFFERENT PASTEURIZATION TEMPERATURES (50°C and 70°C) ON THE QUALITY PARAMETERS OF SHRIMP (*Parapenaeus longirostris*)

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ABSTRACT
The aim of this study was to evaluate the effect of two different pasteurization temperature (50°C and 70°C) on the basic quality parameters of shrimp (*Parapenaeus longirostris*). Physical, chemical, microbiological and sensory quality parameters were investigated to determine how the shrimps were affected after pasteurization. The cook loss, protein and fat percentage of shrimps significantly (P <0.05) increased with increasing temperature. No significant difference was found in terms of chemical parameters (TVB-N, TMA-N, TBARs) in both degrees of pasteurization. Based on microbiological analysis results, a significant (P <0.05) decrease was observed in the microbial load due to the increase in the pasteurization temperature. According to the results of sensory analysis, and color measurement no significant difference (P >0.05) was detected in pasteurization applications at 50°C and 70°C. As a result, it has been observed that the pasteurization application at 70°C generally makes a difference in all the parameters examined.
Keywords: Shrimp, pasteurization, temperature, quality

FARKLI PASTÖRİZASYON SICAKLIKLARININ (50°C ve 70°C) KARİDESİN (*Parapenaeus longirostris*) KALİTE PARAMETRELERİ ÜZERİNDEKİ ANİ ETKİSİ

ÖZ
Bu çalışmanın amacı, iki farklı pastörizasyon sıcaklığının (50°C ve 70°C) karidesin (*Parapenaeus longirostris*) temel kalite parametreleri üzerindeki etkisini değerlendirmektir. Karideslerin pastörizasyon işlemi sonrasında nasıl etkilendiğini belirlemek için fiziksel, kimyasal, mikrobiyolojik ve duyusal kalite parametreleri araştırılmıştır. Pastörizasyon sonrasında artan sıcaklık ile birlikte karideslerin, pişirme kaybı, protein ve yağ yüzdesi önemli ölçüde (P <0.05) artmıştır. Her iki pastörizasyon derecesinde kimyasal parametreler (TVB-N, TMA-N, TBARs) açısından gruplar arasında önemli bir fark (P >0.05) bulunmamıştır. Mikrobiyolojik analiz sonuçlarına göre pastörizasyon sıcaklığındaki artışa bağlı olarak

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mikrobiyel yükte önemli (P <0.05) bir azalma gözlenmiştir. Duyusal analiz ve renk ölçümü sonuçlarına göre 50°C ve 70°C' deki pastörizasyon uygulamalarında önemli bir fark (P >0.05) görülmemiştir. Sonuç olarak, 70°C'deki pastörizasyon uygulamasının incelenen tüm parametrelerde genellikle fark yarattığı gözlemlenmiştir.
Anahtar kelimeler: Karides, pastörizasyon, sıcaklık, kalite

INTRODUCTION

Shrimp is among the most popular seafood consumed around the world. They, which are very economical and commercial, have indisputable importance in human nutrition due to their biochemical composition. Shrimp meat is an excellent source of selenium, calcium, phosphorus, potassium, sodium and unsaturated fatty acid with a high protein content. They are also highly digestible seafood, and very rich in B_{12} (Dayal et al., 2013). However, shrimp, which is in the high-risk food category, can pose a risk for foodborne illnesses when it is subjected to inadequate cooking or if it is not properly handled as in all other seafood (Wang et al., 2018). They are highly perishable seafood. They have a short shelf life if unless appropriately stored (Na et al., 2018), because microbiological and biochemical activities continue during storage. Bacteriological and endogenous enzymatic activities are responsible for quality deterioration (Begum et al., 2012). Therefore, various processing technologies are applied to slow or stop these activities that cause the shrimps to deteriorate. With the processing of such a valuable food, a more attractive product is offered to the consumer, and its quality can be preserved for longer periods of time (Salán et al., 2008).

Pasteurization, which is a widely used food processing method in the world, is used for the preservation of food. Pasteurization is a heat treatment method (usually below 100°C) used to eliminate pathogenic microorganisms found in foods, to inactivate most of the microorganisms and enzymes that cause spoilage (Çoksöyler and Avşaroğlu, 2011; Wang et al., 2018). Thus, the desired sensory properties are preserved and a more stable product is obtained by inactivation of microorganisms and enzymes (Skipnes et al., 2002). However, the time and temperature of the heat treatment to be applied to food should be carefully controlled (Wang et al., 2018). Heat treatment, which is one of the most reliable methods used in ensuring food safety and extending shelf life, can cause undesirable changes in the quality properties of foods, especially when applied at high temperatures (Wang et al., 2018). Although heat treatment applications delay spoilage and extend the shelf life compared to raw products, they may have positive or negative effects on the sensory, physical, microbiological and chemical properties of the food (Delfieh et al., 2013). Several studies have reported the effects of the different thermal process on some quality properties of shrimp. Erdoğdu and Balaban (2000) reported that heat treatment significantly affected the sensory and textural properties of shrimps. In another study, Erdoğdu et al. (2004) found that increasing the internal temperature applied to shrimp causes higher yield losses. Wang et al. (2018) reported that the cook loss, area shrinkage, hardness and overall color change of shrimp was affected by the increase in cooking time and temperature. The aim of this study was to evaluate the effect of two different pasteurization temperature (50°C and 70°C) on the basic quality parameters of shrimp.

MATERIALS AND METHODS

Raw Material Preparation

The shrimps (*Parapenaeus longirostris*) was obtained from the retail fish market in Karaköy, Istanbul. Shrimps were transferred to the laboratory in chilled polystyrene boxes within 30 minutes. The average length and weight of the shrimps were 14.91±1.69 cm and 8.38±3.07g. Shrimps' head, tail, legs and shell were removed by hand, and washed with tap water in a large plastic bowl and blotted dry with paper towels. Raw shrimp's analysis was done immediately.

Shrimp Packaging and Pasteurization Process

Twenty shrimps were placed in thermostable polyethylene-polyamide pouch (O_2 permeability of 160 cm^3/m^2 per 24 h at 23C, 0% RH and water vapor permeability of 8.5 g/m^2 per 24 h at 38C,

90% RH). The packages were heat sealed under atmospheric air. Packages were pasteurized by using water bath (DAIHAN WCB-22). The cool pasteurization process lasted 17 minutes, where, six packages were immersed in a water bath. The shrimp's internal temperature reached 50°C in 7 minutes. Similarly, six packages were placed in water bath for heat pasteurization process (70°) and continued for 20 min. The shrimp internal temperature reached 70°C in 10 minutes. Shrimp internal temperature was monitored using a digital thermocouple (Testo 926). Thermocouple was placed at the second segments of shrimps in pack during cooking process. After the pasteurization process the packages were cooled at room temperature for 30 minutes.

Cook Loss Determination

Raw shrimps were weighed and noted before each pasteurization process (50°C and 70°C). After pasteurization, shrimp meat was placed on filter paper to drain the surface water. Then they were gently covered with another filter paper and weighted after this process. Cook loss was calculated as follows:

Cook loss (%) = $\left(\frac{Wr-Wp}{Wr}\right) x100$

where "*Wr"* is the weight of raw samples and "*Wp"* is the weight of pasteurize samples (Wang et al., 2018).

Proximate Analyses

The shrimp samples were analyzed in triplicate for determination of the proximate composition: the fat content of shrimp was determined by the acid hydrolysis method of the AOAC (1998a), the moisture content by the method of AOAC (1998b) the ash content by the AOAC (1998c) method and total crude protein by the Kjeldhal method (AOAC, 1998d).

Microbiological Analyses

Ten-gram shrimp samples were transferred aseptically to sterile stomacher bag containing 90 mL of 0.1% peptone water (0.1% peptone from meat) (Merck) and homogenized in stomacher (IUL Instrument). Appropriate serial dilutions (1:10 diluent, 0.1% peptone water) were prepared from this homogenized sample. Total mesophilic (TMAB) and total psychrophilic aerobic bacteria (TPAB) were determined using plate count agar (PCA, Merck) (by the pour plate method). The plates were incubated for 24–48 h at 37ºC for total mesophilic aerobic bacteria counts and for 10 days at 7ºC for psychrophilic counts (Baumgart, 1986). Number of *Pseudomonas* spp. was determined using Pseudomonas selective agar (Merck) with added CFC supplement (Merck) and incubated at 25 ˚C for 44±4 h (Martínez-Alvarez et al., 2009). Lactic acid bacteria (LAB) count was determined using MRS Agar (Merck) by the pour plate method which incubated at microaerobic conditions at 30°C for 48 h (Cosansu et al., 2011a). For the detection of *Bacillus cereus*, Mannitol-egg Yolk-Polymyxin Agar (MYP Agar, HI-MEDIA, Kat No: M636) was used. At the end of incubation (48 hours at 28˚C), colonies with pink-violet centers were counted as *B. cereus* (Rhodehamel and Harmon, 2001; Halkman, 2005)

Physicochemical Analyses

All chemical analyses were performed in triplicate. For the pH measurement, homogenized shrimp samples were mixed thoroughly with distilled water (1/10 w/v) at room temperature with Ultra-Turrax (IKA T 25 Basic, Germany). pH was monitored using a calibrated WTW pH Meter (InoLab pH Level 1 model, Weilheim, Germany) (Vyncke, 1981). For the Total Volatile Basic Nitrogen (TVB-N) analysis, 10 grams of minced shrimp was homogenized with 90 mL perchloric acid (6%)(Merck) for 1 min in an Ultra-Turrax. The homogenates were filtered through a Whatman no. 1 filter paper. Before distillation, 20% sodium hydroxide (NaOH, Merck) were added to the filtrates and distillation process was carried with Velp UDK 140 model (Milano, Italy) apparatus. The final distillate was then titrated with 0.01 N hydrochloric acid (HCl Merck). The results were expressed as milligrams of TVB-N per 100 grams of shrimp flesh (Antonacopoulus and Vyncke, 1989). For the estimation of Trimethylamine nitrogen (TMA-N) content of shrimps, 10 g samples were homogenized with 90 mL 10% trichloroacetic acid (TCA) (Merck) solution and homogenates were filtered by filter paper (Whatman No: 1). After filtration, 4 mL of filtrate was shaken in a tube with 10 mL of

toluene, 1 mL of 20% formaldehyde (Merck) and 3 mL of 50% potassium hydroxide (Carlo Erba). Subsequent to this, 5 mL of upper layer of the mix was separated and mixed with 5 mL of 0.2% picric acid for spectrophotometer measurement (UV/VIS T80, PG Instruments Ltd) at 410 nm. The TMA-N values were calculated from the standard curve and expressed as mg/100g samples (Schormüller 1968). The thiobarbituric acid value (TBA) was determined by the modified method of Erkan and Özden (2008). Ten gram homogenized shrimp sample was weighed into a volumetric flask. Ninety mililiters of 5% TCA (Merck) solution and 100 µL butylated hydroxytoluene (SIGMA) was added and in an Ultra-Turrax, homogenized at high speed for two minutes. The mixture was filtered through a Whatman No. 1 filter paper. Five mililiters of filtrate was transferred into test tubes and 5 mL of TBA reagent (0.02 M of the solution of 2-thiobarbituric acid (Merck) in 10% acetic acid, Merck) was added. The test tubes were placed in a water bath at 80 °C for 30 min, then cooled. Absorbance was measured at 532 nm against blank with a UV-VIS spectrophotometer. The thiobarbituric acid values were expressed as mg of malondialdehyde (MDA)/kg of shrimp sample.

Sensory Analysis

Sensory analysis of pasteurized shrimp at 50 and 70°C was carried out in duplicate with 10 trained panelists using a 9-point hedonic scale. Panelists have been working at Istanbul University Faculty of Aquatic Sciences and have been doing sensory analysis for 10 years. Pasteurization process was carried out as described in the method. The sample groups were coded in 3-digit numbers before being presented to the panelists. The sample groups were served to the panelists on a white porcelain plate at room temperature. The analysed characteristics were: Liking of Appearance (1 = Extremely dislike, 9 = Extremely like), Liking of Texture (1 = Extremely dislike, 9 = Extremely like), Liking of Flavour (1 = Extremely dislike, 9 = Extremely like), Juiciness (1 = Very dry, 9 = Very juicy), Tenderness (1-Extremely tough, 9 = Extremely tender), Off-flavour (1 = Imperceptible, 9 = Extremely pronounced) and Overall sensory acceptability (OSA) (1 = Extremely dislike, 9 = Extremely like) (O'Neill et al., 2019).

Color Measurement

In this study, shrimp meat color parameter values (L*: (Lightness/brightness), a*: (+ a, redness; -a, greenness) and b*: (+ b, yellowness; -b, blueness) was measured by a Konica Minolta chromometer (Konica Minolta, Model CR 400/410, Japan). Before starting measurements, the instrument was calibrated using white reference. The color values were measured from 3 different regions of 3 different shrimp.

Statistical Analysis

The study was repeated twice. Statistical analyses were performed using IBM SPSS 21 software (SPSS Inc.; Chicago, IL, USA) program. One-way analysis of variance (ANOVA) was applied to the results obtained from proximate composition, microbiological analysis, physicochemical analysis and color measurement. Results obtained from the sensory analysis of pasteurized shrimps were compared with t-test. Data are presented as means±standard deviations. Differences were accepted as significant when $P < 0.05$.

RESULTS AND DISCUSSION

In this study, the cooking loss in pasteurized shrimps at 50°C and 70°C were found 9.90 % and 28.76 %, respectively. The cook loos of shrimps significantly ($P < 0.05$) increased with rising temperature, in agreement with data reported by Cao et al., (2016) and Wang et al. (2018). Lekjing et al. (2017) reported that in pasteurized oysters at different temperatures (from 57.5°C to 70°C), the cook loss increased with the increase in temperature. Cook loss increases with temperature and water holding capacity of food decreases. The water holding capacity of muscle tissue is associated with the degree of heat denaturation of myofibrillar proteins during heat treatment. As the temperature rises, structural changes occur with denaturation of myosin and actin. This causes the sarcoplasmic fluid to expel from the muscle fibers (Li et al., 2013; Lekjing et al., 2017).

Proximate composition of raw and pasteurized shrimps is shown in Table 1. The proximate composition of raw shrimp was 79.63 % moisture, 22.39 % protein, 0.99 % fat, and 1.61 % ash. Our results are similar to the results of other studies with *Parapenaeus longirostri*s (López-Caballero et al., 2007; Oksuz et al., 2009). The proximate composition of shrimp may vary depending on the species, size, catching season, feeding, age, sexual variation (Nageswararao and Babu, 2019). As would be expected, the moisture percentage of shrimp significantly (P <0.05) decreased after both pasteurization process (50°C and 70°C) (Table 1). This decrease in moisture content may be due to the decrease in water-holding capacity of muscle proteins due to temperature rises (Mohan et al., 2017). In another study, Delfieh et al. (2013) investigated effects of different cooking methods on proximate composition of Indian White Prawn. They reported that different temperature treatments can evaporate muscle water at different levels. The protein percentage of shrimp significantly increased (P <0.05) after pasteurization at 70°C compared raw and processed at 50°C. Mol et al. (2012) reported that the protein percentage of bonito fillets significantly increased (P <0.05) proportionally after sous vide process (at 70°C) due to loss of water from fish tissue. Similarly, Andrés-Bello et al. (2009) reported that the protein percentage of sea bream fillets significantly increased (P <0.05) after vacuum cooking (cook vide) process (at 70-100°C) due to reduced moisture contents in products after cooking. In this study, the fat percentage of shrimp significantly increased (P <0.05) after both pasteurization (50°C and 70°C) process. In another study, Zhang et al. (2013) stated that increase of protein, fat and ash concentration in the fish samples after different cooking methods could be explained by loss of water. Mohan et al. (2006) studied the effect of heat treatment time on the quality characteristics of "shrimp kuruma" in retortable pouches and aluminum cans. In their study, the moisture percentage of shrimps was lower after thermal process while protein and fat percentage were higher as observed in our study. In the current study, no significant change (P >0.05) was observed in the ash percentage of shrimps after pasteurization.

Table 1 Proximate composition, microbiological and chemical analyses results of raw and pasteurized shrimps.

Anlayses	Groups		
Proximate composition results(%)			
	Raw Material	50°C	70°C
Protein	22.39±0.08^{a}	22.78±0.43^{a}	25.39±0.45^{b}
Fat	0.99±0.03^{a}	1.07±0.02^{b}	1.15±0.01^{c}
Moisture	79.63±0.09^{a}	78.64±0.08^{b}	77.76±0.11^{c}
Ash	1.61±0.12^{a}	1.64±0.02^{a}	1.68±0.09^{a}
Microbiological analyses results (log cfu/g)			
	Raw Material	50°C	70°C
TMAB	2.84±0.12^{a}	2.16±0.13^{b}	1.91±0.14^{c}
TPAB	3.30±0.06^{a}	2.17±0.14^{b}	1.38±0.10^{c}
Pseudomonas spp.	2.65±0.40^{a}	2.65±0.40^{a}	<1.00^{b}
LAB	1.15±0.21^{a}	<1.00^{b}	<1.00^{b}
Chemical analyses results			
	Raw Material	50°C	70°C
pH	7.10±0.00^{a}	7.18±0.01^{b}	7.23±0.00^{c}
TVB-N (mg/100g)	9.32±0.14^{a}	9.45±0.23^{a}	8.62±0.71^{a}
TMA-N (mg/100g)	1.08±0.05^{a}	0.96±0.02^{b}	0.99±0.03^{b}
TBARs (mg MDA/kg)	0.18±0.00^{a}	0.17±0.00^{ab}	0.15±0.01^{b}

a-c: Different letters in the same row show significant differences (P <0.05)
±: Standard deviation.

Changes in microbiological load before and after pasteurization were shown in Table 1. The total viable count is used very often as an indicator to determine the microbiological quality in foods (Rezaeifer et al., 2020). In this study, the initial total mesophilic and psychrophilic aerobic bacteria count in raw material were 2.84±0.12 and 3.30±0.06 log cfu/g, respectively. Freshly captured shrimps with a total bacterial load 2 and 3 log indicate high quality (López-Caballero et al., 2019). In the current study, the total mesophilic bacteria count significantly (P <0.05) decreased in both group (50°C and 70°C) compared to raw shrimp after pasteurization. There is significant difference (P <0.05) between the groups (50°C and 70°C). Similar the total mesophilic bacteria count results, the total psychrophilic bacteria count significantly (P <0.05) decreased in both group (50°C and 70°C) compared to raw shrimp after pasteurization. However, the total psychrophilic bacteria load of the pasteurized shrimps at 70°C was significantly lower (P <0.05) than the pasteurized shrimps at 50°C. Many researchers observed that various heat treatment application in different kind of seafood are effective in reducing total bacterial load (Martinez-Alvarez, et al., 2009; Mol et al., 2012; Cosansu et al., 2011b; Dogruyol and Mol, 2017). Mohan et al. (2017) reported that sous-vide cooking reduced total mesophilic count by 3 log. The decrease in total mesophilic count resulting from sous-vide cooking is due to the change in the permeability of the cell wall of microorganisms and protein denaturation (Mohan et al., 2017). *Pseudomonas* spp. are psychotropic spoilage microorganisms responsible for chilled food spoilage (Raposo et al., 2017). In this study, the initial *Pseudomonas* spp. count of the raw shrimp was 2.65±0.40 log cfu/g. Na et al. (2018) reported similar *Pseudomonas* spp. count for pacific white shrimp was 2.80 log cfu/g. No change in the number of *Pseudomonas* spp. was observed after pasteurization at 50°C. On the other hand, *Pseudomonas* spp. was not determined after pasteurization at 70°C. In a study investigating the microbiological quality of sous-vide fish cakes, pseudomonas load in raw fish was 2.08 log cfu/g, whereas pseudomonas was not detected in the samples after 20 minutes of sous-vide cooking at 100°C (Shakila et al., 2009). In another study, Martínez-Alvarez et al. (2009) reported *Pseudomonas* spp. count of raw shrimp was below (<2 log cfu/g) after different cooking treatment (cooking in a steam-oven, boiled in a water bath traditionally and vacuum packed shrimp immersed in a boiled water -at 100°C for 2 min-). In this study, the initial lactic acid bacteria load of the raw shrimp was 1.15±0.21 log cfu/g. It can be suggested that pasteurization process eliminated total lactic acid bacteria in shrimps. Our results are in agreement with those reported by Gonzalez-Fandos et al. (2004) who studied evaluation of microbiological and sensory quality of rainbow trout after sous vide process. They observed that after sous vide process the load of lactic acid bacteria decreased below the detectable limit (<1 log cfu/g). In another study, Martínez-Alvarez et al. (2009) reported that cooking treatment is very effective in eliminating the microflora of the raw deep water pink shrimp (*Parapenaeus longirostris*). Similar to our study results, they found that lactic acid bacteria count of raw shrimp was below detection limit (<1 log cfu/g) after cooking different treatment. *Bacillus cereus* is gram-positive pathogenic bacterium with heat resistant spores and especially a risk factor in mild heat treated food (Webb et al., 2019). *Bacillus cereus* was not detected in raw and all pasteurized shrimps in our study. Similarly, Gonzalez-Fandos et al. (2004) and Cosansu et al. (2013), did not detect *Bacillus cereus* in the fish samples they examined in their studies.

pH is one of the simple and trustworthy freshness indicators (Cheng et al., 2015). The change in pH of fish muscle is usually a good index for quality evaluation (Rathod and Pagarkar, 2013). As shown in Table 1 the initial pH of the fresh shrimp was 7.10±0.00, which was similar to the value of 7.04 reported by Mu et al. (2012). After pasteurization, the pH value of the shrimps increased significantly (P <0.05). The pH value of pasteurized shrimps at 70°C was significantly higher (P <0.05) than that of at 50°C pasteurized shrimps. The results of in this study are in agreement with the results Mohan et al. (2017) who reported that pH value of fresh Indian white shrimp increased after sous vide process.

Similarly, the results of this study are in accordance with several previous studies investigating sous-vide treatment of mackerel (Dogruyol and Mol, 2017; Cropotova et al., 2019) and cooking treatment of deep water pink shrimp (Martínez-Alvarez et al., 2009).

Total volatile basic nitrogen, which is used as a standard indicator for spoilage in fish, formed of ammonia, methylamine, dimethylamine, and other volatile amines (Cao et al., 2016). It is the most sensitive index especially in the evaluation of shrimp freshness (Fang et al., 2019). The European Commission (EC) advised that TVB-N be used for the evaluation of fish freshness when sensory assessment is inadequate. Critical limits of 25, 30 and 35 mg TVB-N/100 g were widely accepted for different groups of fish species (Tolasa et al., 2012). In many literature, the TVB-N limit value of acceptable for shrimp is shown as 30 mg/100 g (Shi et al., 2019; Yu et al., 2019; Alparslan et al., 2019) In this study, initial TVB-N value of raw shrimp samples was 9.32±0.14 mg/100g (Table 1), which was lower than the initial values reported by Alparslan and Baygar, (2017) in deep water pink shrimp (17.32 mg/100g) and by Dabadé et al. (2020) in tropical brackish water shrimp (28.9 mg/100 g). The TVB-N value in fish may vary depending on the species, size, catch season, feeding type, age, sex and microbial activity (Dabadé et al., 2020). After the pasteurization, the TVB-N value of pasteurized shrimps at 50°C and 70°C were 9.45±0.23 and 8.62±0.71 mg/100g, respectively. Similarly, Cosansu et al., (2011b), reported that no significant decrease in TVB-N value of bonito samples after sous vide process (70°C, 10 min) as observed in our study. Similar to our results, Martínez-Alvarez et al. (2009) reported that no significant change was observed in TVB-N values before and after shrimps were cooked different styles (cooking in a steam-oven and boiled in a water bath traditionally). This was linked to the leached nitrogen volatile compounds out of the muscles during cooking. The expected significant reduction of TVB-N was not observed due to short boiling time. In another study, Bongiorno et al. (2018) examined the chemical, microbiological and sensory quality of mussels processed by different sous vide methods during cold storage. They observed that the TVB-N value of mussel samples did not significantly decrease after sous vide cook-chill without vacuum conditions.

The most common chemical method used to assess the quality of fish is the measurement of TMA, a volatile basic compound found at very low levels in fresh fish but which accumulates in altered sea fish as a result of trimethylaminoxid reduction by bacteria. This means that the determination of the TMA does not give any information on the initial autolytic changes or on the freshness, but only on the transformations due to bacteria which occur much later and on the degree of alteration (Huss, 1988). In the current study, TMA-N value of fresh shrimp was determined as 1.08±0.05 mg/100g (Table 1). Similar TMA result (0.97 mg/100g) was determined for pink shrimp by Alparslan et al. (2017). After the pasteurization, the TMA-N value of the shrimps slightly decreased in both group compared to raw shrimp. However, this decrease was found to be statistically significant (P <0.05). No significant difference (P >0.05) was observed between the pasteurization groups (50-70°C) (Table 1). Cosansu et al. (2011b) observed that slight decrease in TMA value of bonito fish after sous-vide process (at 70°C, for 10 min) as observed our study. In another study, Dogruyol and Mol, (2017) determined that the TMA value of mackerel samples slightly decreased after sous-vide process.

Lipid oxidation is very important indicator of quality deterioration, especially in seafood that contains highly unsaturated fats (Hultin, 1994). As seen in Table 1, the initial TBARs value of the fresh shrimp was 0.18±0.00 mg MDA/kg, which was similar to the value of 0.17 mg MDA/kg reported by Alparslan et al. (2019) for deep water pink shrimp. After the pasteurization, the TBA value of pasteurized shrimps was at 50°C and 70°C were 0.17±0.00 and 0.15±0.00 mg MDA/kg, respectively. No significant difference (P >0.05) was observed between the pasteurization groups (50-70°C). Although there was a slight decrease in TBA values of shrimps after pasteurization at 70°C, this was found to be

statistically significant (P<0.05) than raw shrimp. Orlando et al. (2020) studied the effect of different cooking processes (convection-oven, steam-oven and sous-vide accomplished in oven) on antioxidant compounds levels and oxidative status of Atlantic salmon fillets. Similar to our study results, they observed that the TBARs value of the all cooked salmon samples significantly lower (P <0.05) than that of the raw samples. They stated that this decrease in TBARs value might be due to the loss of secondary oxidation products during heat treatment.

The sensory analysis results are shown in Table 2. As a result of the sensory evaluation of the pasteurized shrimp at two different degrees, the panelists did not find a significant difference (P >0.05) in all parameters between the two groups. This indicates two degrees of pasteurizing are acceptable to the consumers. As in our study, Gundavarapu et al. (1998) did not find any difference between the groups in the shrimp that they cooked at different strengths in the microwave oven.

Table 2 Sensory analysis results of pasteurized shrimps.

	Apperance	Texture	Flavour	Juiciness	Tenderness	Overall Sensory Acceptibility
50°C	7.07±1.48[a]	6.85±1.57[a]	5.51±2.29[a]	6.42±2.07[a]	5.57±1.61[a]	6.21±1.62[a]
70°C	6.05±1.68[a]	5.71±2.05[a]	6.42±1.81[a]	4.28±2.21[a]	7.14±1.57[a]	6.00±1.73[a]

[a]: Different letters in the same column show significant differences (P <0.05)
±: Standard deviation

Color is one of the most important factors in evaluating the appearance of the food in consumer preference (Çelik and Çakmakçı, 2020). The results of color parameter measurements of the raw and pasteurized shrimps are illustrated in Table 3. In this study, the lightness (L*) value of shrimp samples increased due to the increase in heat treatment temperature. However, this increase was found to be statistically insignificant (P >0.05). Similarly, Cadun et al. (2016) reported that the L* value of sous-vide cooking shrimp increased in parallel with the increase heating temperature and time. The main cause of whitening in certain muscles is due to denaturation of heme (myoglobin and hemoglobin) proteins. The pink or red color of the shrimp is due to the consumption of marine plants containing the carotenoid astaxanthin. Some carotenoids are attached to proteins. Astaxanthin pigment in raw shrimp is blue and heat denatures the astaxanthin-protein complex. As a result, the visual properties of the pigment change from blue to red (Wang et al., 2018). In the current study, the highest a* and b* values were measured in samples that were heat treated at 70°C. Wang et al. (2018) reported that in pasteurized shrimps at different temperatures the in a* and b* values increased with the increase in temperature. However, in the current study, it was observed that the pasteurization process did not cause statistically significant (P >0.05) changes in a* and b* values of shrimp samples.

Table 3 Color changes of raw and pasteurized shrimps.

	L*	a*	b*
Raw Material	63.52±10.02[a]	3.05±1.42[a]	4.78±1.20[a]
50°C	70.68±1.98[a]	2.14±0.60[a]	4.55±0.94[a]
70°C	71.99±3.78[a]	3.28±2.55[a]	6.09±3.07[a]

[a]: Different letters in the same column show significant differences (P <0.05)
±: Standard deviation.

CONCLUSIONS

The results obtained in the study revealed that pasteurization at 70°C generally made a difference in all parameters examined. On the other hand, pasteurization applied at 50 and 70 °C did not make any difference in the sensory properties of the shrimps. However, the fact that high temperature application gives much better microbial results has revealed that it will be preferred in terms of marketing the product. Investigating the shelf life in the next stages will be beneficial in terms of bringing pasteurized shrimp to the consumer.

CONFLICT OF INTEREST

The authors declare no conflict of interest

ETHICAL STATEMENT

The authors state that no ethical approval was needed.

AUTHOR CONTRIBUTIONS

DÜA, contributed to the planning and analysis of the experimental study, statistical evaluation of the data and writing of the article. ŞYT, contributed to the analysis of the experimental study, statistical evaluation of the data and writing of the article. İCT, contributed to the analysis of the experimental study.

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