# THE EFFECTS OF VACUUM PACKING ON THE QUALITY OF THERMALLY PROCESSED LUMP CRABMEAT (*Portunus pelagicus*)

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## ABSTRACT

The effects of vacuum on the quality of thermally processed lump crabmeat were evaluated in terms of microbiological, sensorial and chemical analyses. The results of sensory analyses showed that vacuumed lump crabmeat were not acceptable at the day of 55 whereas unvacuumed lump crabmeat were rejected by panelists at the day of 48. At the beginning of storage, the total volatile basic nitrogen (TVB-N) value was 26.37 mg/100 g for vacuumed and unvacuumed lump crabmeat, but the TVB-N values increased to 43.79 and 89.71 mg/100 g TVB-N at the end of the storage period, respectively. TBA values for all groups were found to be quite low. There were significant differences ($p<0.05$) in the pH value with the higher increase for unvacuumed samples. Among the biogenic amines, histamine was not detected in all samples throughout the storage period. According to microbiological analyses, if $10^7$ microorganisms/g are considered to be the TVC limit of acceptability, the shelf-life of vacuumed and unvacuumed crabmeat were approximately ~55-58 days and ~48-50 days, respectively.

**KEYWORDS:** Thermal processing, lump crabmeat, *Portunus pelagicus*, vacuum packing

## 1. INTRODUCTION

Crabs are a large group of invertebrates, and commercial fisheries have focused on crabs since they do not only have a delicious taste, but also a unique pleasant aroma and high palatability [1]. Crabmeat being rich of minerals, amino acids and fatty acids are an excellent resource [2, 3]. It is well-documented that polyunsaturated fatty acid (PUFA) contents are beneficial in the reduction of heart diseases [4, 5]. Although the nutritional composition of several commercially important species of crabs has been characterized, they vary widely in their nutrient content [6]. Küley *et al.* [7] also reported differences in concentrations of moisture, fat, ash and protein, in meats from different sex and body parts of the blue crab. The composition of proteins, amino acids, minerals, sterols, total lipids and fatty acids of the most commercially significant crabs can be found in previous publications [2].

Blue swimmer crabs (*Portunus pelagicus*) annual output has increased during the past decade in Turkey, from 55,071 tons in 2003 to 95,871 tons in 2007 [8]. The crab industry is generally interested in pasteurization, freezing and canning. Therefore, the quality of raw material is considered to be the most important factor, determining the end product quality and safety [9]. The principal objective of this investigation was to determine the effects of vacuuming on the shelf-life of thermally processed lump crabmeat.

## 2. MATERIALS AND METHODS

### 2.1. Sample preparation

The crabs were caught by dip net in the eastern Mediterranean Sea and transported to laboratory alive. Average weight, carapace width and carapace length of the crabs were 210.1±30.6 g, 145±0.6 mm and 77.1±0.3 mm, respectively. Carapaces of all of raw specimens were removed, and the two largest portions of meat connected to the swimming legs (lump crabmeat) were carefully scraped out with a scalpel. Lump crabmeat was thermally processed at +83±3 ºC for 130 min, and then divided into two groups (vacuum- and unvacuum-packed). The samples were stored under refrigerator conditions (4±1 ºC). Each polyethylene bag contained approximately 0.5 kg sample.

### 2.2. Sensory analysis

Sensory analyses (appearance, odor, texture, color, taste and general acceptance) of thermally processed lump crabmeats were assessed according to the method of Paulus *et al.* [10]. A hedonic scale from 9 to 1 was used to evaluate thermally processed crabmeats. A score of 9 represents 'very good quality', a score of 7-8 'good quality', a score of 5-6 'acceptable', while a score of 1-4 was regarded as 'bad or unacceptable'.

#### 2.3. Analytical methods

The TVB-N content of crabmeat was determined according to the method of Antonacopoulos [11] and expressed as mg TVB-N per 100 g muscle. The value of TBA was determined according to Tarladgis *et al.* [12] in crabmeat to evaluate the oxidation stability during the storage period, and the results were expressed as TBA value, mg of malondialdehyde per kg flesh. The pH of thermally processed lump crabmeats was determined using a pH-meter (315i, Germany). The sample was homogenized in distilled water in the ratio 1:10 (w/v). Biogenic amines, AMO (ammonium) and TMA (trimethlyamine) were analyzed using an HPLC method [13]. Benzoyl chloride as a derivatization reagent was used and the derivatization procedure was based on that of Redmond & Tseng [14].

#### 2.3.1. HPLC apparatus

An HPLC apparatus Shimadzu LC-10VP (Shimadzu, Kyoto, Japan) equipped with UV/VIS detector (Spectra-Physics SP 8450, Analytical Inc., UK) and a low gradient pump (Shimadzu LC-10ATVP) with four channel mixer (Shimadzu FVC-10ALVP) was used. For biogenic amine analysis, the column was a reversed phase Nucleosil C18, 250 x 4.6 mm, particle diameter 5 μm (Macherey-Nagel, Duren, Germany). For nucleotide determination, a Sphereclone ODS(2) C18 column, 150 x 4.60 mm, particle diameter 5 μm (Phenomenex, Macclesfield, Cheshire, UK) was used.

#### 2.4. Microbiological analysis

Lump crabmeat (10 g) was mixed with 90 ml of Ringer solution (Merck, 1.15525.0001, Darmstadt, Germany), and then "stomachered" (IUL instrument, Barcelona, Spain) for 3 min. Further decimal dilutions were made, and then 0.1 mL of each dilution was pipetted onto the surface of Nutrient Agar (NA, Fluka, 70148, Steinheim, Spain) for total viable count (TVC). They were then incubated for 2 days at 30 °C. XLD agar (Merck 1.05287, Darmstadt, Germany) was used for *Salmonella* bacterial count. Plates were incubated at 37 °C for 24 h. The coliform and *Escherichia coli* counts were performed with Violet Red Bile Lactose (VRBL) agar (Merck 1.01406, Darmstadt, Germany) and MacConkey MUG agar (Fluka 63014, Steinheim, Spain), respectively. Plates were incubated at 30 °C for 24 h.

#### 2.5. Statistical analysis

Statistical analyses of data were carried out with SPSS 16.0. One-way ANOVA (analysis of variance) and t-test were used to evaluate the effects of vacuum packing on the quality of thermally processed lump crabmeat.

## 3. RESULTS AND DISCUSSION

#### 3.1. Sensory analysis

Table 1 shows the sensory evaluation results of the effects of vacuum packing on thermally processed lump crabmeat. Vacuumed lump crabmeat was not acceptable after 55 days whereas unvacuumed lump crabmeat samples were rejected by panelists already after 48 days.

#### 3.2. Chemical analysis

AMO and TMA levels of lump crabmeat were increased during storage for both groups linearly (Table 2). A linear increase in the amount of AMO and TMA was observed

**TABLE 1 - Sensory assessment of thermally processed lump crabmeat**

| | Day 1 | | Day 36 | | Day 48 | | Day 55 | |
|---|---|---|---|---|---|---|---|---|
| | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ |
| Appearance | 8.88±0.35$^{a}$ | 8.75±0.46$^{a}$ | 7.38±0.52$^{b}$ | 7.00±0.76$^{a}$ | 7.25±0.89$^{b}$ | 4.50±0.54$^{a}$ | 5.00±1.07$^{a}$ | 4.25±0.46$^{a}$ |
| Odour | 9.00±0.00$^{a}$ | 8.88±0.35$^{a}$ | 7.63±0.52$^{b}$ | 5.75±0.89$^{a}$ | 6.75±0.46$^{b}$ | 2.75±0.89$^{a}$ | 4.75±0.46$^{b}$ | 2.25±0.89$^{a}$ |
| Texture | 8.75±0.46$^{a}$ | 8.63±0.52$^{a}$ | 6.63±0.52$^{b}$ | 5.75±0.89$^{a}$ | 6.25±0.89$^{b}$ | 3.25±1.39$^{a}$ | 4.00±0.76$^{b}$ | 2.75±0.89$^{a}$ |
| Colour | 8.75±0.46$^{a}$ | 8.88±0.35$^{a}$ | 7.50±0.54$^{a}$ | 7.25±0.46$^{a}$ | 6.88±0.35$^{b}$ | 4.75±0.89$^{a}$ | 5.00±0.76$^{a}$ | 4.50±0.54$^{a}$ |
| Taste | 8.75±0.46$^{a}$ | 8.75±0.46$^{a}$ | 7.00±0.76$^{b}$ | 6.00±0.76$^{a}$ | 6.63±0.52$^{b}$ | 3.00±0.76$^{a}$ | 3.50±0.93$^{a}$ | 2.50±0.54$^{a}$ |
| General acceptance | 8.88±0.35$^{a}$ | 8.75±0.46$^{a}$ | 7.25±0.46$^{b}$ | 6.50±0.54$^{a}$ | 6.50±0.76$^{b}$ | 3.25±0.89$^{a}$ | 4.75±0.46$^{b}$ | 3.00±0.76$^{a}$ |

*Different letters in the same row (a,b) indicate significant differences for every day ($p<0.05$). $\bar{X} \pm S_{\bar{X}}$: Average ± standard deviation

**TABLE 2 - The changes in AMO and TMA contents of thermally processed lump crabmeat (mg/100g).**

| | AMO | | TMA | |
|---|---|---|---|---|
| Days | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ |
| 1 | 1.01±0.26$^{a, x}$ | 1.01±0.26$^{a, x}$ | 0.39±0.08$^{a, x}$ | 0.39±0.08$^{a, x}$ |
| 36 | 1.27±0.29$^{a, y}$ | 1.71±0.27$^{b, y}$ | 0.61±0.09$^{a, y}$ | 0.81±0.03$^{b, y}$ |
| 48 | 2.07±0.42$^{a, z}$ | 2.47±0.39$^{b, z}$ | 0.87±0.04$^{a, z}$ | 0.92±0.15$^{a, y}$ |
| 55 | 2.59±0.52$^{a, q}$ | 3.51±0.14$^{b, q}$ | 1.16±0.15$^{a, q}$ | 1.38±0.04$^{a, z}$ |
| 68 | 5.10±0.16$^{a, w}$ | 5.38±1.80$^{a, q}$ | 1.33±0.04$^{a, q}$ | 3.53±0.48$^{b, q}$ |
| 71 | 6.43±0.53$^{a, v}$ | 9.74±6.53$^{b, v}$ | 2.37±0.12$^{a, w}$ | 7.21±0.45$^{b, w}$ |

*Different letters in the same row (a,b) and column (x,y,z,q,w,v) indicate significant differences ($p<0.05$). $\bar{X} \pm S_{\bar{X}}$: Average ± standard deviation

**TABLE 3 - The changes in TVB-N, TBA and pH contents of thermally processed lump crabmeat.**

| Days | TVB-N | | TBA | | pH | |
|---|---|---|---|---|---|---|
| | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ | Vacuumed $\bar{X} \pm S_{\bar{X}}$ | Unvacuumed $\bar{X} \pm S_{\bar{X}}$ |
| 1 | 26.37±0.36$^{a,x}$ | 26.37±0.36$^{a,x}$ | 0.08±0.01$^{a,x}$ | 0.08±0.01$^{a,x}$ | 6.55±0.01$^{a,y}$ | 6.55±0.01$^{a,x}$ |
| 36 | 31.43±0.37$^{a,y}$ | 34.95±0.05$^{b,y}$ | 0.09±0.01$^{a,x}$ | 0.23±0.04$^{b,z}$ | 6.59±0.01$^{a,z}$ | 6.59±0.01$^{b,y}$ |
| 48 | 34.93±0.26$^{a,z}$ | 40.08±0.16$^{b,z}$ | 0.10±0.02$^{a,x}$ | 0.13±0.01$^{b,y}$ | 6.69±0.01$^{a,q}$ | 6.71±0.01$^{a,z}$ |
| 55 | 49.40±0.27$^{a,v}$ | 64.42±0.71$^{b,w}$ | 0.11±0.01$^{a,x}$ | 0.12±0.01$^{b,y}$ | 6.74±0.01$^{a,w}$ | 6.83±0.01$^{b,q}$ |
| 68 | 40.62±0.34$^{a,q}$ | 60.44±0.14$^{b,q}$ | 0.10±0.01$^{a,x}$ | 0.25±0.01$^{b,z}$ | 6.67±0.01$^{a,q}$ | 6.91±0.00$^{b,w}$ |
| 71 | 43.79±2.01$^{a,w}$ | 89.71±89.71$^{b,v}$ | 0.08±0.02$^{a,x}$ | 0.14±0.01$^{b,y}$ | 6.51±0.02$^{a,x}$ | 6.73±0.03$^{b,z}$ |

*Different letters in the same row (a,b) and column (x,y,z,q,w,v) indicate significant differences ($p<0.05$). $\bar{X} \pm S_{\bar{X}}$: Average ± standard deviation

during the storage [15]. AMO values of vacuumed and unvacuumed lump crabmeat were increased during storage and ranged from 1.01 to 6.43 mg/l00 g for the vacuumed as well as 1.01 to 9.74 mg/l00 g for the unvacuumed group. There were significant differences ($p<0.05$) in the group levels of AMO at all days (except from days 1 and 68). Initial TMA amounts of 0.39 mg/100 g reached 2.37 mg/ 100 g for vacuumed thermally processed lump crabmeat and 7.21 mg/100 g for unvacuumed thermally processed lump crabmeat (Table 2).

Total volatile basic nitrogen (TVB-N) is a product of bacterial spoilage and endogenous enzymes action, and its content is often used as an index to assess the keeping quality and shelf-life of products [16]. TVB-N concentrations of vacuumed and unvacuumed lump crabmeat are shown in Table 3. At the beginning of the storage, the TVB-N value was in the range of 26.37 mg 100 $g^{-1}$ flesh for the samples. The TVB-N values showed an increasing pattern during storage. However, the TVB-N value for the vacuumed group increased up to 49.40 mg TVB-N 100 $g^{-1}$ flesh (day 55) and then started to decrease to 40.62 mg TVB-N 100 $g^{-1}$ (day 68). The TVB-N value for the unvacuumed group increased up to 64.42 mg TVB-N 100 $g^{-1}$ flesh (day 55) and then started to decrease to 60.44 mg TVB-N 100 $g^{-1}$ (day 68). The TVB-N values for the vacuumed group remained low compared to the unvacuumed one. There were significant differences ($p<0.05$) in the levels of TVB-N of both groups at all days (except from day 1). The levels of 30-35 mg N per 100 g muscle are considered to be the limit of acceptability for ice-stored cold water fish [17, 18]. Gates *et al.* [19] reported that TVB-N value of fresh blue crabmeat was 26.2 mg 100 $g^{-1}$ and reached 35 mg 100 $g^{-1}$ in cooked meat during the storage at 0 $^{o}$C for 18 days. TVB-N and TMA-N concentrations in the muscle of *postmortem* Chinese mitten crab (*Eriocheir sinensis*) stored at 4 and 20 $^{o}$C were also studied [9]. It was reported that their levels did not change greatly throughout 72-h storage at refrigerated temperature. Therefore, the authors concluded that TVB-N and TMA-N were not reliable indicators of the freshness of crabs. As the samples were heat-treated and taken out of the vacuum pack only at the time of analysis, the meat samples were not exposed to any additional microbial contamination. However, it appears that microbial enzymes from the original microbial flora were present [20], contributing to a significant increase in TVB-N level during the storage period.

Thiobarbituric acid (TBA), a second breakdown product of lipid oxidation, is widely used as an indicator of degree of lipid oxidation. The concentration of TBA in freshly caught fish is typically between 3 and 5 mg of MDA equivalents per kg flesh, but levels of 5–8 mg of MDA equivalents per kg of flesh are generally regarded as the limit of acceptability for fish stored in ice [21]. Table 3 shows TBA contents during storage. TBA values indicating rancidity development in all lump crabmeat remained low (<0.25 mg MDA $kg^{-1}$ meat) and below the limit level at which rancid favors may become evident. This fact can be explained by low level of fat content of crabmeat.

The pH values of samples of thermally processed lump crabmeat stored at 4 $^{o}$C (Table 3) increased in parallel with the storage duration. Significant difference was found ($p<0.05$) between both vacuumed and unvacuumed groups in sample pH during storage period (except from day 1 and 48). Samples in advanced stages of spoilage showed a higher pH value than fresh samples.

### 3.3. Biogenic amines

Table 4 shows the biogenic amine contents of vacuumed and unvacumed thermally processed lump crabmeat. The biogenic amine content of fish is useful in estimating the freshness and degree of spoilage of fish and fish products. These amines are found in fresh fish at low levels, and their presence is associated with bacterial spoilage [22, 23]. The biogenic amine content of fish depends on fish species, free amino acid content, the moment of capture and stomach contents at death since microbial flora varies seasonally [24]. Among the biogenic amines, histamine is potentially hazardous and believed to be the causative agent in Scombroid poisoning [25]. Hungerford [26] reviewed that contamination of fish with histamine is due to mishandling and bacterial production of histamine. Fresh fish contain no histamine, or traces of histamine at levels much lower than the 50 mg $kg^{-1}$ action levels used in the US [27], or the 100–200 mg kg-1 action levels used in Europe [28]. The concentrations of biogenic amines in the muscle of lump crabmeat with or without vacuumed packaging are given in Table 4.

**TABLE 4 - The changes in biogenic amines contents of thermally processed lump crabmeat .**

| Days | KAD $\bar{X}\pm S_{\bar{X}}$ | | SER $\bar{X}\pm S_{\bar{X}}$ | | AGM $\bar{X}\pm S_{\bar{X}}$ | | SPD $\bar{X}\pm S_{\bar{X}}$ | | TRYP $\bar{X}\pm S_{\bar{X}}$ | | SPN $\bar{X}\pm S_{\bar{X}}$ | | DOP $\bar{X}\pm S_{\bar{X}}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | U | V | U | V | U | V | U | V | U | V | U | V | U |
| 1 | 0.09±0.0$^a$ | 0.09±0.0$^a$ | 1.07±0.0$^a$ | 1.07±0.0$^a$ | 0.56±0.1$^a$ | 0.56±0.1$^a$ | 0.32±0.1$^a$ | 0.32±0.11$^a$ | 0.88±0.1$^a$ | 0.88±0.1$^a$ | 0.36±0.0$^a$ | 0.36±0.0$^a$ | 0.87±0.2$^a$ | 0.87±0.2$^a$ |
| 36 | 0.18±0.0$^a$ | 0.26±0.0$^b$ | 1.72±0.1$^a$ | 2.29±0.2$^a$ | 1.96±0.2$^a$ | 2.08±0.3$^a$ | 2.91±0.0$^a$ | 4.16±0.06$^b$ | 1.92±0.4$^a$ | 2.06±0.3$^a$ | 1.03±0.2$^a$ | 2.48±0.5$^b$ | 1.11±0.1$^a$ | 2.01±0.6$^b$ |
| 48 | 0.60±0.0$^a$ | 0.77±0.0$^b$ | 2.05±0.3$^a$ | 2.44±0.2$^a$ | 2.14±0.1$^a$ | 3.04±0.1$^b$ | 3.03±0.0$^a$ | 3.07±0.12$^a$ | 2.04±0.5$^a$ | 2.28±0.3$^a$ | 3.00±0.4$^a$ | 3.59±0.5$^a$ | 2.17±0.5$^a$ | 2.34±0.3$^a$ |
| 55 | 0.73±0.0$^a$ | 1.12±0.0$^b$ | 3.64±0.3$^s$ | 4.70±0.2$^b$ | 2.57±0.2$^a$ | 3.24±0.2$^b$ | 3.27±0.3$^a$ | 4.24±0.20$^b$ | 2.02±0.3$^a$ | 2.54±0.3$^a$ | 2.13±0.2$^a$ | 3.65±0.7$^b$ | 2.87±0.9$^a$ | 2.47±0.5$^a$ |
| 68 | 0.91±0.1$^a$ | 3.24±0.1$^b$ | 4.04±0.4$^s$ | 5.07±0.4$^b$ | 4.04±0.3$^a$ | 5.00±0.5$^b$ | 3.56±0.4$^a$ | 3.87±0.03$^a$ | 1.74±0.2$^a$ | 2.01±0.3$^a$ | 3.36±0.8$^a$ | 3.91±0.3$^a$ | 3.28±0.3$^a$ | 3.41±0.9$^a$ |
| 71 | 3.39±0.4$^a$ | 8.14±0.2$^b$ | 5.04±0.2$^a$ | 7.12±0.4$^b$ | 5.08±0.4$^a$ | 6.01±0.3$^b$ | 4.00±0.5$^a$ | 4.40±0.53$^a$ | 2.06±0.3$^a$ | 2.89±0.4$^b$ | 5.43±0.4$^a$ | 6.34±0.3$^b$ | 2.89±0.3$^a$ | 3.00±0.4$^a$ |

**Different letters in the same row (a,b) indicate significant differences for every day ($p<0.05$). $\bar{X}\pm S_{\bar{X}}$: Average ± standard deviation; V: vacuumed; U: Unvacuumed.

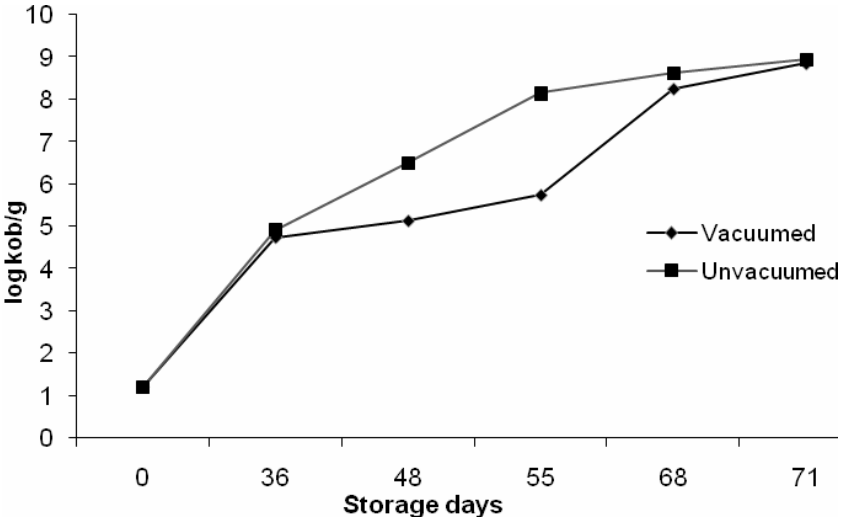


**FIGURE 1 - TVC content of thermally processed lump crabmeat.**

In the present study, histamine produced by bacterial decarboxylation of free histidine was not detected in the groups during storage. Histamine, putrescine, tyramine and 2-phenylethylamine were not found in any samples, but cadaverine, serotonin and agmatine levels increased throughout the storage period, being significantly different ($p< 0.05$) between vacuumed and unvacuumed groups (Table 4). When thermally processed lump crabmeat were rejected by the sensory panel, the levels of serotonin were 3.64 mg 100 g$^{-1}$ for the vacuumed group and lower than 3 mg 100 g$^{-1}$ for the unvacuumed one. However, typtamine, spermine and dopamine levels fluctuated for the unvacuumed group during storage period whereas typtamine, spermidine, spermine and dopamine levels fluctuated for the vacuumed group during storage period. The concentrations of dopamine and tryptamine were negligible in both groups.

### 3.4. Microbiological quality

Microbial counts on the samples of vacuumed and unvacuumed lump crabmeat stored at 4 $^oC$ are shown in Fig. 1. In the present study, *Escherichia coli, Salmonella* and coliform bacteria were not detected. Initial TVC (total viable counts) of thermally processed lump crabmeat was below 1.5 log cfu g$^{-1}$ (day 1), and population of microorganisms significantly ($p<0.05$) increased to >4 log cfu g$^{-1}$ after 36 days of storage. After 55-days storage, TVC was 5.74 cfu g$^{-1}$ for vacuumed and 8.15 cfu g$^{-1}$ for unvacuumed lump crabmeat. A somewhat higher ($10^7$ cfu g$^{-1}$) microbial safety criterion is normally applied for determining storage life of fresh seafood [29]. The shelf-life of thermally processed lump crabmeat was approximately ~48-50 days for unvacuumed and ~55-56 days for vacuumed crabmeat indicating that sensory analysis correlated well with microbiological analysis. Thermal processing (83 $^oC$ for 130 min) reduced the bacterial counts in the products from 4 cfu g$^{-1}$ for raw crab meat to 1.20 cfu g$^{-1}$ for thermally processed lump crabmeat.

## 4. CONCLUSION

Generally, thermal processing improved the sensory quality of unvacuumed and vacuumed lump crabmeat. The results of chemical analyses showed that the application of vacuuming also delayed spoilage of thermally processed lump crabmeat. Sensory analysis correlated well with microbiological analysis, showing a longer shelf-life in the vacuumed group. This study provides useful information on the use of vacuuming and thermal processing to improve the sensory quality but also to delay the spoilage of lump crabmeat during storage.

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