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Investigating the quality changes and shelf life of vacuum shrink-packaged raw and steam-cooked blue crabs under cold storage

Yunus ALPARSLAN[1], Cansu METİN[1], Servet EMİROĞLU[2], Taçnur BAYGAR[1]

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[1]Muğla Sıtkı Koçman University, Faculty of Fisheries, Department of Seafood Processing Technology, Muğla, Türkiye

[2]Republic of Türkiye Ministry of Agriculture and Forestry Muğla Directorate of Provincial Agriculture and Forestry, Muğla, Türkiye

ORCID IDs of the author(s):
Y.A. 0000-0002-8833-996X
C.M. 0000-0002-2290-1489
S.E. 0000-0002-1135-8046
T.B. 0000-0001-8070-0653

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Correspondence:
Cansu METİN
E-mail: cansumetin@mu.edu.tr

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ABSTRACT

This study aimed to determine the quality changes and shelf life of raw and steam-cooked blue crab meat caught in the DALKO Fisheries Cooperative processing plant in the Köyceğiz Dalyan region. Both fresh and cooked crabs were taken from DALKO Fisheries Cooperative and brought to the laboratory under cold chain conditions. After the initial analyses (sensory, chemical, microbiological, and nutrient content) were made for the fresh and cooked blue crabs, the remaining samples were shrink packed. Packaged samples were kept under refrigerator (+/- 4ºC ±1) conditions and shelf-life analyses were carried out during cold storage.

The results determined fresh and cooked crabs' initial nutritional values (protein, lipid, moisture, ash) as 16.22%, 1.06%, 81.17%, 1.45%, and 17.13%, 0.94%, 79.88%, 1.88%, respectively. At the end of storage, these values were determined as 15.88%, 1.51%, 80.18%, 1.67%, and 17.83%, 1.06%, 78.65%, and 2.13% for fresh and cooked crabs, respectively. According to the sensory and microbiological analysis results, the consumable limit values were exceeded on the sixth day for fresh samples and the eighth day for cooked samples. When sensory and microbiological analyses were considered, it was determined that the fresh crabs have a shelf life of 4 days and cooked crabs have six days in vacuum-packaged refrigerator conditions.

Keywords: Blue crab, Shelf life, Vacuum shrink packaging

Introduction

The blue crab (*Callinectes sapidus*) is an allochthonous crab species originating from the Western Atlantic Ocean that was colonized in the coastal areas of Greece in 1940, especially in the Gulf of Thermaikos (Serbetis, 1959), also reported in the marine area of Rhodes Island in 1976 (Lewinshon, 1976). Blue crabs are harvested from estuarine and coastal waters. Factors more sensitive to the microbiological flora of crabs are usually environmental influences. (Balasaraswathy et al., 2008). Crabs are highly priced seafood products that are preferred in terms of edible meat quality and economic value, especially in developed countries (Dernekbaşı et al., 2021). Crab meat, rich in protein and mineral substances, is an important food in a balanced diet, especially calcium, iron, zinc, potassium and phosphorus, vitamins, and low-fat content (Gökoğlu and Yerlikaya, 2003; Erkan et al., 2008). Studies were carried out to determine the biochemical composition of blue crab meat obtained from different regions (Gökoğlu & Yerlikaya, 2003; Ayas & Özoğul, 2011; Khamassi et al., 2022; Tufan, 2023).

Crab meat is among the perishable seafood products. If adequate preservation methods are not applied, its quality can deteriorate rapidly. Cold storage is one of the most effective and accessible methods of preserving crabs. Due to crabs' meat value and susceptibility to rapid spoilage, research has identified the microbial flora responsible for spoilage (Balasaraswathy et al., 2008).

DALKO Dalyan Fisheries Cooperative was established by the people of the region in 1971 within the borders of Köyceğiz Lagoon, Dalyan town of Köyceğiz district in Muğla/Turkey. The cooperative was established in order to protect the small fishermen in the region, provide job opportunities, market the fishery products, continue the old lagoon fishery, and protect the environment and nature. DALKO cooperative stated that they have difficulty packaging the blue crabs offered fresh or steamed cooked to the consumers. Tearing vacuum bags during the packaging of shellfish products reduces the effect of packaging on the product's shelf life. Blue crabs in the cooperative are sold to the consumer in aluminum foils or wrapped in paper packages. The consumer has to consume the product that is bought either immediately or in a short time under refrigerator conditions. These punctures are thought to be prevented when shrink packaging is applied to these samples taken into the bowl. In addition, it is thought that the supply quality in the market will be increased by having some knowledge about the nutritional compositions of aquatic products produced by DALKO Fisheries Cooperative and marketed to the local and foreign markets.

This study aimed to determine the nutritional content and shelf life of shrink-packaged raw and steam-cooked blue crab caught by the DALKO Fisheries Cooperative fishermen in Köyceğiz Dalyan region and cleaned and steam-cooked (ready-to-eat) in the processing facility. This research is to contribute to our country's economy by providing added value to the product in the foreign market by promoting the consumption of our local products and extending the shelf life by packaging.

Material and Methods

Material

Blue crab caught from Köyceğiz Dalyan was used. Blue crabs (*Callinectes sapidus*) were brought to Muğla Sıtkı Koçman University, Faculty of Fisheries, Quality Control Analysis Laboratory from DALKO Fisheries Cooperative within 1 hour under cold chain conditions after the upper shell part was removed. The crabs were divided into two groups (first group had steamed crabs for 30 minutes, and the other group had freshly prepared crabs). 200 mature crabs were used in this study.

Method

Vacuum Packaging of the Samples

The raw and cooked crabs brought to the laboratory from DALKO Fisheries Cooperative were packed in plastic containers in 2 pieces, then packed with a vacuum shrink machine and stored in the refrigerator. Samples were analyzed periodically (0., 2., 4., 6., and 8. day) for microbiological, chemical, and sensory assessment of quality.

Nutritional Composition Analysis

In the raw and cooked blue crab meat, nutritional compositions analyses; % protein; according to AOAC (2006a, 984.13) by Kjeldahl method, the % lipid content of crab meats according to Bligh and Dyer (1959), % moisture; according to AOAC (2006b, 934.01) and % ash content analyses; according to AOAC (1990, 950.46) were carried out at the beginning and at the end of the storage.

Sensory Analysis

Ten trained panelists conducted sensory analysis for raw and cooked edible crabs on each sampling day. A hedonic scale test applied for raw crab was used in sensory analysis. Fresh crab meat was evaluated over 5 points (5: best quality, 0: poorest quality) in terms of color, texture, smell, appearance, and general appreciation criteria (Amerina et al., 1965). For

steamed crab meat, sensory analyzes were evaluated for odor, taste, and texture (clumping, firmness, juiciness, and consistency). It was scored between 0 and 8 using the hedonic scale and evaluated as 0 (best quality) and 8 (lowest quality). The general average of the scores was taken, and 6 was accepted as the acceptability limit (Anacleto et al., 2011).

Chemical Analysis

Over the 8-day period, chemical analyses were carried out. The pH value of crab samples was determined with a digital pH meter (InoLab pH Level 1 model, WTW, Weilheim, Germany) according to Manthey et al. (1988). The TVB-N analysis was carried out according to Antonocopoulus (1973). Homogenized crab samples were steam-distilled, and the distillate was collected in a 0.1 N HCl solution containing a beaker. Then, this solution was titrated with 0.1 NaOH solution. TVB-N value was expressed as mg nitrogen/kg of sample. TBA was determined as described by Tarladgis et al. (1960). Ten grams of crab sample homogenized was distilled with hydrochloric acid (HCl), then TBA reagent prepared with glacial acetic acid (90%) was added to the distillate. Distilatte incubated in a water bath, the mixture's absorbance was measured using a spectrophotometer (Shimadzu UV-1700, Japan) at 538 nm. TBA value was expressed as mg malonaldehyde/kg fish sample.

Microbiological Analysis

The following groups of microflora were monitored: total viable count (TVC) and psychotropic bacteria count (PBC). A sample of 10 g was removed aseptically from the filet using a scalpel and forceps, transferred to a stomacher bag containing 90 mL of sterile peptone water (PW) solution (0.1%), and homogenized at room temperature. Further serial decimal dilutions were prepared for each sample in PW solution (0.1%). The appropriate dilutions were subsequently used for the enumeration and differentiation of microorganisms. Total viable counts were determined using plate count agar (PCA, Code: 1.05463, Merck, Darmstadt, Germany) after incubation for 2 days at 37°C, and psychotropic bacteria counts were determined after incubation at 7°C for 10 days with the same medium (FDA/BAM, 2009).

Statistical Analysis

Experiments were performed in triplicate (n = 3) for three independent samples, and a completely randomized design (CRD) was used. Statistical analyzes were performed using the Statistical Package for Social Sciences v.21 Software Package (SPSS for Windows, SPSS Inc., Chicago, IL, USA). Data are given as mean values ± standard deviations, and a probability value of $P < 0.05$ was considered significant. Analysis of Variance (ANOVA) was applied to the obtained results, and the averages were compared with Duncan's multiple interval tests.

Results and Discussion

Nutritional Composition Analysis Results

At the beginning and the end of storage, nutritional composition analyses; protein, lipid, moisture, and ash analyses were made in the raw and steam-cooked crab meat. At the beginning (Day 0), protein, lipid, moisture, and ash was determined for raw and cooked crabs as 16.22%, 1.06%, 81.17%, 1.45% and 17.13%, 0.94%, 79.88%, 1.88%, respectively. At the end of storage, these values were determined as 15.88%, 1.51%, 80.18%, 1.67%, and 17.83%, 1.06%, 78.65%, 2.13% for raw and cooked crabs, respectively (Table 1). Protein and moisture content decreased slightly during storage. There were significant differences ($P < 0.05$) in the moisture, protein, fat, and ash contents of edible meat for raw and cooked crabs. The differences could be attributed to decreased moisture content during cooking. Zotti et al. (2016) find the moisture, protein, and ash values of blue crabs (*Callinectes sapidus*), 80.12%, 15.13%, and 1.63%, respectively, in their study in Acquatina Lagoon (SE Italy). The results are quite similar to the results in our study. Umer et al. (2021) determined the amount of lipid in commercial crab species; *P. pelagicus*, *P. sanguinolentus*, *S. serrata,* and *C. feriatus* in the range of 0.25-1.86 g/100 g. In the study of Anacleto et al. (2011**)** that investigated the shelf life of cooked *Cancer pagurus* at cold storage, moisture, protein, fat, and ash contents were determined as 76.9%, 18.0%, 0.6%, and 2.6%, respectively. As in our study, crabs have high protein and low lipid values. Balasaraswathy et al. (2008) observed a significant decrease in protein values of uncooked and cooked crab (*Portunus pelagicus*) meat under ice storage for 10 and 12 days, respectively. Unlike this study, no significant protein loss was observed in our study.

Table 1. Nutritional composition analysis results

Nutritional Composition (%)					
Storage Period	**Groups**	**Protein**	**Lipid**	**Moisture**	**Ash**
Initial (0. day)	**Raw**	16.22 ±0.28^{A}	1.06 ±0.04^{A}	81.17 ±0.26^{A}	1.45 ±0.04^{A}
	Cooked	18.05 ±0.60^{B}	1.46 ±0.02^{B}	76.88 ±0.11^{B}	1.88 ±0.01^{B}
End of Storage (8th day)	**Raw**	15.88 ±0.55^{a}	1.51 ±0.12^{a}	80.18 ±0.29^{a}	1.67 ±0.18^{a}
	Cooked	17.83 ±0.21^{b}	0.94 ±0.06^{b}	78.65 ±0.15^{b}	2.13 ±0.22^{b}

(Mean ± SD, n:4) Capital letters indicate the statistical difference between groups at the beginning, and lower letters indicate the differences between groups at the end of storage.

Sensory Analysis Results

According to the sensory analysis results, fresh samples' consumable limit values were exceeded on the sixth day. The odor and texture deteriorated after the fourth day, and the panelists evaluated these characteristics unfavorably. Color properties also deteriorated. The acceptability limit of 6 points for cooked crabs was exceeded on the eighth day for each sensory criteria. A statistically significant difference was found between the sensory analysis results of fresh and cooked crabs ($P < 0.05$). Lorentzen et al. (2014), in their study of determining the shelf life of red king crab (*Paralithodes camtschaticus*), sensory quality, especially odor and flavor parameters, deteriorated during chilled storage.

Chemical Analysis Results

While TVB-N values of fresh crabs were 12.42 mg/100 g at the beginning of storage, this value was much higher in cooked samples (Figure 1). A continuous increase was observed in TVB-N values of fresh samples during storage, while a fluctuation was detected in these values in cooked samples. During the storage, the TVB-N value of cooked crab samples exceeded the consumable limit of 25-35 mg/100 g according to the European Commission Regulation No 2074/2005 for fishery products (EC, 2005). In this study, the limit value of 35 mg/100 g for crab meat was exceeded on the eighth day for fresh samples. Higher results were obtained with cooked crabs than with fresh crabs throughout storage. The contents of TVB-N throughout storage were significantly different ($P < 0.05$) for fresh and cooked crab meat.

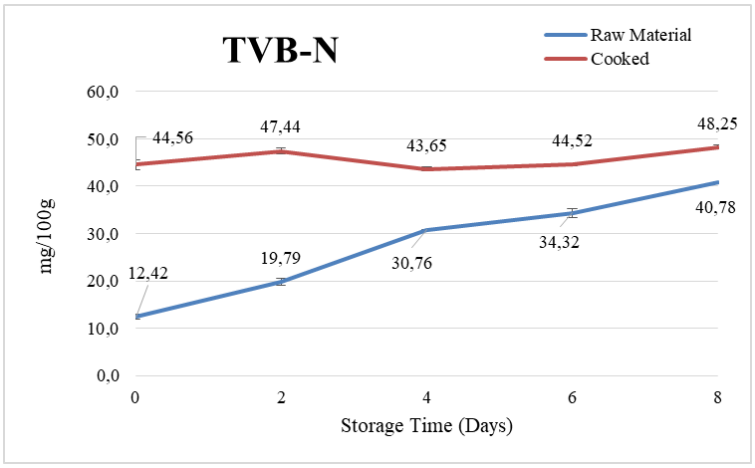

Figure 1. TVB-N analysis results

Lorentzen et al. (2016) studied the shelf life of snow crab stored at 0 and 4ºC in raw meat, the level of TVB-N was 20 mg/100 g from day 0, and it did not change during the storage period of 7 days. Sun et al. (2017), in their study about the effects of super chilling with modified atmosphere packaging on the shelf life of swimming crab, the TVB-N of air-packaged samples (without MAP) increased rapidly, and the value reached 30.64 mg N/100 g on the fifth day of storage at 4ºC. Similar results were obtained in our study for fresh samples. In this present study, higher TVB-N results were obtained in cooked crab samples than in fresh crabs. Anacleto et al. (2011) reported that TVB-N formation in cooked samples can increase by thermal breakdown during cooking. They found that TVB-N levels exceeded the consumable limits of 35 mg/100 g in their study of the shelf-life of cooked crab samples. Therefore, it was concluded that the TVB-N could not determine the chemical quality of steam-cooked blue crabs.

Generally, the pH value for fresh crabs increased continuously during storage, while for cooked samples, these values varied in equilibrium (Figure 2). It was reported that pH 7.80–7.95 is an acceptable critical limit for shrimps and prawns (Chung & Lain, 1979). In our study, only cooked crabs exceeded this value at the end of storage. One of the most obvious reasons for this increase may be the breakdown and deamination of tissue proteins. Especially during the deterioration of seafood, spoilage products such as ammonia and trimethylamine produced by endogenous enzymes and microorganisms are released (Finne, 1982).

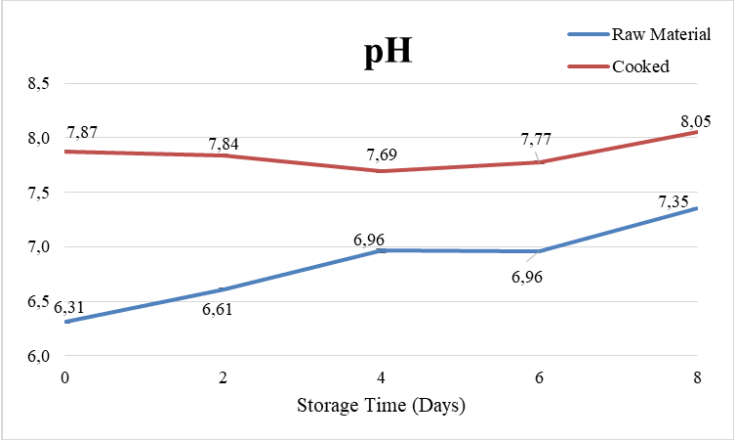

Figure 2. pH analysis results

Lorentzen et al. (2014) examined the shelf life of cooked red king crab at 4ºC, and the pH value was found to be between 7.3-7.9 during the 14-day study. Lorentzen et al. (2016), in the other study about the shelf life of snow crab stored at 0 and 4ºC, the pH of raw leg crab meat was 6.5 on day 2, and the final pH was 7.0 on day 7. Similarly, in this study, the pH increased from 7.0 to approximately 7.6 on day 2 in steamed crabmeat, independent of storage temperature. During refrigerated storage, Anacleto et al. (2011) found progressively increased pH in cooked crab (*Cancer pagurus*) samples. They reported that because of the higher content of non-protein nitrogenous compounds in crustaceans, crabs have a higher pH than fish and mammalian species.

TBA value increased slightly for fresh and cooked crabs during cold storage. There were no significant differences between these groups statistically (P>0.05) (Figure 3). During the storage, values were obtained entirely below the 8 mg malonaldehyde/kg limit for both samples. This value was not exceeded during storage.

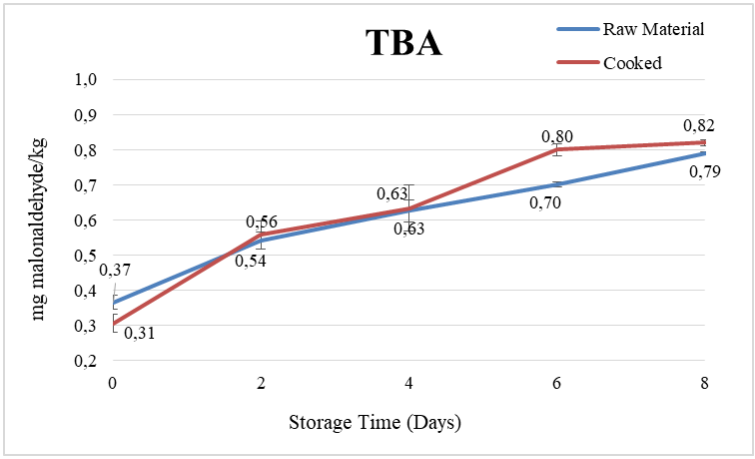

Figure 3. TBA analysis results

Sun et al. (2017), in the study that examined the effects of super chilling with modified atmosphere packaging on the shelf life of swimming crab, on day 4 of storage, the TBARS value reached 1.5 mg MDA/kg muscle for air-packed (without MAP) samples. Higher results were obtained than in our study.

Microbiological Analysis Results

Total Viable Count Results (TVC)

The total viable count was determined as 4.82 log CFU/g at the beginning of storage in fresh crabs and reached 7.44 log CFU/g on the sixth day of storage. An increase occurred during the storage of both samples. There was no microbiological growth for cooked crabs until the fourth day of storage; the total viable count was determined as log 4.4 CFU/g on the sixth day and log 7.41 CFU/g on the eighth day (Figure 4). Due to the cooking process, a lower microbiological load was determined in the cooked samples compared to the fresh samples. A statistically significant difference was found between each group in terms of total viable count until the sixth day of storage ($P < 0.05$). However, at the end of storage, this difference was found to be insignificant ($P > 0.05$). The recommended limit of $\log10^6$ CFU/g for refrigerated and frozen crab meat, according to ICMSF (1986), was exceeded on the sixth day for fresh crab and on the eighth day for cooked crab.

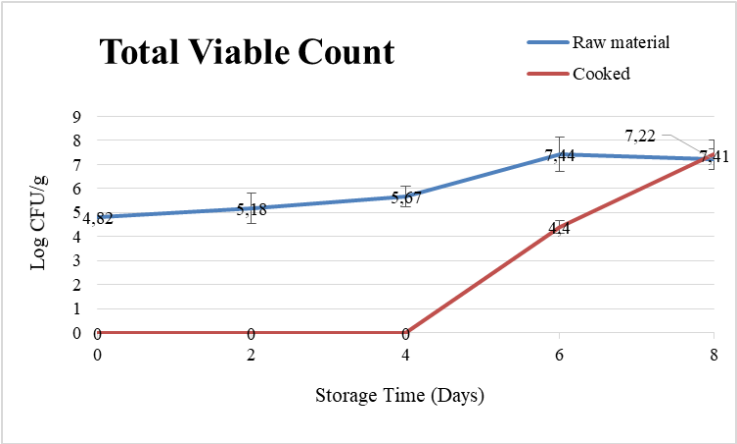

Figure 4. Total viable count results

The total number of psychrotrophic bacteria was determined as 3.35 log CFU/g in fresh crabs at the beginning of storage, and this value reached 7.64 log CFU/g at the end of storage. There was no psychrotrophic bacteria growth for cooked crabs until the fourth day of storage; it was log 2.75 CFU/g on the sixth day and log 5.72 CFU/g on the eighth day (Figure 5). An increase occurred during storage for both samples. The values of psychrotrophic bacteria throughout storage were significantly different ($P < 0.05$) for fresh and cooked crab meat.

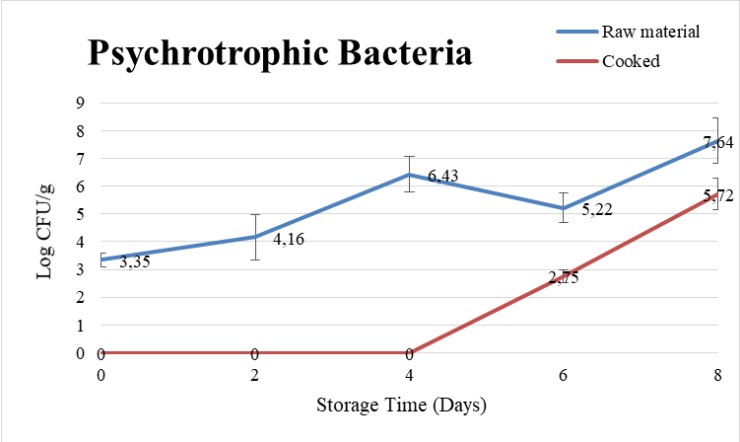

Figure 5. Psychrotrophic bacteria results

Anacleto et al. (2011) found that the TVC of cooked *Cancer pagurus* was below 4 log CFU/g until day 4 for the samples stored in the refrigerator. Lorentzen et al. (2014) examined the shelf life of cooked red king crab at 4ºC, the TVC value was found below the viable count up to 5 days, and it logged 4.4 CFU/g on the fifth day. Lorentzen et al. (2016), in the study of the shelf life of snow crab stored at 0 and 4ºC, up to day 4, the level of TVC was below consumable limit values of log1.7 CFU/g for cooked crab, and TVC increased to the maximum level of log 5.5 CFU/g at 4ºC on day 10. While the TVC level of fresh snow crab was approximately log 2.5 CFU/g at the beginning of storage, this value was reported to increase by approximately one unit during the next seven days of storage at 0ºC. Lower values were obtained than in our study due to storage at lower temperatures. Sun et al. (2017) in the study investigated the effects of super chilling with modified atmosphere packaging on the shelf life of swimming crabs; for air packed (without MAP) samples, the initial total aerobic plate count (TPC) was 3.96 log CFU/g for fresh crabs, and TPC reached log10^5 CFU/g at day 4.

Conclusion

This study applied shrink packaging to raw and cooked crabs, and shelf-life analyses were carried out during eight days of cold storage. As a result of the analyses, it was concluded that the shelf life of the packaged fresh and cooked crabs was 4 and 6 days, respectively, according to the results of sensory and microbiological analysis. The chemical analysis of the packaged crab samples determined that they preserved their quality properties during storage for up to 6 days. The high initial microbial loads of the samples prevented further shelf life extension. It is thought that pre-treatments such as cooking or disinfection before packaging to extend the shelf life will reduce the microbiological load and improve the product's sensory and chemical properties. In addition, it is suggested that compliance with the personnel and plant hygiene rules during the capture, processing, and storage of the product is important for future studies in terms of the quality of the product. It is thought that crabs, which are beneficial for human health due to being rich in protein, vitamins, and minerals and have low saturated and high unsaturated fatty acid content, by applying pre-treatments, cooking methods, and providing appropriate storage conditions under appropriate conditions will increase their consumption.

Compliance with Ethical Standards

Conflict of interest: The authors declare that they have no actual, potential, or perceived conflict of interest for this article.

Ethics committee approval: Ethics committee approval is not required for this study.

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Disclosure: -

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