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COMPARISON CHEMICAL, SENSORY, MICROBIOLOGICAL AND TEXTURAL CHANGES OF CUTTLEFISH (*SEPIA OFFICINALIS)* STORED UNDER DIFFERENT PACKAGING

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Abstract

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Cuttlefish (*Sepia officinalis*) consumption is limited because of high costs in Turkey. It is essential that this product should be protected from the spoilage in a short time. For this purpose cuttlefishes were packaged in MAP (50%/50% CO_2/N_2: M1, 80%/20 CO_2/N_2%: M2, 65%/35% CO_2/N_2: M3) conditions, vacuumed (VP) and air packaged (A). During storage, period of cuttlefishes; chemical, microbiological, sensory, colour and textural changes were determined. The TVB-N values exceeded acceptability limits on day 5 for group A, but on day 9 for the groups VP, M1, M2 and M3. MAP and VP extended the shelf life of cuttlefishes 4 days when compared with A. The information about extending the shelf life of cuttlefishes for 4 days will be very helpful for fishery industry. The results of this study can be evaluated by studying in this field, for processors, fish processing industries and consumers.

Key words: microbiological, chemical, modified atmosphere packaging, cuttlefish, quality changes

Introduction

Cuttlefish consumption is limited because of high costs in Turkey, where this commodity is mainly consumed as frozen (breaded) rings destined for frying. On the other hand, considerable amounts of frozen-cuttlefish are exported to the other Mediterranean countries.

Seafood such as cuttlefish has a short shelf life because its muscle is rich in non-protein nitrogenous (NPN) compounds, such as trimethylamine oxide (TMAO), nucleotides, and free amino acids. These substances serve as a substrate for the growth of contaminating bacteria, which are the principal cause of fish muscle spoilage (Albenese et al., 2005). For this reason, it is very important to extend the shelf life of sea products with progressed techniques.

In the 1930s beef carcasses were transported in atmospheres containing CO_2, which approximately doubled the storage life previously obtained (Davies, 1995). Modified atmosphere packaging (MAP) extends shelf life of most products by inhibiting bacterial growth and oxidative reactions (Sivertsvik et al., 2002). There are many studies in the literature on the effect of MAP on fish and fish products (Reddy et al., 1992; Swiderski et al., 1997; Davies 1997; Dalgaard et al., 2006; Caglak et al., 2008; Fernandez et al., 2010 and Caglak et al., 2012).

Although there were many works done about modified atmosphere packaged fish and fishery products, there is no study in the literature on the effects of MAP on the preservation of cuttlefishes. For this reason, the purpose of the present work was to determine the effects of MAP in comparison with vacuum packaging (VP) on the shelf-life and quality of cuttlefishes stored at 2±1°C.

Materials and Methods

Preparation of cuttlefish samples and storage conditions

Cuttlefish (*Sepia officinalis*), of commercial size were taken from the fisherman after catching**.** Cuttlefishes were transported to the laboratory within 2h in styrofoam boxes containing ice. The ratio of ice /cuttlefish was (3:1). The cuttlefishes

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were rapidly gutted and washed with water. 100 cuttlefishes were used in total and 2 pieces of cuttlefish approximately 300-350 g were in each bag. Three bags were used for each treatment. Two pieces of cuttlefish (300-350 g) were packed in a polystyrene tray, which was placed inside a polyamide/polyethylene gas barrier bag. Three groups were done with the ratio of different gas mixtures: M1: 50%/50% (CO_2/N_2); M2:80%/20% (CO_2/N_2), M3: 65%/35% (CO_2/N_2). The ratio of cuttlefish to package volume was 1/3. The gas composition inside the packages was measured with a gas analyzer (PBI DANSENSOR CheckPoint 02/CO_2). Modified atmosphere packaged cuttlefish were sealed by a Multivac B500 machine and a home fridge stored at 2±1°C. Air packaged (A) group was used as control group. Analyses were done on air, vacuum and modified atmosphere packaged cuttlefishes by using three packaging separately. The results of the analyses were given as the mean value of three packaging for air, vacuum and modified atmosphere packaging.

Chemical composition analysis

The chemical composition of cuttlefishes was determined as crude fat (Blig and Dyer, 1959) and moisture (Ludorff and Meyer, 1973). Analyses were done in triplicate.

Microbiological analysis

Cuttlefish flesh (10 g) was aseptically put into a stomacher bag (Seward, Medical, UK) including 90 ml of 0.1% peptone water and homogenized by using a stomacher (IUL, Barcelona, Spain) for 2 min. Decimal dilutions were prepared and inoculations were done from appropriate dilutions. Total mesophilic and psychrotrophic bacteria counts were determined by the pour plate method, using Plate Count Agar (Difco, 0479-17) as the medium. Plates were incubated at 30˚C for 24–48 h and 7˚C for 10 days, respectively (Harrigan and McCance, 1976). For determining moulds and yeast count Oxytetracycline Yeast Extract Agar (LABMX89) was used. After inoculations, plates were incubated at 30˚C for 3–5 days (Harrigan and McCance, 1976). Lactic acid bacteria count was determined by using pour plate method using MRSA (LAB M 93) as the medium. Plates were incubated at 30˚C for 3–5 days for lactic acid bacteria count (Debevere and Boskou, 1996).

Chemical analysis

pH values were determined by using digital pH meter (HANNA) according to the method of Lima dos Santos et al. (1981). Total volatile basic nitrogen (TVB-N) was determined according to the method of Vyncke (1996). Thiobarbituric acid (TBA), mg malonaldehyde/kg was examined by using the method Tarladgis et al. (1960). Trimethylamine nitrogen (TMA-N) analysis was determined according to the method of AOAC (1995). Water activity was determined by using Testo 650 a_w meter.

Colour measurement

The colour measurement on cuttlefish samples were examined by using the spectral colour meter Spectro- pen R _ (Dr. Lange, Dusseldorf, Germany). The colorimeter was calibrated against a white Standard (LZM 224). The colour was measured on homogenates prepared from cuttlefishes. The homogenate was placed in plastic petri dishes and the colour measurement was repeated ten times. In the CIELab system L^* denotes lightness on a 0–100 scale from black to white; a^*, (+) red or (−) green; and b^*, (+) yellow or (−) blue (Schubring, 2002).

Texture analyses

The measurement of the texture properties (texture profile analysis or TPA) of cuttlefish was carried out by using a TA.XT Plus. The samples used for TPA measurement were cut out using a cork borer (Ø1.5 cm). The TPA measurements were done at 60% compression. In both cases a cylindrical probe of 5.0 cm diameter was used with a test speed of 0.8 mm/s. Instrumental TPA is a measurement method which imitates the chewing process thus giving the possibility to observe and differentiate between single texture attributes and to characterize on this basis the very complex impression of food texture on humans. The texture attribute hardness is defined as the maximum force of the first compression. Chewiness, as the quantity to simulate the energy required to masticate a sample to a steady state of swallowing, is calculated as the product of hardness, cohesiveness and springiness. Resilience can be seen as the property defining how well a product fights to regain its original position. Springiness gives an explanation of how well a product physically springs back after it has been deformed during the first compression. Cohesiveness is the attribute describing how well the product withstands a second deformation relative to how it behaved under the first deformation (Schubring and Oehlenschlager, 1997).

Sensory analysis

The sensory qualities of all packaged raw cuttlefish were determined by using a seven member-trained panel. Cuttlefish samples were presented to the panelists. Panelists were asked to score using (1-3) acceptability scale for colour and texture, (0-4) acceptability scale for odour of raw cuttlefishes. (Anonymous, 1999)

Statistical analysis

The results of the all packaged cuttlefish were given as mean±SD (n=3). Differences between means were analyzed

by one-way analysis of variance (ANOVA) followed by Tukey and Duncan test, using SPSS 9.05.

Results and Discussion

Chemical composition

The changes of moisture and lipid contents of cuttlefish were given in Table 1. When comparing moisture contents of cuttlefish in vacuumed and modified atmosphere packaged with polietilene bags packaged, significant difference was found ($p<0.05$) between the groups.

Table 1
Moisture and lipid contents of cuttlefish in aerobically, vacuumed and modified atmosphere packaging

Groups	Analyses	
	Moisture %	Lipid %
M1	79.23 ± 0.18^{A}	0.58 ± 0.04^{AB}
M2	80.16 ± 0.12^{B}	0.60 ± 0.05^{AB}
M3	81.50 ± 0.30^{C}	0.55 ± 0.06^{A}
VP	80.76 ± 0.12^{B}	0.73 ± 0.03^{B}
A	82.63 ± 0.32^{D}	0.63 ± 0.09^{AB}

n=3 (Mean value ± standard deviation). Means in the same column and in the same row with the same letter do not differ significantly at the level of 0.05 significance
A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO_2+%50 N_2 modified atmosphere packaged cuttlefish, M2: %80 CO_2 +%20 N_2 modified atmosphere packaged cuttlefish, M3: %65 CO_2 +%35 N_2 modified atmosphere packaged cuttlefish.

Microbiological changes

Total mesophilic bacteria counts of all the gas atmosphere packaging were given in Table 2. The initial total mesophilic counts of A, VP, M1, M2, M3 were determined as 3.87, 3.06, 2.95, 2.29, 2.68 log cfu/g, respectively. After 5 days of storage, total mesophilic counts increased to 5.11, 4.20, 3.86, 3.07, 3.39, log cfu/g for A, VP, M1, M2, M3. After the storage period of 9 days, total mesophilic counts of A, VP, M1, M2, M3 increased to 8.71, 7.42, 7.29, 7.04, 7.22, log cfu/g. At the end of the storage period of 9 days; significant differences ($p<0.05$) were observed between the total mesophilic counts for A, VP and M2, but no significant differences ($p>0.05$) were observed between M1 and M3. In one report, mussels were packaged in MAP and VP. Microbiological results revealed that the M2 (80%/20% CO_2/N_2) and M3 (65%/35 CO_2/N_2 %) delayed microbial growth compared with that of M1 (50%/50% CO_2/N_2). Storage at low temperature in combination with the presence of CO_2 inhibited bacterial growth. Mussels packed in MAP showed a reduction in bacterial counts compared to mussels packed in vacuum packages. The shelf-life of M2 (80%/20% CO_2/N_2) and M3 (65%/35 CO_2/N_2 %) gave a longer shelf-life compared with VP and M1 (50%/50% CO_2/N_2). M2 (80%/20% CO_2/N_2) gas mixture was found the most effective for mussel

Table 2
Microbiological changes of aerobically, vacuum and modified atmosphere packaged cuttlefish

Storage time, days	Total mesophilic bacteria counts, logCFU/g				
	M1	M 2	M3	VP	A
1	2.95 ± 0.02^{a}	2.29 ± 0.06^{b}	2.68 ± 0.10^{c}	3.06 ± 0.07^{a}	3.87 ± 0.09^{d}
5	3.86 ± 0.04^{a}	3.07 ± 0.08^{b}	3.39 ± 0.03^{c}	4.20 ± 0.05^{d}	5.11 ± 0.13^{e}
9	7.26 ± 0.18^{a}	7.04 ± 0.09^{b}	7.22 ± 0.07^{a}	7.42 ± 0.01^{c}	8.71 ± 0.04^{d}
Storage time, days	Psychrotrophic bacteria counts, log CFU/g				
	M1	M 2	M3	VP	A
1	2.42 ± 0.03^{a}	2.18 ± 0.09^{b}	2.39 ± 0.06^{a}	3.00 ± 0.03^{c}	3.24 ± 0.03^{d}
5	3.98 ± 0.11^{a}	3.39 ± 0.04^{b}	3.62 ± 0.17^{c}	4.58 ± 0.06^{d}	5.47 ± 0.05^{e}
9	7.45 ± 0.02^{a}	7.20 ± 0.02^{b}	7.32 ± 0.07^{ab}	7.53 ± 0.02^{a}	8.97 ± 0.01^{c}
Storage time, days	Lactic acid bacteria counts, log CFU/g				
	M1	M 2	M3	VP	A
1	2.49 ± 0.10^{ac}	2.12 ± 0.09^{b}	2.39 ± 0.11^{a}	2.62 ± 0.05^{c}	2.89 ± 0.09^{d}
5	3.38 ± 0.08^{a}	3.17 ± 0.07^{a}	3.28 ± 0.03^{a}	3.98 ± 0.06^{b}	4.52 ± 0.06^{c}
9	5.98 ± 0.05^{a}	5.42 ± 0.05^{b}	5.68 ± 0.04^{c}	6.40 ± 0.17^{d}	6.93 ± 0.12^{e}

n=3; (Mean value±standart deviation)Means in the same column and in the same row with the same letter donat differ significantly at the level of 0.05 significance A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO_2+%50 N_2 modified atmosphere packaged cuttlefish, M2: %80 CO_2 +%20 N_2 modified atmosphere packaged cuttlefish, M3: %65 CO_2 +%35 N_2 modified atmosphere packaged cuttlefish.

preservation (Caglak et al., 2008). In another report sodium chloride used in smoking showed a further inhibition of biochemical, microbiological and sensory deterioration of hake slices stored under MAP conditions. It has been suggested that some bacteria can not stand NaCl dips (5%); consequently, they would be subjected to a too high osmotic pressure, so TVC decreases. It has been pointed out that CO_2 inactivates some microbial enzymes thus delays bacterial growth (Mitsuda et al., 1980). It has been reported that CO_2 has an important effect on microbial growth, exerting a selective inhibitory action (Huss, 1972). Aerobic microorganisms are generally sensitive to CO_2, therefore MAP delays the spoilage of fish and other seafood. These results are very similar to our findings about reducing the bacterial loads with MAP.

Psychrotrophic bacteria counts of all packaging were given in Table 2. The initial psychrotrophic bacteria counts of A, VP, M1, M2, M3 were 3.28, 3.00, 2.42, 2.18, 2.39 log cfu/g, respectively. At the end of the storage period of 9 days psychrotrophic bacteria counts had increased to 8.97, 7.53, 7.45, 7.20, 7.32 log cfu/g for A, VP, M1, M2, M3. On day 9; significant differences were determined between A and MAP ($p < 0.05$).

Lactic acid bacteria counts of all packaging were given in Table 2. Significant differences were determined between A and MAP ($p<0.05$) at the end of the 9 days storage period. Yeast and mould were not detected in cuttlefishes during the storage period. Debevere and Boskou (1996) were determined that lactic acid bacteria can not be inhibited by using carbon dioxide. The role of lactic acid bacteria in preserving vacuum-packed fishery products has been considered by some authors (Pelroy et al., 1982; Crandall and Matville, 1993; Debevere and Boskou, 1996 and Gonzalez et al., 2002). These investigations are very similar to our findings about increasing lactic acid bacteria counts in modified atmosphere packaging.

Chemical analyses

TVB-N values of cuttlefish were given in Table 3. TVB-N value of cuttlefishes stored for 9 days in A, VP, MAP exceeded the acceptability limit of 35 mg N 100 g^{-1} (Connell, 1990; EEC, 1995) on day 5 for A, on day 9 for VP and MAP. The TVB-N value of Group A, VP, M1, M2, M3 were 9.83, 9.55, 8.68, 8.68, 9.40 mg N 100 g^{-1} at the beginning and 59.21, 51.34, 42.76, 39.00, 45.98 mg N 100 g^{-1} at the end of the stor-

Table 3
Chemical changes of aerobically, vacuum and modified atmosphere packaged cuttlefish

Days	TVB-N				
	M1	M2	M3	VP	A
1	$8.68 \pm 0.24^{A}{}_{a}$	$8.68 \pm 0,24^{A}{}_{a}$	$9.40 \pm 0.15^{B}{}_{a}$	$9.55 \pm 0.00^{B}{}_{a}$	$9.83 \pm 0.14^{B}{}_{a}$
5	$22.72 \pm 0.17^{AB}{}_{b}$	$21.64 \pm 0.18^{B}{}_{b}$	$27.37 \pm 0.31^{C}{}_{b}$	$31.66 \pm 0.00^{D}{}_{b}$	$41.85 \pm 0.82^{E}{}_{b}$
9	$42.76 \pm 0.18^{A}{}_{c}$	$39.00 \pm 0.78^{B}{}_{c}$	$45.98 \pm 1.1^{C}{}_{c}$	$51.34 \pm 0.94^{D}{}_{c}$	$59.21 \pm 0.47^{E}{}_{c}$
Days	TMA-N				
	M1	M2	M3	VP	A
1	$2.43 \pm 0.02^{A}{}_{b}$	$2.15 \pm 0.03^{B}{}_{a}$	$2.80 \pm 0.02^{C}{}_{a}$	$3.17 \pm 0.04^{D}{}_{a}$	$3.74 \pm 0.09^{E}{}_{a}$
5	$7.73 \pm 0.04^{AC}{}_{b}$	$6.75 \pm 0.11^{B}{}_{b}$	$7.91 \pm 0.08^{C}{}_{b}$	$9.71 \pm 0.11^{D}{}_{b}$	$10.72 \pm 0.18^{E}{}_{b}$
9	$16.64 \pm 0.03^{A}{}_{c}$	$13.13 \pm 0.09^{B}{}_{c}$	$16.91 \pm 0.07^{C}{}_{c}$	$17.63 \pm 0.1^{D}{}_{c}$	$19.34 \pm 0.02^{E}{}_{c}$
Days	TBA				
	M1	M2	M3	VP	A
1	$0.07 \pm 0,00^{AB}{}_{a}$	$0.07 \pm 0,00^{A}{}_{a}$	$0.08 \pm 0,00^{B}{}_{a}$	$0.08 \pm 0,00^{AB}{}_{a}$	$0.08 \pm 0,00^{AB}{}_{a}$
5	$0.11 \pm 0.01^{AB}{}_{a}$	$0.08 \pm 0.00^{A}{}_{a}$	$0.09 \pm 0.00^{A}{}_{a}$	$0.11 \pm 0.01^{AB}{}_{a}$	$0.13 \pm 0.01^{B}{}_{b}$
9	$0.22 \pm 0.02^{A}{}_{b}$	$0.15 \pm 0.00^{B}{}_{b}$	$0.27 \pm 0.00^{C}{}_{b}$	$0.35 \pm 0.00^{D}{}_{b}$	$0.40 \pm 0.01^{E}{}_{c}$
Days	PH				
	M1	M2	M3	VP	A
1	$6.94 \pm 0.01^{A}{}_{a}$	$6.93 \pm 0.00^{A}{}_{a}$	$6.94 \pm 0.00^{A}{}_{a}$	$6.94 \pm 0.01^{A}{}_{a}$	$6.93 \pm 0.00^{A}{}_{a}$
5	$6.99 \pm 0.00^{AB}{}_{a}$	$6.97 \pm 0.01^{A}{}_{b}$	$7.01 \pm 0.01^{B}{}_{b}$	$7.11 \pm 0.01^{C}{}_{b}$	$7.11 \pm 0.00^{C}{}_{b}$
9	$7.10 \pm 0.01^{AC}{}_{b}$	$7.00 \pm 0.01^{B}{}_{b}$	$7.09 \pm 0.01^{C}{}_{c}$	$7.32 \pm 0.00^{D}{}_{c}$	$7.68 \pm 0.00^{E}{}_{c}$

n=3; (Mean value±standart deviation). Means in the same column and in the same row with the same letter donat differ significantly at the level of 0.05 significance A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO2+%50 N2 modified atmosphere packaged cuttlefish, M2: %80 CO2 +%20 N2 modified atmosphere packaged cuttlefish, M3: %65 CO2 +%35 N2 modified atmosphere packaged cuttlefish.

age period (9 days), respectively. According to the results of TVB-N; statistically significant differences ($p<0.05$) were determined between the groups on day 9.

TMA-N values are used as an indicator for spoilage by decreasing TMA-O. It is reported that in fresh fish, the TMA-N value is about 1 mg/100 g; in spoiled samples it is above 8 mg/100 g. (FAO, 1986). At the beginning of the storage; The TMA-N values of cuttlefish were found to be 3.74, 3.17, 2.43, 2.15, 2.80 for A, VP, M1, M2, M3. These values increased to 19.34, 17.63, 16.64, 13.13, 16.91 mg/100 g, at the end of the storage, respectively (Table 3). Albenese et al, (2005) reported that an increase in TVB-N and TMA-N values during storage was observed in cuttlefish samples. However, the increase in cuttlefishes sealed in MAP+Ads was less than in the control and in the MAP cuttlefishes. No statistically significant differences between the control and MAP samples were found during the first 7 storage days, although samples stored in MAP with adsorbent showed lower amounts of TVB-N ($P<0.05$) on days 5 and 11. Thus, there was a high correlation observed between TMA-N and TVB-N during the storage time for control. These results showed that it was difficult (with classical packaging) to extend the storage of cuttlefish samples beyond 5-7 days. MAP slowed down the production of TMA-N and TVB-N, but only to a limited extent. These results are very similar to our findings about MAP slowing down the production of TVB-N and TMA-N with the previous investigation.

TBA analysis is an important quality indicator for fat oxidation. Oxidative rancidity that is a complex spoilage especially occurs in fatty fish (Connell, 1980). Schormüller (1969) reported that in "perfect material" TBA value should be less than 3 mg malonaldehyde/kg sample, in "good material" TBA value should not be more than 5 mg malonaldehyde/kg sample and consumption limit for TBA value is between 7 and 8 mg malonaldehyde/kg sample On day 1; TBA values of group A, VP, M1, M2 and M3 were 0.08, 0.08, 0.07, 0.07, 0.08 mg malonaldehyde/kg, respectively. On day 9; these values increased to 0.40, 0.35, 0.22, 0.15, 0.27 mg malonaldehyde/kg for group A, VP, M1, M2 and M3, respectively. The data obtained in the present study suggest that TBA values of cuttlefish are within the perfect quality limits during the storage period (Table 3).

pH value is not only used for spoilage, but it should be supported by other analysis results (Ludorff and Meyer, 1973; Schormuller, 1968). pH values of group A, VP, M1, M2 and M3 were determined as 6.93, 6.94, 6.94, 6.93, 6.94 at the beginning of the storage (day 1). This pH value increased throughout the storage period. On day 9; pH value of group A, VP, M1, M2 and M3 increased to 7.68, 7.32, 7.10, 7.00, 7.09, respectively. During the storage period pH value increased according to storage time (Table 3). In one report, the pH of the control cuttlefish samples increased from 6.32 to 7.65 ($P<0.05$) by the 11th day of storage at 3°C The pH of cuttlefish samples stored in both types of MAP also increased ($P<0.05$), but by day 11 the values were lower with respect to the control. The increase in pH during the first 5 days was less in the samples stored in MAP only, but by the end of storage, the MAP+Ads packages had a significantly lower pH ($P<0.05$) than the control and MAP only samples (Albenese et al., 2005). These results are very similar to our findings about increasing the pH values of cuttlefish samples during storage period.

Colour measurement

Colour measurements of cuttlefish samples were indicated in Table 4. At the beginning of the storage period (on day 1) L

Table 4
Colour values of aerobically, vacuum and modified atmosphere packaged Cuttlefish

Days	Colour	M1	M2	M3	VP	A
1	L*	$55.05\pm0.69^{A}{}_{a}$	$53.78\pm0.43^{AB}{}_{a}$	$53.59\pm0.54^{AB}{}_{a}$	$52.32\pm0.59^{B}{}_{a}$	$53.89\pm0.81^{AB}{}_{ab}$
	a*	$-2.33\pm0.14^{A}{}_{a}$	$-2.23\pm0.05^{A}{}_{a}$	$-2.67\pm0.08^{B}{}_{a}$	$-2.73\pm0.09^{B}{}_{a}$	$-2.68\pm0.09^{B}{}_{a}$
	b*	$1.27\pm0.21^{ACE}{}_{a}$	$2.10\pm0.09^{B}{}_{a}$	$0.95\pm0.19^{CDE}{}_{a}$	$0.42\pm0.37^{D}{}_{a}$	$0.79\pm0.35^{DE}{}_{a}$
5	L*	$51.94\pm0.32^{A}{}_{b}$	$49.75\pm0.39^{B}{}_{b}$	$54.76\pm0.28^{CE}{}_{b}$	$53.06\pm0.17^{D}{}_{a}$	$55.17\pm0.47^{E}{}_{a}$
	a*	$-2.9\pm0.05^{A}{}_{b}$	$-2.86\pm0.05^{AC}{}_{b}$	$-2.74\pm0.09^{AC}{}_{ab}$	$-2.48\pm0.07^{B}{}_{b}$	$-2.71\pm0.04^{C}{}_{a}$
	b*	$-0.73\pm0.14^{A}{}_{b}$	$-0.75\pm0.14^{A}{}_{b}$	$-1.12\pm0.19^{B}{}_{b}$	$-0.89\pm0.08^{AB}{}_{b}$	$-1.1\pm0.1^{AB}{}_{b}$
9	L*	$53.51\pm0.38^{AE}{}_{c}$	$57.43\pm0.13^{BC}{}_{c}$	$56.78\pm0.25^{C}{}_{c}$	$52.69\pm0.36^{D}{}_{a}$	$53.50\pm0.23^{DE}{}_{b}$
	a*	$-2.61\pm0.06^{ADE}{}_{a}$	$-2.75\pm0.03^{B}{}_{b}$	$-2.96\pm0.04^{C}{}_{b}$	$-2.54\pm0.04^{D}{}_{ab}$	$-2.70\pm0.02^{BE}{}_{a}$
	b*	$0.80\pm0.21^{A}{}_{c}$	$1.36\pm0.16^{A}{}_{c}$	$1.34\pm0.30^{A}{}_{a}$	$0.84\pm0.17^{A}{}_{a}$	$1.34\pm0.16^{A}{}_{a}$

Mean value±standart deviation, Means in the same column and in the same row with the same letter donat differ significantly at the level of 0.05 significance n= 10 A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO_2+%50 N_2 modified atmosphere packaged cuttlefish, M2: %80 CO_2 +%20 N_2, modified atmosphere packaged cuttlefish, M3: %65 CO_2 +%35 N_2 modified atmosphere packaged cuttlefish.

value of group A, VP, M1, M2, M3 were determined as 53.89, 52.32, 55.05, 53.78, 53.59, respectively. L values of group A, VP, M1, M2, M3 changed to 53.50, 52.69, 53.51, 57.43, 56.78 at the end of the storage period (on day 9), respectively. When comparing L values of group A,VP, M1, M2, M3, no significant differences ($p>0.05$) were determined between the groups (day 1), but at the end of the storage period of 9th day significant differences ($p<0.05$) were determined. 'a' values of group A, VP, M1, M2, M3 changed from -2.68, -2.73, -2.33, -2.23, -2.67 to -2.70, -2.54, -2.61, -2.75, -2.96. 'b' values of group A, VP, M1, M2, M3 changed from 0.79, 0.42, 1.27, 2.10, 0.95 to 1.34, 0.84, 0,80, 1.36, 1.34 at the end of the storage period of 9th day. Between the groups statistically significant differences ($p<0.05$) were determined in a and b values during the storage. Thanonkaew et al. (2006) reported that the increased lipid oxidation of cuttlefish with added iron was coincidental with the increase in b* values (yellowness). Similar results were determined with this investigation about increasing the b values of cuttlefish with increasing lipid oxidation.

Sensory analysis

Concentration of several amino acids that give flavor to meat (Beltrán-Lugo et al., 2006). Sensory analysis results of the raw cuttlefish samples were given in Table 5. According to the results of sensory analysis; at the beginning of the storage (on day 1), the differences in all groups were not significant for colour, odour and textural attributes ($p>0.05$). On day 9; the differences between A and M2, M3 were found to be statistically significant ($p<0.05$) for colour and odour. However, there was no significant ($p>0.05$) differences between A, VP and M1 for odour and colour attributes.

Texture analysis

Humidity, protein, and lipid concentrations decreasing, makes the muscles tenderer, as confirmed by texture parameters of cut, hardness, elasticity, chewiness, gumminess, and adhesiveness. Changes in texture were explained by a decrease in collagen, which is an important component of connective tissue, and a lower density of muscle fibers per surface area (Beltrán-Lugo et al., 2006). The texture quality of vacuumed and modified atmosphere packaged cuttlefishes was given in Table 6. When comparing resilience and cohesiveness significant differences were not determined between the groups ($p>0.05$), but according to texture quality of adhesiveness, springiness, chewiness and hardness, significant differences ($p<0.05$) were determined between A and MAP.

Conclusions

Quality determination of cuttlefishes under air, modified atmosphere and vacuumed packaging were carried out using microbiological, chemical and sensory analyses. Colour and textural analyses were also examined. TVB-N results showed us that the modified atmosphere and vacuum packaging were

Table 5
Sensory evaluation of cuttlefish (Codex Guıdelines, 1999)

Days	Sensory analyses (Colour)				
	M1	M2	M3	VP	A
1	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$
5	$3 \pm 0.00^{A}{}_{b}$	$3 \pm 0.00^{A}{}_{b}$	$2 \pm 0.00^{B}{}_{b}$	$2 \pm 0.00^{B}{}_{a}$	$2 \pm 0.00^{B}{}_{a}$
9	$2.8 \pm 0.2^{A}{}_{b}$	$2.4 \pm 0.24^{AC}{}_{b}$	$2 \pm 0.00^{BC}{}_{b}$	$2 \pm 0.00^{B}{}_{b}$	$2 \pm 0.00^{B}{}_{a}$
Days	Sensory analyses (Texture)				
	M1	M2	M3	VP	A
1	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$	$3 \pm 0.00^{A}{}_{a}$
5	$2 \pm 0.00^{A}{}_{ab}$	$2 \pm 0.00^{A}{}_{ab}$	$3 \pm 0.00^{B}{}_{ab}$	$3 \pm 0.00^{B}{}_{b}$	$3 \pm 0.00^{B}{}_{b}$
9	$2.2 \pm 0.2^{A}{}_{b}$	$2.2 \pm 0.2^{A}{}_{b}$	$2.4 \pm 0.24^{A}{}_{b}$	$2.4 \pm 0.24^{A}{}_{b}$	$2.4 \pm 0.24^{A}{}_{b}$
Days	Sensory analyses (Odour)				
	M1	M2	M3	VP	A
1	$4 \pm 0.00^{A}{}_{a}$	$4 \pm 0.00^{A}{}_{a}$	$4 \pm 0.00^{A}{}_{a}$	$4 \pm 0.00^{A}{}_{a}$	$4 \pm 0.00^{A}{}_{a}$
5	$3 \pm 0.00^{A}{}_{b}$	$3 \pm 0.00^{A}{}_{b}$	$2 \pm 0.00^{B}{}_{b}$	$2 \pm 0.00^{B}{}_{a}$	$2 \pm 0.00^{B}{}_{ab}$
9	$1.8 \pm 0.91^{A}{}_{c}$	$1.2 \pm 0.73^{A}{}_{c}$	$0 \pm 0.00^{B}{}_{c}$	$0 \pm 0.00^{B}{}_{b}$	$0 \pm 0.00^{B}{}_{b}$

Mean value±standart deviation, Means in the same column and in the same row with the same letter donat differ significantly at the level of 0.05 significance n= 10 A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO_2+%50 N_2 modified atmosphere packaged cuttlefish, M2: %80 CO_2 +%20 N_2, modified atmosphere packaged cuttlefish, M3: %65 CO_2 +%35 N_2 modified atmosphere packaged cuttlefish.

Table 6
Textural changes of aerobically, vacuum and modified atmosphere packaged cuttlefish

Days	Resilience				
	M1	M2	M3	VP	A
1	$0.51\pm0.13^{A}_{a}$	$0.49\pm0.16^{A}_{a}$	$0.51\pm0.12^{A}_{a}$	$0.53\pm0.17^{A}_{a}$	$0.59\pm0.10^{A}_{a}$
5	$0.59\pm0.09^{A}_{a}$	$0.66\pm0.09^{BC}_{b}$	$0.62\pm0.10^{AC}_{b}$	$0.63\pm0.08^{AC}_{b}$	$0.68\pm0.04^{BC}_{b}$
9	$0.55\pm0.03^{A}_{a}$	$0.55\pm0.09^{A}_{a}$	$0.56\pm0.07^{A}_{ab}$	$0.51\pm0.05^{A}_{a}$	$0.53\pm0.04^{A}_{c}$
Days	Cohesiveness				
	M1	M2	M3	VP	A
1	$0.64\pm0.13^{A}_{a}$	$0.62\pm0.17^{A}_{a}$	$0.65\pm0.14^{AB}_{a}$	$0.79\pm0.24^{B}_{a}$	$0.74\pm0.08^{AB}_{a}$
5	$0.73\pm0.08^{A}_{b}$	$0.79\pm0.09^{A}_{b}$	$0.75\pm0.10^{A}_{a}$	$0.76\pm0.07^{A}_{a}$	$0.79\pm0.03^{A}_{b}$
9	$0.71\pm0.03^{A}_{ab}$	$0.70\pm0.09^{A}_{ab}$	$0.70\pm0.07^{A}_{a}$	$0.66\pm0.05^{A}_{a}$	$0.69\pm0.04^{A}_{a}$
Days	SPRINGINESS				
	M1	M2	M3	VP	A
1	$0.21\pm0.08^{A}_{a}$	$0.20\pm0.07^{A}_{a}$	$0.21\pm0.07^{A}_{a}$	$0.19\pm0.08^{A}_{a}$	$0.17\pm0.03^{A}_{a}$
5	$0.17\pm0.02^{AB}_{ab}$	$0.15\pm0.03^{A}_{b}$	$0.19\pm 0.03^{B}_{a}$	$0.17\pm0.02^{AB}_{a}$	$0.17\pm0.02^{AB}_{a}$
9	$0.16\pm0.02^{AD}_{b}$	$0.14\pm0.01^{B}_{b}$	$0.18\pm 0.01^{C}_{a}$	$0.19\pm0.03^{C}_{a}$	$0.16\pm0.01^{D}_{a}$
Days	HARDNESS				
	M1	M2	M3	VP	A
1.	$21.09\pm1.92^{A}_{a}$	$14.47\pm4.37^{A}_{a}$	$14.48\pm7.26^{A}_{a}$	$14.47\pm4.46^{A}_{a}$	$16.77\pm6.61^{A}_{a}$
5.	$26.31\pm7.75^{AB}_{a}$	$20.12\pm7.59^{B}_{b}$	$31.22\pm8.60^{AC}_{b}$	$28.76\pm5.62^{AC}_{b}$	$33.96\pm5.81^{C}_{b}$
9.	$22.98\pm1.94^{AC}_{a}$	$24.77\pm7.14^{AB}_{b}$	$28.35\pm6.32^{B}_{b}$	$28.95\pm4.89^{B}_{b}$	$18.78\pm2.95^{C}_{a}$
Days	CHEWINESS				
	M1	M2	M 3	VP	A
1.	$4.84\pm4.06^{A}_{a}$	$2.89\pm1.91^{A}_{a}$	$2.82\pm2.08^{A}_{a}$	$2.74\pm2.84^{A}_{a}$	$2.43\pm1.47^{A}_{a}$
5.	$3.47\pm1.26^{ACD}_{a}$	$2.91\pm1.03^{AC}_{a}$	$5.41\pm1.19^{B}_{b}$	$4.76\pm1.03^{BC}_{a}$	$4.13\pm1.36^{BD}_{b}$
9.	$2.50\pm4.79^{A}_{a}$	$2.25\pm1.62^{A}_{a}$	$4.95\pm1.88^{B}_{ab}$	$3.32\pm6.66^{B}_{a}$	$2.58\pm5.22^{A}_{a}$
Days	ADHESIVENES				
	M1	M2	M3	VP	A
1.	$-2.93\pm1.32^{A}_{a}$	$-1.97\pm1.75^{BC}_{a}$	$-1.38\pm9.34^{AC}_{a}$	$-1.01\pm1.54^{BC}_{a}$	$-2.07\pm9.69^{AC}_{a}$
5.	$-2.14\pm1.47^{A}_{a}$	$-2.50\pm1.65^{A}_{b}$	$-2.93\pm1.55^{ABC}_{a}$	$-1.99\pm8.26^{C}_{a}$	$-1.63\pm1.39^{C}_{a}$
9.	$-1.62\pm3.86^{AB}_{b}$	$-2.7\pm4.66^{B}_{a}$	$-2.32\pm153,80^{AC}_{a}$	$-2.26\pm1.35^{C}_{b}$	$-2.21\pm1.94^{C}_{a}$

n=3; (Mean value±standart deviation). Means in the same column and in the same row with the same letter donat differ significantly at the level of 0.05 significance A: cuttlefish in plastic bag ; VP: Vacuum packaged cuttlefish; M1: %50 CO_2+%50 N_2 modified atmosphere packaged cuttlefish, M2: %80 CO_2 +%20 N_2 modified atmosphere packaged cuttlefish, M3: %65 CO_2 +%35 N_2 modified atmosphere packaged cuttlefish.

determined more effective than air packaged to extend the shelf-life of cuttlefish. The TVB-N values of modified atmosphere and vacuum packaged cuttlefish exceeded acceptability limits of 35 mg N/100g on day 9, but air packaged cuttlefishes exceeded this limit on day 5. MAP and VP extended the shelf-life of cuttlefishes 4 days when compared with A. Cuttlefish are valuable and expensive fishery products. For this reason it is very important for economies of countries to extend the shelf-life of cuttlefish. In the light of the results of this study, cuttlefishes can be saved for 4 days by using modified atmosphere and vacuumed packaging. The information about extending the shelf-life of cuttlefish for 4 days will be very helpful for seafood industry. The results of this study can be evaluated by studying in this field, for processors, fish processing industries and consumers.

References

Albanese, D., L. Cınquanta, M. T. Lanorte and M. D. Matteo, 2005. Cuttlefish (*Sepia officinalis)* stored in active packaging: some chemical and microbiological changes. *Italian Journal of Food Science*, **3** (17): 325-332.

Anonym., 1999. Codex Guidelines for the Sensory Evaluation of Fish and Shellfish in Laboratories CAC-GL. **31:** 1-33

AOAC, 1995. Official Methods of Analysis, 14th ed. *Association of Official Analytical Chemistry*, Washington. D. C.

Beltran-Lugo, A. I., A. N. Maeda-Martinez, R. Pacheco-Aguilar and H. G. Nolasco-Soria, 2006. Seasonal variations in chemical, physical, textural, and microstructural properties of adductor muscles of Pacific lions-paw scallop (*Nodipecten subnodosus*). *Aquaculture*, **258:** 619–632.

Blig, E. G and W. J. Dyer, 1959. A rapid methods of total lipid extraction and purification. *Can. J. Biochem. Phiys.*, **37**: 911-917.

Caglak, E., S. Cakli and B. Kilinc, 2008. Microbiological, chemical and sensory assessment of mussels (*Mytilus galloprovincialis*) stored under modiWed atmosphere packaging. *Eur. Food Res. Technol*., **226:** 1293–1299.

Caglak, E., S. Cakli, and B. Kilinc, 2012. Effect of modified atmosphere packaging on Quality and Shelf life of Salted Bonito (*Sarda sarda*). *Journal of Aquatic Food Product Technology*, **21:** 206-221.

Connell, J. J., 1990. Methods of assessing and selecting for quality. In: Control of Fish Quality (3rd edn) ed. Connell, J.J. pp. 122–150. Oxford, UK: *Fishing News Books.*

Crandall, A. D. and T. J. Montville, 1993. Inhibition of *Cl. Botulinum* growth and toxinogenesis in a model gravy system by coinoculation with bacteriocin producing lactic acid bacteria. *Journal of Food Protection*, **56:** 485–488

Dalgaard, P. and V. L. Jorgensen, 2000. Cooked and brined shrimps packed in a modified atmosphere have a shelf-life > 7 months at 0°C, but spoil in 4-6 days at 25°C. *International Journal of Food Science and Technology*, **35:** 422- 431.

Davies, A. R., 1995. Advances in modified atmosphere packaging. In new methods of food preservation Gould, G.W. (ed) pp. 304-20. Blackie Academic and Professional, Glasgow.

Davies, A. R., 1997. Modified-atmosphere packaging of fish and fish products. In Fish Processing Technology (2nd edn) ed. Hall, G.M. pp. 200–223. London, UK: Blackie Academic and Professional.

Debevere, J. and G. Boskou, 1996. Effect of modified atmosphere packaging on the TVB/TMA producing microflora of cod fillets. *International Journal of Food Microbiology,* **31:** 221–229

EEC, 1995. Total volatile basic nitrogen (TVB-N) limit values for certain categories of fishery products and specifying the analysis methods to be used. Commission Decision 95/149/EEC of 8 March 1995, *Official Journal of European Communities* L **97:** 84–87.

FAO, 1986. Food and Nutrition Paper Manuals of Food Quality Control Food Analysis: Quality, Adulteration, and Tests of Identity. Food and Agriculture Organization of the United Nation, Rome.

Fernandez, K., E. Aspe and M. Roeckel, 2010. Scaling up parameters for shelf-life extension of Atlantic Salmon (Salmo salar) fillets using super chilling and modified atmosphere packaging. *Food Control*, **21** (6): 857-862.

Gonzalez, R. M. N., J. J. Sanz, J. A. Santos, A. Otero and M. L. Garcia-Lopez, 2002. Numbers and types of microorganisms in vacuum –packed cold smoked fresh water fish at the retail level. *International Journal of Food Microbiology,* **77**(1–2): 161–168

Harrigan, W. F. and M. E. Mccance, 1976. Laboratory methods in food and dairy microbiology. *Academic Press,* New York

Huss, H., 1972. Storage life of prepacked wet fish at 0°C, I plaice and haddock at 0°C. *Journal of Food Technology*, **7:** 13-19.

Kilinc, B. and S.Cakli, 2005. Chemical, enzymatical and textural changes during marination and storage period of sardine (*Sardina pilchardus*) marinades. *European Food Research and Technology*, **221:** 821-827.

Lima, Dos Santos C., D. James and F. Teutscher, 1981. Guidelines for chilled fish storage experiments. *FAO Fish Tech Pap* 210 pp.

Ludorff, W. and V. Meyer, 1973. Fische und fischerzeugnisse. Hamburg-Berlin: *Paul Parey Verlag.*

Mitsuda, H., K. Nakajima, H. Mizuno and F. Kawai, 1980. Use of sodium chloride solution and carbon dioxide for extending shelf-life of fish fillets. *Journal of Food Science,* **45:** 661-666.

Pelroy, G. A., M. W. Eklund, R. N. Paranjpye, E. M. Suzuki and M. E. Peterson, 1982. Inhibition of *Clostridium botulinum* types A and E toxin formation by sodium nitrite and sodium chloride in hotprocess (smoked) salmon. *Journal of Food Protection,* **45** (9): 833–841.

Poli, B. M., A. Messıni, G. Parisi, F. Scappini, V. Vigiani, G. Giorgi and M. Vincenzini, 2006. Sensory, physical, chemical and microbiological changes in European sea bass (*Dicentrarchus labrax*) fillets packed under modified atmosphere/air or prepared from whole fish stored in ice. *International Journal of Food Science and Technology,* **41:** 444–454.

Reddy, N. R., D. J. Armstrong, E. J. Rhodehamel and D. A. Kauter, 1992. Shelf-life extension and safety conderns about fresh fishery products packaged under modified atmospheres: a review. *Journal of Food Safety*, **12:** 87–118.

Schubring, R., 2002. Influence of freezing/thawing and frozen storage on the texture and color of brown shrimp (*Crangon crangon*). *Archiv für Lebensmittelhygiene,* **53** (2): 34–36.

Schubring, R. and J. Oehlenschlager, 1997. Comparison of the ripening process in salted Baltic and North Sea herringas measured by instrumental and sensory methods. *Z Lebensmittel Unters Forsch* A, **205:** 89-92.

Schormuller, J., 1969. Handbuch der Lebensmittel Chemie, Band IV, Fette und Lipoide (Lipids), *Springer-Verlag, Berlin- Hiedelberg-New York*, pp. 872–878.

Sivertsvik, M., W. K. Jeksrud and J. T. Rosnes, 2002. A review of modified atmosphere packaging of fish and fishery products – significance of microbial growth activities and safety. *International Journal of Food Science and Technology*, **37:** 107–127.

Swiderski, F., S. Russel, B. Waszkiewicz-Robak and E. Cholewinska, 1997. Evaluation of vacuum-packaged poultry meat and its products. *Rocz. Panstw. Zakl. Hig.*, **48:** 193–200.

Tarladgis, B. G., B. M. Watts, M. S. Younathan and L. Jr. Dugan, 1960. A Distillation method for the quantitative determination of malonaldehyde in rancid foods. *Journal of American Oil Chemistry Society*, **37:** 44–48.

Thanonkaew, A., S. Benjakul, W. Viessanguan and E. A. Decker, 2006. The effect of metal ions on lipid oxidation, colour and physicochemical properties of cuttlefish (*Sepia pharaonis)* subjected to multiple freeze–thaw cycles. *Food Chemistry*, **95:** 591–599.

Vyncke, W., 1996. Comparison of the official EC method for the determination of total volatile bases in fish with routinemethods. *Archiv für Lebensmittelhygiene,* **47:** 110–112.

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