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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Quality changes of fish balls prepared from of mosul bleak (*Alburnus mossulensis*) stored at -18 ºC under air or vacuum

Hava ve vakum altında ambalajlanarak -18 ºC'de depolanan gümüş balığı'ndan (*Alburnus mossulensis*) hazırlamış balık köftelerinin kalite değişimleri

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Abstract: In the present study, microbiological, chemical and sensory qualities of fish balls prepared from *Alburnus mossulensis* mince as air and vacuum packed (Group AP and Group VP, respectively) were determined during frozen storage at -18 ºC for 180 days. All samples total viable counts (TVC), the total volatile basic nitrogen (TVB-N) content, free fatty acid analysis (FFA), thiobarbituric acid (TBA) values increased significantly ($p<0.05$), while sensory attributes decreased during storage. It was determined that the amounts of TVB-N and TBA during storage period in fish meatball samples did not exceed the consumption limit value. At the beginning of storage, fish balls samples were more appreciated sensory point of view, but the level of appreciation was gradually decreased later. Use of vacuum packaging in the fish balls had a significant effect on the quality of the products during the storage period ($p<0.05$). In conclusion, according to the results of chemical and sensory analysis, it was found fish meatballs samples stored at -18 ºC protected their consumable quality up to 6 months.

Keywords: *Alburnus mossulensis, balls, quality properites, shelf life*

Öz: Bu araştırmada, *Alburnus mossulensis* etinden hazırlanan, hava ve vakum olarak ambalajlanarak dondurulan köfte örneklerinin -18°C de 180 gün muhafazası sırasında meydana gelen mikrobiyolojik, kimyasal ve duyusal kalite değişimleri incelenmiştir. Toplam canlı sayısı (TVC), toplam uçucu bazik azot (TVB-N) sayısı, serbest yağ asidi (FFA) ve tiyobarbitürik asit (TBA) sayısı değerleri tüm örneklerde muhafaza süresince giderek artığı, duyusal analiz sonuçlarının ise azaldığı belirlenmiştir ($p<0,05$). Balık köftesi örneklerinin TVB-N ve TBA miktarı bakımından muhafaza süresince tüketilebilirlik sınır değerini aşmadığı belirlenmiştir. Balık köfte örneklerinin muhafazanın başlangıcında, duyusal açıdan daha fazla beğenildiği, ilerleyen günlerinde ise beğeni düzeyinin giderek azaldığı saptanmıştır. Vakum ambalajın ürünün kalitesi üzerine önemli etkisi olduğu tespit edilmiştir. Çalışmada duyusal, kimyasal ve mikrobiyolojik analiz sonuçlarına göre balık köfte örneklerinin -18ºC'de 6 ay tüketilebilir niteliğini koruduğu tespit edilmiştir

Anahtar kelimeler: *Alburnus mossulensis, köfte, kalite özellikleri, raf ömrü*

INTRODUCTION

Alburnus mossulensis (Heckel, 1843) are Cyprinid fish found in the Euphrates and Tigris rivers in Turkey and their adjacent basins in Iran. *Alburnus mossulensis* (mosul bleak), which live in the dam lake but are not fished due to their low economic value (Geldiay and Balık, 2007; Uçkun and Gökçe, 2015). Hence, there is a need to develop some convenience products from the flesh of mosul bleak to enhance their consumer acceptability.

Fish and fishery products play an important role in human nutrition as a source of proteins, fatty acids, fat-soluble vitamins macro and trace elements (Belitz et al., 2009). However, fish is a highly perishable commodity and its post-harvest handling and processing being labor intensive, result in increased microbial contamination. There is an increasing growth in the demand for convenience ready-to-cook/eat minimally processed meat products in both developed and developing countries (Lee et al., 2005). Ready-to-cook/eat meat products are susceptible to environmental contamination with spoilage and pathogenic microorganisms during handling of these products after cooking and before or during packaging (Zhu et al., 2004). There are numerous food processing tools available that provide food protection. Individually frozen fish and fish products are available in the market. However, fish and fishery products can undergo undesirable changes during frozen storage and deterioration may limit the storage time. These undesirable changes result from lipid oxidation and protein denaturation. The aim of this study was to produce fish balls from mosul bleak flesh and to investigate the quality changes during frozen (-18ºC) storage.

MATERIAL AND METHOD

Sample preparation

Fresh mosul bleak (*Alburnus mossulensis*) were obtained from Karakaya Dam Lake (Malatya, Turkey). After purchase, the fish were transferred to the laboratory in polystyrene boxes with crushed ice within 1 h. In total 15 kg of fish with an average weight of 29.7±3.6 g were taken. On arrival at the laboratory, quality control analyses of the fish were performed and balls were prepared.

The fish were gutted, filleted and washed. After the handling process, the fish were boiled in boiling water for 2 min and then minced using a 3 mm diameter holes plate. Ingredients were added to the minced fish (64%) according to the following formulation: 18% boiled rice, 11.39% onion, 3.84% sunflower oil, 1.79% parsley, 0.72% salt and 0.26% black pepper. The ingredients were homogenized with a kitchen blender. The mixture was kept in a refrigerator at 4º C for 1 h and processed into meat balls (1.5 cm thick and 100 mm diameter) by using a metal shaper. Balls of approximately 25 g in weight were first dipped wheat flour followed by rolling in egg albumen liquid. Balls were then dipped in galata flour, removed and fried at 180 ± 10 °C for 7 min in sunflower oil and then cooled to room temperature (20±2 °C). The fish balls were divided into two groups: one group was air-packed in a polyethylene plastic bag (AP), another group was vacuum packed [high-barrier nylon polyethylene bags (VP)] and stored at -18 ºC for six months. For each group 42 and totally 84 packaged were used in the study. The experiments were duplicated for each fish ball treatment at different time periods (3 × 2 = 6 samples).

Proximate composition analysis

The moisture content and crude ash were determined in an oven at 103 °C and 550 °C, respectively, until the weight became constan (AOAC, 1990). The total crude protein was determined by Kjeldahl's method (AOAC, 1990) and the lipid content was analysed according to the procedure of Bligh and Dyer (1959). Carbohydrate content was estimated by difference: 100 g - total grams of water, protein, lipids and ash. The analyses were duplicated for each fish balls at different time periods.

Microbiological analysis

A sample of fish (10 g) was diluted with 90 ml sterile 0.1% peptone water and homogenized in a Stomacher (Model 400, Seward, London, UK) at regular speed for 2 min. For microbial enumeration, 0.1 ml samples of serial dilutions (1:10, diluent, 0.1% peptone water) of fish homogenates were spread on the surface of dry media. Total viable counts (TVC) were determined using plate count agar (PCA, Merck) after incubation for 48 h at 30 °C (ICMSF, 1986).

Chemical analysis

The pH values were measured by immersing a glass-calomel electrode directly into the sample by using a pH meter (Thermo Scientific Orion 3-Star Benchtop, Cambridge, UK). The total volatile basic nitrogen (TVB-N) content was determined according to the method of Antonocopoulus (1989). Free fatty acid analysis (FFA), expressed as % of oleic acid, was carried out by AOCS (1998) method. The value of thiobarbituric acid (TBA) value (mg malonaldehyde/kg) was determined according to Tarladgis et al. (1960).

Sensory analysis

The sensory quality of fish sample was evaluated by ten trained panelists. The whole fish ball products in one package were thawed in a microwave and warmed in a hot pan (90 −100°C) for 3–4 min. Panellists scored for sensory characteristics, such as colour, odour, flavour, texture and general acceptability of fish ballsaccording to the method of Amerine et al. (1965). A hedonic scale from 9 to 1 was used to evaluate fish ball. 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'. Sensory analyses were carried out at each sampling time (day 0, 30, 60, 90, 120, 150) during storage period.

Statistical analysis

All data were studied with one-way analysis of variance (ANOVA) followed by Duncan's multiple-range test. Statistical significance level was considered to be p= 0.05. All statistical analyses were carried out using SPSS Version 12.0 (SPSS, IL, USA).

RESULTS AND DISCUSSION

Proximate composition analysis

Proximate compositions of raw fish, raw fish meat balls and cooked fish meat balls were given in Table 1. The compositions of the raw fish were similar to the findings of other researchers (Weber et al., 2008). Moisture content of raw fish was determined as 76.6 ± 1.06% but after the process, it decreased to 71.3 ± 1.41 % in the raw fish meat balls and 58.25 ± 1.48% in the cooked fish meat balls, respectively ($p<0.05$). Lipid content of raw fish was 1.24%. After the process, lipid content increased to 3.81%, in the raw fish meat balls, and 8.16 ± 0.01% in the cooked fish meat ball ($p<0.05$). Protein contents of fish balls also increased after the cooking process as compared to the raw fish. Significant differences were found between the protein, lipid, ash and carbohydrate contents of raw and cooked fish balls ($p< 0.05$). The proximate composition of the fish balls showed similarities to the findings of Duman and Özpolat (2012). The increase in protein, lipid, ash and carbohydrate content found in cooked silver fish meat balls was explained by the reduction in moisture (Table 1). In general, fish are known to have low amounts of carbohydrate in their muscle. However, the higher amount of carbohydrate in balls might be derived from rice Table 1.

Table 1. Proximate analysis results of raw material, raw meat balls and cooked meat balls

Parameter	Raw fish	Raw fish meat balls	Cooked fish meat balls
Moisture	76.6±1.1^{a}	71.3±1.4^{b}	58.25±0.91^{c}
Crude proteins	19.3±0.1^{a}	17.6±0.1^{b}	20.51±0.19^{c}
Crude lipids	1.24±0.1^{a}	3.8±0.2^{b}	10.18±0.04^{c}
Ash	1.00±0.0^{a}	1.2±0.1^{a}	1.3±0.1^{b}
Carbohydrate	1.92±0.6^{a}	6.1±0.2^{b}	9.90±0.32^{c}

$^{a\text{-}c}$ Means in the same line followed by different superscripts are significantly different ($p < 0.05$).

Microbiological analysis

Results of total viable counts (TVC) were given in Fig. 1. Total viable counts in the fishery products are the useful tool for quality evaluation of shelf-life and post-processing contamination (Duman and Ozpolat, 2012). The initial total viable count (TVC) of sample was 1.5 log CFU/g, and the low initial TVC in balls indicated very good quality. Total viable counts increased with storage time for all groups. However, TVC content of fish balls did not exceed the maximum limits (7 log CFU/g) of microbiological criteria for fresh and frozen fish given by the ICMSF (1986). A significant ($p<0.05$) increase in total plate counts of fish balls stored under refrigeration was in agreement with findings of Mahmoudzadeh et al. (2010), Uçak et al.(2011), Ozoğul and Ucar (2013) reported the similar results in mackerel fish burgers, mackerel burgers and fish balls respectively. Significant differences ($p< 0.05$) were observed among the groups. AP contained high level of TVC compared to VP.

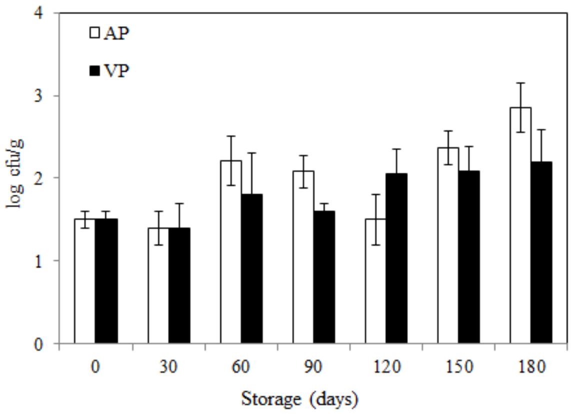

Figure. 1. Changes in TVC of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

Chemical analysis results

Variations in values of pH during the frozen storage are given in Fig. 2. The initial pH of the fish ball was 6.15. All samples showed an increase H value with an extended storage period. The increase of pH was postulated to be due to an increase in volatile bases produced, e.g. ammonia and trimethylamine, by either endogenous or microbial enzymes (Fan et al., 2009). Significant statistical differences were found between the samples ($p< 0.05$). At the end of the storage time, the pH values of the samples in the present study reached the maximum levels of 6.63 and 6.61 for AP and VP, respectively. The increase in pH might be due to accumulation of metabolites of bacterial action on meat and meat products and deamination of meat proteins (Jay, 1996). Similar increase in pH was also reported by Tokur et al. (2006) in carp fish burgers, Duman and Özpolat (2012) in Inegöl style fish balls.

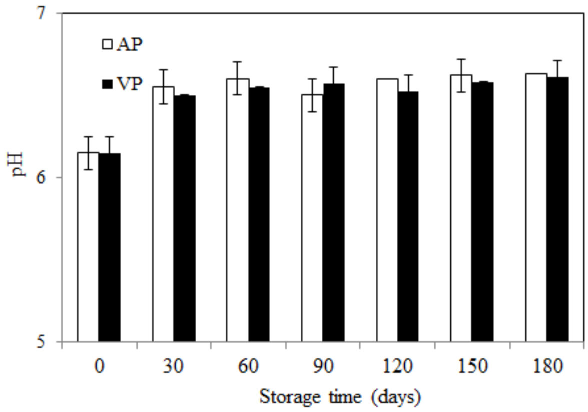

Figure 2. Changes in pH of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

Total volatile basic nitrogen (TVB-N) is a general term which includes the measurement of trimethylamine (TMA), dimethylamine (DMA), ammonia, and other volatile basic nitrogenous compounds associated with seafood spoilage (Huss, 1995). TVB-N is one of the most widely used for evaluation of the degree of spoilage in seafood. Changes in TVB-N value during storage are shown in Fig. 3. The initial TVB-N value was 11.48 mg/100 g and it increased progressively with time of frozen storage for both samples. Its increase was elated to the activity of spoilage bacteria and endogenous enzymes because enzymes were till active. Similar TVB-N values were reported by Yerlikaya et al. (2005) and Lin et al. (2011). According to Huss (1995), the acceptable TVB-N level is 35–40 mg N/100g. The final TVB-N values of both balls samples did not exceed the upper acceptability limit after 150 days of frozen storage. The data also showed that TVB-N increase was significantly lower in the VP sample than in AP ($p<0.05$). After 150 days of frozen storage, TVB-N contents increased from an initial value to 27.3 mg/100 g in VP to 33.74 mg/100 g in AP. Similar TVB-N values were reported by Duman and Özpolat (2012) and Yerlikaya, et al. (2005). These results indicated that there was a relationship between TVB-N release and loss of freshness.

Free fatty acids (FFA) in frozen fish are a result of enzymatic decomposition of lipids (Hardy, 1980). Changes in FFA values of fish balls during frozen storage are shown in Fig 4. The initial FFA values of AP and VP were found to be 1.25 (oleic acid %). Results indicate an increasing trend in all the samples during storage. Similar observations were made by several authors (Tokur at al., 2004; Uçak et al., 2011; Ozogul and Ucar, 2013). These values gradually ($p < 0.05$) increased to 3.82 and 2.62%, respectively, at the end of 150 days of storage. An increase in FFA resulted from the enzymatic hydrolysis of esterified lipids. The connection between lipolysis and lipid oxidation is that FFA oxidise more readily than esterified lipids (Uçak et al. 2011). These results showed that even the low temperature (−18 °C) could not stop lipid hydrolysis and the rate was reduced by vacuum-packing.

The TBA index is widely used as an indicator of degree of lipid oxidation. The oxidative rancidity measured by TBA values was presented in Fig. 5. Schormuller (1969) suggested the levels of 7–8 mg malonaldehyde/kg as the upper limit of acceptable of consumption. The amount of TBA raw fish samples was 0.94 mg malonaldehyde/kg and this value increased to 1.05 mg malonaldehyde/kg in the cooked fish ball. The final TBA values of both fish balls samples did not exceed the upper acceptability limit after 150 days of frozen storage. TBA value followed a significant ($p<0.05$) increasing trend from all samples during the frozen storage. A difference among the AP and VP also existed as the TBA values of VP were significantly ($p<0.05$) lower then AP on lower than AP during the storage except on day 0. The increase in TBA values on storage might be attributed to oxygen permeability of packaging material (Brewer et al., 1992) that led to lipid oxidation. Similar results were reported by Yanar and Fenercioglu (1998), Tokur et al. (2006) in various fish balls.

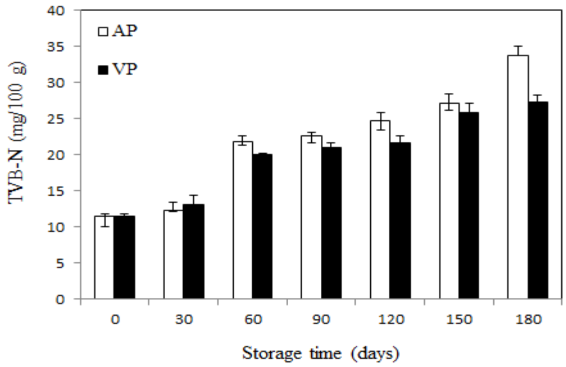

Figure 3. Changes in TVB-N values of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

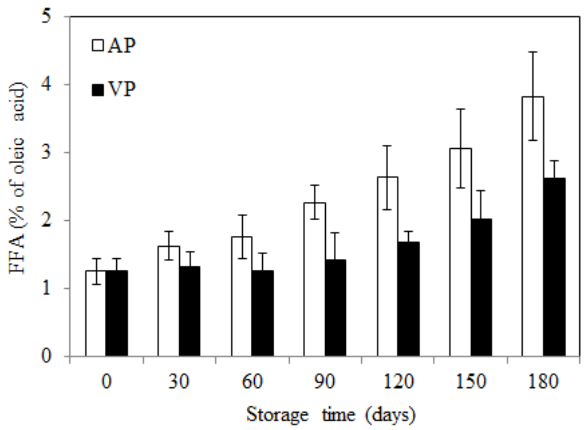

Figure 4. Changes in FFA values of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

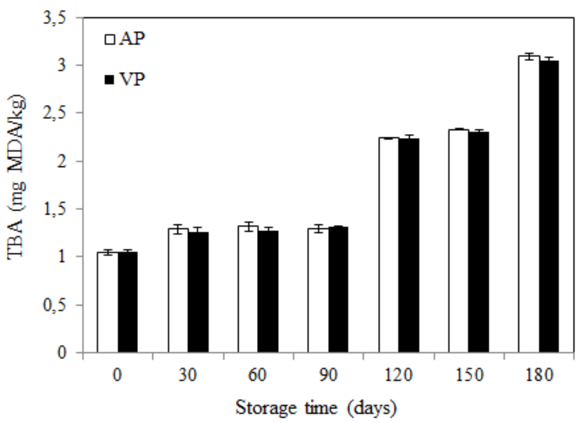

Figure 5. Changes in TBA values of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

Sensory analyses results

The results of the sensory evaluation of samples were given in Fig. 6. The fish balls were considered to be acceptable for consumption until the sensory score reached to 4. The acceptability of fish and fishery products during frozen storage depends on the changes in their sensory attributes. The sensory scores, in both AP and VP declined significantly throughout the 150 days of frozen storage ($p<0.05$). However, both groups remained fresh after the storage periods. The decrease in appearance scores might be due to pigment loss and rancidity resulting in non-enzymatic browning. A decrease in appearance and colour scores of meat products with increase in storage period was also reported by Kilinc (2009) in anchovy patties, Yi et al. (2011) in Collichthys fish ball, Duman and Özpolat (2012) in fish balls and Noordin et al. (2014) in fish balls. This finding is supported by the results of chemical and microbiological quality analyses.

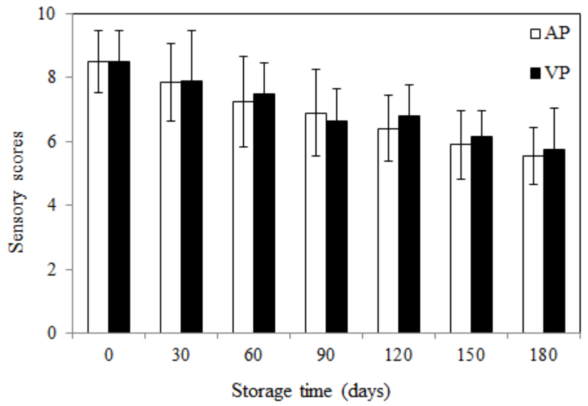

Figure 6. Changes in sensory scores of fish balls sample during frozen storage. Each point is the mean of three samples taken from two replicate experiments (n = 3 × 2 = 6). Vertical bars = standard deviation

CONCLUSIONS

Thanks to the present study, the fish balls produced from mosul bleak, as an alternative product, can be stored for 150 days in a frozen state without undesirable changes of microbiological, chemical and sensory quality. these balls or similar products may open new options to include fish species normally not well accepted at fresh fish markets and thus can contribute to an increase in overall fish consumption. Thus, the fish can be consumed in different ways and fish consumption can be increased. Fish balls as highly acceptable food products and they can be purchased by consumers in the market.

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