Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.28722

The effect of vacuum packaging on fish balls prepared from *Capoeta trutta* with different concentrations of liquid smoke

Emine ÖZPOLAT[1]*

Abstract

In this study, both the evaluation of fish as a different product and he use of liquid smoke in fish balls and the effect of vacuum packaging were investigated. awn and cheap *Capoeta trutta* were used. Fish balls prepared by adding 3 different rates of liquid smoke (volume/weight) (0%, 0.2% and 0.4% added liquid smoke) were packaged both vacuum and air packaged and stored under 4 ± 1 °C. The samples were analyzed sensory (taste, odor and texturing), chemical (total volatile basic nitrogen-TVB-N, Thiobarbituric acid-TBA,) and microbiological quality (Total mesophilic aerobic bacteria, Coliforms, *Escherichia coli, Staphylococcus aureus,* yeasts and molds) of storage at 0, 7, 14, 21, 28 and 35 days of storage. When the results were evaluated, it was determined that the addition of liquid smoke positively affected the sensory taste, but it was found that it did not have a significant effect on microbiological and chemical quality. Defineds limits for mesophilic aerobic bacteria and TVB-N were reached vacuum-packaged groups (A, C and E) 35 days, non-vacuum packaged groups (B, D and E) 14 days. It was determined that vacuum packaging extended the shelf life of the product by two weeks on average.

Keywords: fish ball; smoke; liquid smoke; shelf-life; vacuum packaged.

Practical Application: The addition of liquid smoke at different rates positively affected the sensory taste of fish balls. Vacuum packaging, on the other hand, made the life of the product approximately two weeks longer. The combined use of liquid incense and packaging techniques, it could be form the basis for new studies.

1 Introduction

Fish is low in carbohydrates in addition to being a very ideal food in terms of amino acids, fatty acids, minerals and vitamins it contains. The transformation of fish into products such as meatballs, patties, burger and sausages is increasing due to its stringy structure and unique smell (Kolekar et al., 2012; Kolekar & Pagarkar, 2013; Özpolat et al., 2014).

Smoking is one of the oldest food preservation methods. While the purpose of this technology was to make the product durable, today it is aimed to improve the sensory properties of the product by using the flavor and color of the smoke. The use of traditional smoking methods, or recently liquid smoking, have proven that this means of preservation still being vastly practiced in community as well as in food industry. Liquid smoking in preserving protein-based foods, namely meat, fish, and cheese, has been increasingly utilized, owing to pleasant flavour and inhibitory effects on pathogens. Liquid smoke has several advantages compared to traditional smoking techniques in terms of easiness of application, speed, uniformity of the product, good reproducibility of desired characteristics obtained in the final smoked food, lower cost, environmental friendliness and easier control of smoke contaminants like polycyclic aromatic hydrocarbons, and carcinogenic and mutagenic molecules produced during pyrolysis of wood (Hattula et al., 2001; Soldera et al., 2008; Zuraida et al., 2011; Özpolat & Patir, 2016; Keryanti et al., 2020).

The aim of this study was to investigate the microbiological, chemical and organoleptic characteristics in fish ball produced from fillets of *Capoeta trutta* with liquid smoke and effect of different packaging (air and vacuum) on the shelf life during storage at 4 ± 1 °C. As a result of the study, we aim to increase the economical use of the specie and promote liquid smoke implementation to the benefit of fish ball production.

2 Materials and methods

2.1 Fish meat and ingredients

The fish (*Capoeta trutta*), were obtained from a local market and fish were transported on ice to the Firat University Laboratories. For each repetition, approximately 5-6 kg of fish was used, and each fish weighed approximately 350-400 g. The fish were cut, gutted, skinned and filleted. Fish fillets were minced with a mechanical mincer (hole size: 3 mm in diameter). Parsley, onions, salt, cumin, black pepper, bread were purchased from local markets in Elazig, Turkey. Commercial liquid smoke (oak wood-based smoke) was bought from a food trade company (Zesti Eurosmoke, Istanbul, Turkey). Formulation of fish balls was shown in Table 1.

2.2 Preparation of fish balls

The formula used for the production of fish balls was given in Table 1. Fish ball batter was obtained by mixing until homogeneous all the ingredients. After that, batter divided into three groups. The first group was not added liquid smoke.

Received 01 Apr., 2022
Accepted 21 July, 2022
[1] *Department of Fisheries Technology, Faculty of Fisheries, Firat University, Elazig, Turkey*
*Corresponding author: emineozpolat@firat.edu.tr

Liquid smoke was added at 0.4% and 0.2% of the batter weight and the batter was mixed for the last time so the second and third groups were created. The mixtures were then shaped into fish ball weighing 20 g each. Each group was divided into two and packed with vacuum packing and non-vacuum packing (high barrier nylon polyethylene bags, Henkelman, Boxer 42). Preparation of samples is shown in Figure 1. Packaged samples were stored at 4 ± 1 °C. Microbiological, chemical, and sensory analysis was conducted following 0, 7, 14, 21, 28 and 35 days of storage. The study was composed of three replicates.

2.3 Microbiological analysis

Samples were taken from fish balls in accordance with the microbiological analysis method. Then, necessary dilutions (10^{-1} - 10^{-8}) were prepared and microbiological analyzes were made as indicated in Table 2. All microbiological tests were carried out in duplicate, and the results were expressed as the logarithm of colony forming units per gram (CFU/g) (Oxoid, 1982; Halkman, 2005).

Table 1. Formulation of fish balls.

Ingredients	%
Fish Meat	82.5
Parsley	5
Onions	5
Bread (crumb)	5
Cumin	0.5
Black Pepper	0.5
Salt	1,5

2.4 Chemical analysis

Chemically, thiobarbituric acid (TBA) and total volatile basic nitrogen (TVB-N) value of the samples were determined. TVB-N content was determined according to the method of Antonocopoulus (1973). TBA was determined according to Tarladgis et al. (1960).

2.5 Sensory analysis

Five experienced panelists (3 male and 2 female, aged 25-45 years) from Firat University, who were familiar with the sensory assessment of seafood products, evaluated the sensory quality. Sensory analysis was performed using the methods of Kurtcan & Gonul (1987). To conduct sensory analyses, fried fish balls were evaluated with respect to their colour, odour, flavour, appearance, texture, and general acceptability. The fish balls were fried (3 min) separately in small amounts of vegetable oil until they turned brown before being presented to the panellists. After frying, they were cooled room temperature and samples were served to the panellists who were asked to evaluate on a 5-point hedonic scale ranging from very poor (1) to very good (5) where: 1 – very poor, 2 – poor, 3 – normal, 4 – good, and 5 – very good (Kurtcan & Gonul, 1987).

Table 2. Broth and incubation times for microbiological analysis (Oxoid, 1982; Halkman, 2005).

Mikroorganism	Broth	Incubation	
		°C	Time
Mezophilic aerob bacteria	Plate count agar (PCA)	30	72 h
Coliform	Violet red bile agar (VRBA)	35	24 h
Yast-Mold	Potato Dextrose (PDA) agar, 10% tartaric acid additive	21	5 days
Staphylococcus aureus	Baird-Parker agar	37	24 h
Escherichia coli	Chromocult TBX agar	44	24 h (Than)
		30	4 h

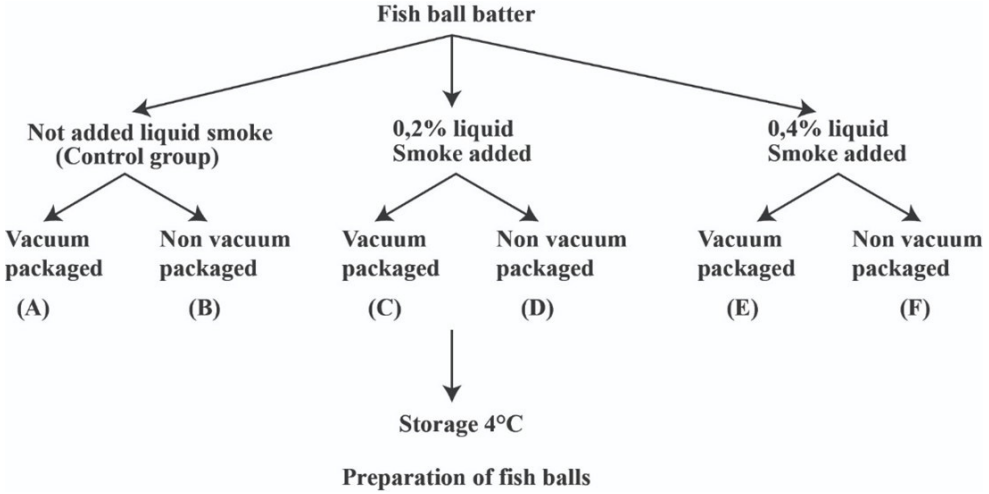

Figure 1. Applicatin of liquid smoke and packaging process.

2.6 Statistical analysis

All analytical determinations were on days 0, 7, 14, 21, 28 and 35. Experiments were replicated twice on different occasions with different fish samples. Each sample was analyzed three times and the mean was calculated. Data were subjected to analysis of variance. The Tukey's honest significant difference procedure was used to test for differences between means ($P < 0.05$) using SAS 6.1 (SAS Institute, 1999).

3 Results and discussion

In all experimental fish ball samples, the initial total mesophilic aerobic bacteria count (TMAE) was determined as 4.03 ± 0.12 log cfu/g. The total mesophilic aerobic bacteria analysis results obtained in the study are given in Figure 2. With the storage period, this number started to increase in all groups. According to the Turkish Food Codex Microbiological Criteria Communique (2009), the total number of mesophilic aerobic bacteria in all food stuffs is an acceptable limit value of 10^6 cfu/g. TAMB exceeded the value of 7 log cfu/g, which is considered as the upper acceptability limit for fresh water and marine species (International Commission on Microbiological Specifications for Foods, 1986). Accordingly, when the results were evaluated, it was seen that this limit was exceeded on the 14th day in the non-vacuum packed groups (B, D and F), while this limit was exceeded on the 35th day in the vacuum packed groups (A, C and E). It has also been determined in various studies that vacuum packaging has a positive effect on the total number of aerobic bacteria in products (Sachindra et al., 2005; Cicek et al., 2013; Özpolat et al., 2014).

Data of coliform group bacteria are given in Figure 3. Coliform bacteria cannot be found in fish under hygienic conditions. The presence of this group of bacteria indicates that any fecal contamination may occur. According to relevant literature (Jay, 1996; Al-Bulushi et al., 2005), the number of coliforms accepted as an indicator of fecal contamination in fish is at most 2.0 x 10^2 cfu/g; 2.5 x 10^2 cfu/g; or 1.6 x 10^3 cfu/g. In the study, the value of 2.79 cfu/g at the beginning of the storage increased over time and it was determined that this increase was statistically significant after the 7th day among packaging types ($p < 0.05$) and the smoke did not have a statistically different effect on the coliform bacteria. Differences in microbial load in fish-derived products in studies; can be attributed to the difference in the type of fish from which the product is made, the other additives used, and the shape of the storage. Packaging techniques are effective on microbial growth of food products (Kilinc & Cakli, 2001).

Yeast-mold values of the experimentally prepared fish ball samples are given in Figure 4. According to these data, while there was no statistically significant difference between all groups at the beginning of the storage period, it was observed that significant differences emerged between the packaging types from the 7th day of the storage ($p < 0.05$). Yeast and molds are not found in the normal flora of fish. These are generally of soil origin and the fish are contaminated when they are caught, from the water or from the tools and materials used after hunting (Goktan, 1990). In the study, the yeast-mold value, which was 1.79 log cfu/g at the beginning of storage, gradually increased in all groups and became noticeable on the surface of the product on the last day of storage (21th day) in groups packed without vacuum. In vacuum-packed meatball samples, they exceeded 4 log cfu/g on the last day of storage. According to relevant studys (Sachindra et al., 2005; Özpolat et al., 2014); vacuum packaging has negative effects on the development of yeast and molds. It has been reported that liquid incense is effective on yeast molds (Faisal et al., 2019). When analyzed in terms of liquid smoke, it was observed that microbiological development

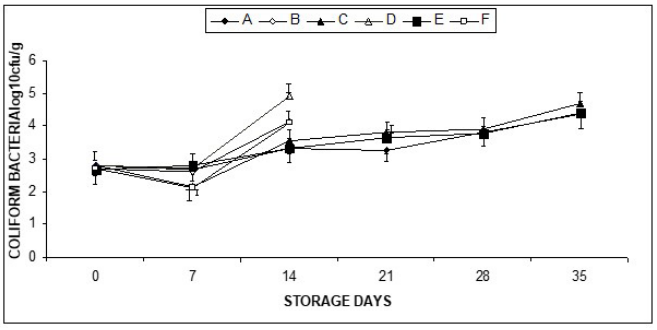

Figure 3. Changes in the counts of (log_{10} CFU/g) coliform bacteria of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

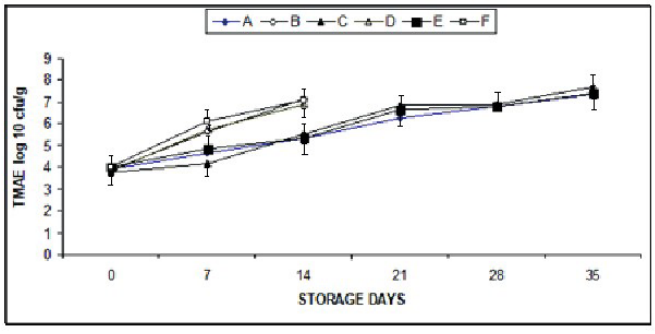

Figure 2. Changes in the counts of (log_{10} CFU/g) mesophilic aerob bacteria of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

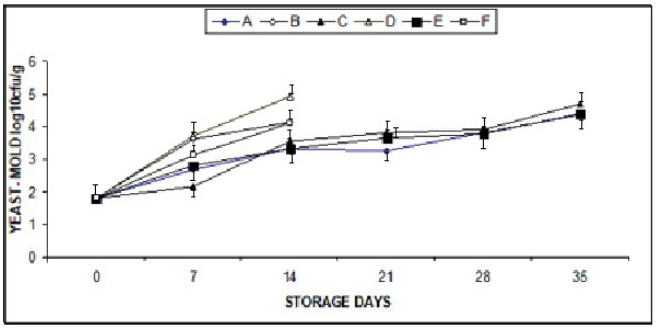

Figure 4. Changes in the counts of (log_{10} CFU/g) yeast-mold of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

in liquid smoked groups was lower than in non-smoked groups, but this difference is statistically significant has not been found.

S. aureus is a significant cause of food-borne disease. *S. aureus* can cause contamination of food products during food preparation and processing. *S. aureus* is one of the microorganisms known as the indicator of hygiene (Kadariya et al., 2014). According to the Turkish Food Codex Microbiological Criteria Communique (2009), the maximum acceptable concentration of *S. aureus* is 10^3 cfu/g. *S. aureus* did not exceed this limit during the study. The changes in the concentration of *S. aureus* during storage of samples were not significant. Therefore, the *S. aureus* (results not shown) were low in all samples.

E. coli naturally form part of the normal flora in the gut of humans and other animals. *E. coli* can cause severe illness (Yang et al., 2017). Therefore, *E. coli* must not be evident in any food and was not detected in this study.

Total volatile basic nitrogen (TVB-N) is often used as a biomarker of protein and amine degradation. TVB-N increases with storage and is aligned with other biomarkers of spoilage There are different recommendations of TVB-N limits for fish freshness (Bekhit et al., 2021). According to researchers the the acceptable TVB-N level is 35-40 mg N/100 g (Huss, 1995), 32-36 mg N/100 g (Varlik et al., 1993) and 35 mg N/100 g (Pastoriza et al., 1996). When TVB-N values were examined, it was determined that it increased during storage in all groups and this increase was statistically significant ($p < 0.05$). TVB-N value was determined as 8.32 ± 0.21 mg/100 g in all groups at the beginning of the storage period. It was determined as 33.7 ± 0.02 mg/100 g in group B and 35.1 ± 0.07 mg/100 g in group D and 34.2 ± 0.41 mg/100 g in group F on the 14th day in fish ball samples packed without vacuum. In vacuum packed samples (A, C and F), however, the value of 33 mg/100 g was exceeded on the 35th day of storage (Figure 5).

TBA is a commonly used parameter to determine the level of lipid oxidation (Yu et al., 2002). Acceptable limit value of TBA content is between 7-8 mg MDA/kg (Sinnuber & Yu, 1958). In this study; TBA value, which was around 3 mg MDA/kg in all fish ball samples at the beginning, increased with the storage time ($p < 0.05$), but it did not exceed the consumable limit value in any group (Figure 6). In many studies (Oksuztepe et al., 2010; Dikici et al., 2021), it has been observed that the TBA value does not exceed the limit value at the end of the storage period. The fact that the fish used as the material is freshwater fish and the low oil rate is among the reasons for this situation.

Data on sensory evaluation (The overall acceptability calculated was made up of: texture 40% and taste, odour, colour and appearance each at 15% (Dondero et al., 2004) are given in Figure 7. It was observed that the addition of liquid smoke increased the appreciation of the product, but it was found that there was no statistically significant effect on the storage time of the product ($p > 0.05$). It has been stated in some studies that liquid smoke application has positive effects on fish products (Alcicek, 2011; Zuraida et al., 2011; Özpolat, 2012; Faisal & Gani, 2018). In liquid smoke applications, concentration and duration are very effective on sensory taste (Faisal et al., 2019; Leviyani et al., 2019). For example, in a study on mackerel it

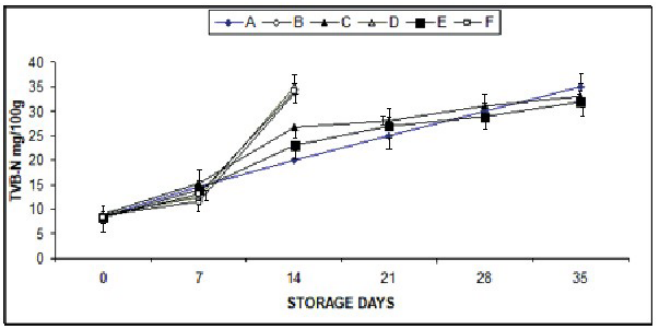

Figure 5. Changes in the TVB-N of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

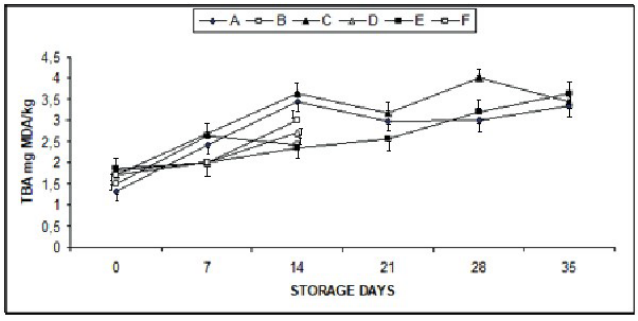

Figure 6. Changes in the TBA of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

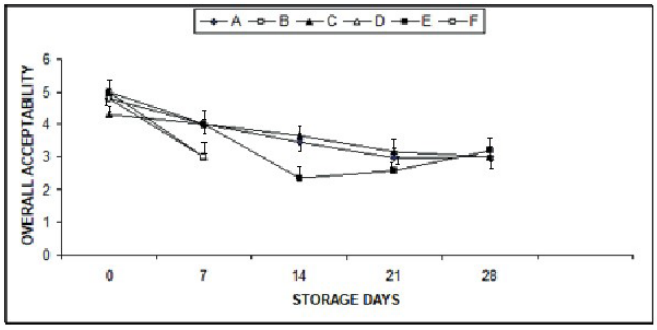

Figure 7. Changes in the sensory assessment of fish (*Capoeta trutta*) balls with different concentration of liquid smoke addition during storage at 4 ± 1 °C.

was reported that the best results were 3% and 42 h (Faisal et al., 2019). Samples that were not vacuum packed (B, D and F) showed sensory deterioration on the 14st day of storage, and those that were vacuum packed groups (A, C and E) on the 35nd day of storage, so they were not evaluated on this day. It has been determined that the shelf life of fish balls was extended by an average of two weeks with vacuum packaging. It has also been emphasized in some studies (Özpolat et al., 2014; Çoban et al., 2016) that vacuum packaging preserves the sensory properties of foods during storage.

4 Conclusion

According to the results obtained in the study, it was determined that *Capoeta trutta* can be evaluated as meatballs

and sensory evaluation was increased by adding liquid smoke. It has been determined that vacuum packaging has positive effects on the sensory, chemical and organoleptic properties of the product, thus extending the shelf life.

References

Al-Bulushi, I. M., Kasapis, S., Al-Oufi, H., & Al-Mamari, S. (2005). Evaluating the quality and storage stability of fish burgers during frozen storage. *Fisheries Science*, 71(3), 648-654. http://dx.doi.org/10.1111/j.1444-2906.2005.01011.x.

Alcicek, Z. (2011). Determination of shelf life and PAHs content of smoke anchovy (Engrualis encrasicolus, Linneeaus, 1758) nugget with different level liquid smoke flavours during chilled storage. *Journal of Animal and Veterinary Advances*, 10, 2691-2695.

Antonocopoulus, N. (1973). Bestmmung des fluchhtigen base nsticktoofs. In W. Ludorf & V. Meyer (Eds.), *Fische und fischerzeugnisse* (pp. 224-225). Berlin: Aulage Verlag Paul Parey.

Bekhit, A. A., Holman, B., Giteru, S., & Hopkins, D. (2021). Total volatile basic nitrogen (TVB-N) and its role in meat spoilage. *Trends in Food Science & Technology*, 109, 280-302. http://dx.doi.org/10.1016/j.tifs.2021.01.006.

Cicek, U., Karabıyıklı, Ş., Çabuk, D., İyiekmekçi, B., Kurbandurdiyev, H., & Cevahiroğlu, H. (2013). The effects of packaging methodologies and storage period on some physicochemical and microbiological properties of beef. *Journal of Agricultural Faculty of Gaziosmanpasa University*, 30(2), 62-70.

Çoban, O. E., Patir, B., Özpolat, E., & Kuzgun, N. K. (2016). Improving the quality of fresh rainbow trout by sage essential oil and packaging treatments. *Journal of Food Safety*, 36(3), 299-307. http://dx.doi.org/10.1111/jfs.12242.

Dikici, A., Özpolat, E., Bozatlı, S. B., Koluman, A., Patir, B., & Çalıcıoğlu, M. (2021). Investigating the effect of decontaminants on microbiological and chemical properties of rainbow trouts. *Turkish Journal of Veterinary and Animal Sciences*, 45(4), 691-699. http://dx.doi.org/10.3906/vet-2011-39.

Dondero, M., Cisternas, F., Carvajal, L., & Simpson, R. (2004). Changes in quality of vacuum-packed coldsmoked salmon (Salmo salar) as a function of storage temperature. *Food Chemistry*, 87(4), 543-550. http://dx.doi.org/10.1016/j.foodchem.2004.01.005.

Faisal, M., & Gani, A. (2018). The effectiveness of liquid smoke produced from palm kernel shells pyrolysis as a natural preservative in fish balls. *International Journal of Geomate*, 15(47), 145-150. http://dx.doi.org/10.21660/2018.47.06109.

Faisal, M., Utari, S., Hayvia, Z., & Mulana, F. (2019). A preliminary study of the utilization of CU(II) modified liquid smoke to inhibit the activity of white-rot fungi (Schizophyllum commune fr) in a pinewood in-vitro. *International Journal of GEOMATE*, 17(61), 56-61.

Goktan, D. (1990). *Gidalarin mikrobiyal ekolojisi* (Vol. 1). Izmir: Ege Universitesi Muhendislik Fakultesi.

Halkman, A. K. (2005). *Merck gida mikrobiyolojisi uygulamalari*. Ankara: Basak Matbaacilik.

Hattula, T., Elfving, K., Mroueh, U. M., & Luoma, T. (2001). Use of liquid smoke flavouring as an alternative to traditional flue gas smoking of rainbow trout fillets (Oncorhynchus mykiss). *Lebensmittel-Wissenschaft + Technologie*, 34(8), 521-525. http://dx.doi.org/10.1006/fstl.2001.0794.

Huss, H. H. (1995). *Quality and quality changes in fresh fish*. Rome: Food and Agriculture Organization of United Nations. FAO Technical Paper, no. 348.

International Commission on Microbiological Specifications for Foods – ICMSF. (1986). *Micro-organisms in food-2. Sampling for microbiological analysis: principles and specific applications*. Oxford: Blackwell Scientific Publications.

Jay, J. M. (1996). *Modern food microbiology*. New York: Chapman and Hall. Indicators of food microbial quality and safety, pp. 387-407.

Kadariya, J., Smith, T. C., & Thapaliya, D. (2014). Staphylococcus aureus and Staphylococcal food-borne disease: an ongoing challenge in public health. *BioMed Research International*, 2014, 827965. http://dx.doi.org/10.1155/2014/827965. PMid:24804250.

Keryanti, A. R., Permanasari, F., Yulistiani, R., Sihombing, P., & Wibisono, W. (2020). Applications of liquid smoke from biomass on food products: a review. *Advances in Engineering Research*, 198, 518-524. http://dx.doi.org/10.2991/aer.k.201221.086.

Kilinc, B., & Cakli, S. (2001). Packaging technics, the effects on microbial flora of fish and shellfish. *Ege Journal of Fisheries and Aquatic Sciences*, 18(1-2), 279-291.

Kolekar, A. D., & Pagarkar, A. U. (2013). Quality evaluation of ready-to-eat fish ball in curry. *SAARC Journal of Agriculture*, 11(1), 35-43. http://dx.doi.org/10.3329/sja.v11i1.18373.

Kolekar, A. D., Pagarkar, A. U., Kedar, J. C., Baug, T. E., & Bhatkar, V. R. (2012). Standardisation of recipe for fish ball in curry from Catlacatla. *Biosciences Biotechnology Research Asia*, 9(2), 831-835. http://dx.doi.org/10.13005/bbra/1072.

Kurtcan, U., & Gonul, M. (1987). Scoring method of sensory evaluation of foods. *Ege University Journal of the Faculty of Engineering*, 5, 137-146.

Leviyani, R. A., Kurniasih, R. A., & Swastawati, F. (2019). Application of liquid smoke for Chikuwa tilapia. *IOP Conference Series: Earth and Environmental Science*, 246, 012084. http://dx.doi.org/10.1088/1755-1315/246/1/012084.

Oksuztepe, G., Coban, O., & Güran, H. S. (2010). The effect of addition of sodium lactate in fish balls made from fresh rainbow trout (*Oncorhynchus mykiss* W.). *Kafkas University of Veterinary Faculty*, 16, 65-72.

Oxoid. (1982). *The Oxoid manual* (50th ed.). Hampshire: Oxoid Limited.

Özpolat, E. (2012). *Determination of shelf life for sausages produced from some freshwater fish with two different smoking methods* (PhD thesis). Fırat University, Elazığ.

Özpolat, E., & Patir, B. (2016). Determination of shelf life for sausages produced from some freshwater fish using two different smoking methods. *Journal of Food Safety*, 36(1), 69-76. http://dx.doi.org/10.1111/jfs.12214.

Özpolat, E., Patir, B., Guran, H. S., & Gul, M. R. (2014). Effect of vacuum-packing method on the shelf-life of Capoeta umbla sausages. *Iranian Journal of Fisheries Science*, 13(1), 178-184.

Pastoriza, L., Sampedro, G., Herrera, J. J., & Cabo, M. L. (1996). Effect of carbon dioxide atmosphere on microbial growth and quality of Salmon slices. *Journal of the Science of Food and Agriculture*, 72(3), 348-352. http://dx.doi.org/10.1002/(SICI)1097-0010(199611)72:3<348::AID-JSFA666>3.0.CO;2-O.

Sachindra, N. M., Sakhare, P. Z., Yashoda, K. P., & Rao, N. (2005). Microbial profile of buffalo sausage during processing and storage. *Food Control*, 16(1), 31-35. http://dx.doi.org/10.1016/j.foodcont.2003.11.002.

SAS Institute. (1999). *Version 6.1*. Cary: SAS Institute.

Sinnuber, R. O., & Yu, T. C. (1958). 2-Thiobarbituric acid method for the measurement of rancidity in fishery products. II. The quantitative determination of malonaldehyde. *Food Technology*, 12(2), 9-12.

Soldera, S., Sebastianutto, N., & Bortolomeazzi, R. (2008). Composition of phenolic compounds and antioxidant activity of commercial aqueous smoke flavorings. *Journal of Agricultural and Food Chemistry*, 56(8), 2727-2734. http://dx.doi.org/10.1021/jf072117d. PMid:18348527.

Tarladgis, B. G., Watts, B. M., Younathan, M. T., & Dugan, L. Jr. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. *Journal of the American Oil Chemists' Society*, 37(1), 44-48. http://dx.doi.org/10.1007/BF02630824.

Turkish Food Codex Microbiological Criteria Communique. (2009). Mikrobiyolojik kriterler tebligi. Teblig no. 2009/6. Degisiklik 2010/16. *Official Gazette of the Republic of Türkiye*.

Varlik, C., Ugur, M., Gokoglu, N., & Gun, H. (1993). *Su urunlerinde kalite kontrol ilke ve yontemleri* (No. 17). Istanbul: Gıda Teknolojisi Dernegi.

Yang, S. C., Lin, C. H., Aljuffali, I. A., & Fang, J. Y. (2017). Current pathogenic Escherichia coli foodborne outbreak cases and therapy development. *Archives of Microbiology*, 199(6), 811-825. http://dx.doi.org/10.1007/s00203-017-1393-y. PMid:28597303.

Yu, L., Scanlin, L., Wilson, J., & Schmidt, G. (2002). Rosemary extracts as inhibitors of lipidoxidation and color change in cooked turkey products during refrigerated storage. *Journal of Food Science*, 67(2), 582-585. http://dx.doi.org/10.1111/j.1365-2621.2002.tb10642.x.

Zuraida, I., Sukarno, S., & Budijanto, S. (2011). Antibacterial activity of coconut shell liquid smoke (CS-LS) and its application on fish ball preservation. *International Food Research Journal*, 18, 405-410.