Combined effect of sodium polyphosphate and smoking on quality parameters of fish (*Capoeta umbla*) sausage

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Abstract

Improving food quality is one the major issues for the food processing industry. Since food produced from fish spoils quickly, it obviously cannot be kept for an extended time. The aim of the present study was to determine the effects of sodium polyphosphate and smoking on the shelf life of fish sausage that was produced from *Capoeta umbla* and stored at 4±1°C. Therefore, we designed four groups: control group (A), which used neither sodium polyphosphate nor smoking; and treatment groups that used only sodium polyphosphate (group B), smoking (group C) and a combination of sodium polyphosphate and smoking (group D). The shelf life of fish sausage in each group was evaluated according to microbiological (total mesophilic and psychrotrophic bacteria, lactic acid bacteria, yeasts and molds), chemical (pH, thiobarbituoric acid and total volatile basic nitrogen) and sensory analysis. The shelf life of groups A, B, and C was determined as 42 days, while the shelf life of group D was 56 days. Thus, we found significant differences between group D and the other two treatment groups, B and C (p<0.05). The findings of the present study indicated that the combination of sodiumpolyphosphate+smoking showed a positive ability to extend the shelf life of fish sausage.

Keywords: Smoking, Sodium polyphosphate, Fish sausage, Shelf life

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Introduction

The seafood industry depends on the processing of a few popular fish species because of consumer choices. On the other hand, low-cost fish species constitute a massive potential food source that can be easily utilized for human usage by processing. However, the traditional food processing techniques such as canning and freezing have a limited usage for low-cost fish species; alternative techniques have achieved a bigger role to process these species. Low-cost fish processing techniques may be roughly grouped as flavourization, texturization, and extraction of edible components. For these processes, the meat from low-cost fish species is initially recovered by filleting or deboning, and then used for secondary product development. Also, some of these methods include surimi and surimi-based products, composite fillets and extruded/cooked products. For successful fish protein utilization in food, protein should ideally possess significant functional properties (Venugopal, 1997; Rustad, 2003; Yapar*et al.*, 2006).

Phosphate compounds have been used in fishery products to improve the functionality especially to increase the water holding capacity. Addition of phosphates to seafood products inhibits the growth of bacteria and reduces the oxidation of unsaturated fatty acids in seafood products (Kim *et al*., 1995; Masniyom *et al*., 2005; Etemadian *et al*., 2012). Phosphates are considered the most efficient additive for solubilising muscle proteins, which once solubilised can immobilise high levels of added water as well as emulsify high amounts of fat. Phosphates improve the stability of meat emulsions such as sausages. Moreover, the enhanced water holding capacity provided by phosphates reduces cooking losses and leads to increased yields, better texture and juicier products (Feiner 2006; Hurtado, 2012).

Smoking as a traditional preserving method is used for both fish and meat products, globally. Smoked products have characteristic flavor and color and also smoking has antimicrobial and antioxidant characteristics for the food (Koral *et al*., 2009).

The aim of this study was to determine the significance (if any) of using phosphate and smoking combination to improve the quality of fish sausage. For this, the combinative effects of sodium polyphosphate and smoking on the shelf life of *Capoeta umbla* sausage, microbiological, chemical and sensory changes throughout the storage in 4±1°C were monitored.

Materials and methods

Preparation of sausages

Capoeta umbla fish were purchased from a local market in Elazig, Turkey. Fish were placed in a box using a fish/ice ratio of 1:2 and transported to the laboratory, within 45 min. Fish were manually decapitated, eviscerated and washed, and then bone and skin

were removed. Fish fillets were minced using a meatgrinder. The sausages were prepared by minced fish meat (66.0%), soybean flour (2.54%), potato starch (2.74%), red pepper (0.11%), black pepper (0.2%), pimento (0.05%), coriander (0.13%), ginger (0.05%), sugar (0.15%), salt (2.0%), sodium nitrite (0.01%), ascorbic acid (0.02%), ice (18.0%) and fat (beef fat) (8.0%). The minced fish meat was mixed with all the other ingredients in a bowl cutter to obtain the sausage batter. The batter was then stuffed into natural casings (from sheep) with a diameter of 1.5 cm, by using manual filler. The stuffed sausages were linked to a length of 10 cm. The sausage of the control group was neither smoked nor was sodium polyphosphate added (A). To investigate the effect of smoking, the sausages of the first treatment group were smoked but sodium polyphosphate was not added (B), the sausages of the second treatment group had sodium polyphosphate added but not smoked (C). To study the combinative effect of sodium polyphosphate, the sausages of the third treatment group were both smoked and had sodium polyphosphate added (D). The ratio of the sodium polyphosphate was 0.25 % for B and D groups that were treated with sodium polyphosphate. Sausages were smoked at 75±3°C in a convection oven with an internal temperature of 71±3°C and held for 30 minutes. Smoke was produced from oak with combustion. After, all sausage groups were cooked at 85±3°C convection boiler with an internal temperature of 75±3°C and held for 10 minutes. Cooked sausages were immediately cooled in cold water (1:1, 6-7°C). Finally, all samples were vacuum packed (high barrier nylon polyethylene bags) and stored at 4±1°C. All samples were taken for microbiological, chemical and sensory analyses on different days (0^{h}, 7^{th}, 14^{th}, 21^{st}, 28^{th}, 42^{nd} and 56^{th} day) of the storage.

Microbiological analysis

The samples were analyzed for microbial profile using standard procedures (APHA, 1992; Halkman, 2005) for total mesophilic aerobic bacteria (TMAB) counts (30°C, 3 days) and total psychrotrophic aerobic bacteria (TPAB) counts (7°C, 10 days) on plate count agar (PCA), yeasts and molds on potato dextrose agar (PDA) (21°C, 5 days) and lactic acid bacteria on Man, Rogosa and Sharpe agar (MRS) (28°C, 2 days). Microbiological data were transformed into logarithms of the number of colony-forming units.

Chemical analysis

pH was measured by using standard methods, following AOAC (1990). Thiobarbituricacid (TBA) index was determined by a selective third-order derivative spectrophotometric method (Tarladgis *et al.*, 1960). TBA was expressed as mg of malondialdehyde (MDA)/kg for sausage samples. Determination of total volatile basic nitrogen (TVB-N) was based on the method of Varlik *et al*. (1993).

Sensory analysis

Six experienced panelists 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 and Gonul (1987). Panelists were asked to evaluate sample taste, odour, colour, appearance and texture on a 5 point hedonic scaler anging from very poor (1) to very good (5). The overall acceptability calculated was made up of: texture 40% and taste, odour, colour and appearance each at 15% (Dondero *et al*. 2004).

Statistical analysis

All experiments were replicated in triplicates. Each sample was analyzed three times and the mean calculated. Data were subjected to the analysis of variance (ANOVA). Statistical analysis was performed using the Statistical Analysis System (SAS, 1999) program. Turkey's honesty significant difference procedure was used to test for difference between means (p<0.05).

Results

Changes in microflora of *Capoeta umbla* sausages affected by smoked and phosphate pretreatment during storage are shown in Fig. 1.

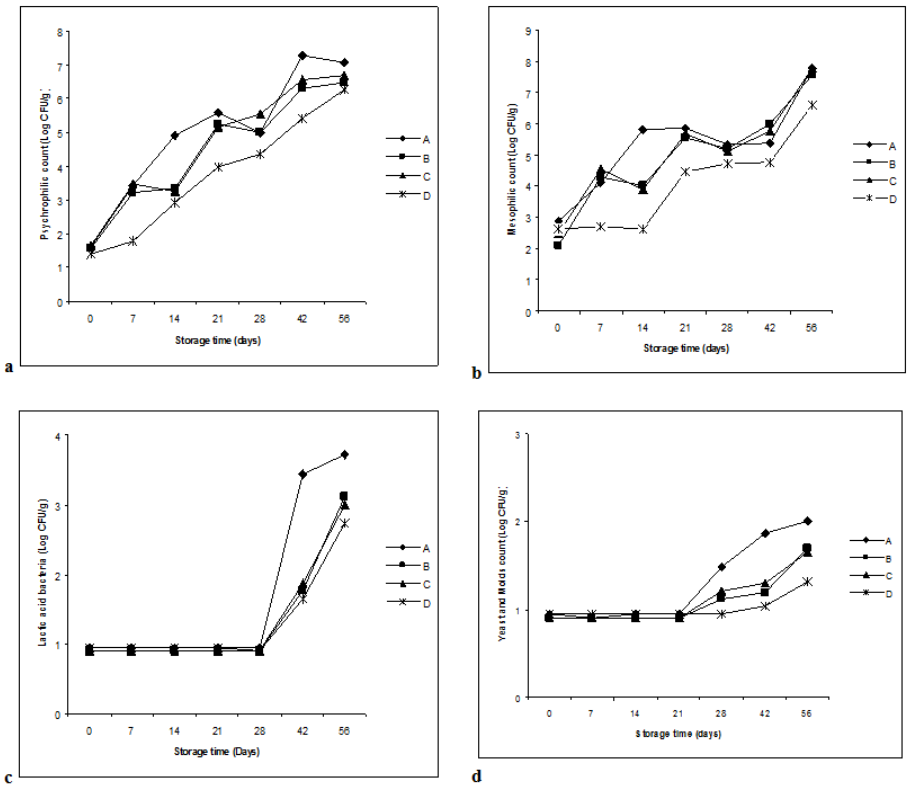

Figure 1: Changes psychrotrophic (a), mesophilic (b), lacticacid bacteria (c) and yeasts and molds counts (d) in *Capoeta umbla* sausages as affected by smoked and phosphate pretreatment during storage at 4±1°C: control (without sodium polyphosphate and smoked) A; nosmoked with sodium polyphosphate B; smoked without sodiumpolyphosphate C; with smoked and sodium polyphosphate D.

TMAB and TPAB counts of all samples increased in time of storage (p<0.05) (Fig. 1a, b). TMAB and TPAB counts in samples that were smoked and treated with polyphosphate were lower than those of other samples (p<0.05). Lactic acid bacteria counts were generally higher in samples after 28 days of storage (Fig. 1c) (p<0.05). Lactic acid bacteria counts in samples within the control group were higher than those of other groups. Yeasts and molds were higher in samples after 21 days of storage (Fig. 1d) (p<0.05). Yeasts and molds in samples within the control group were higher than those of the other groups.

The change in TVB-N, TBA and pH of fish affected by smoked and phosphate pretreatment during storage shown in Fig 2.

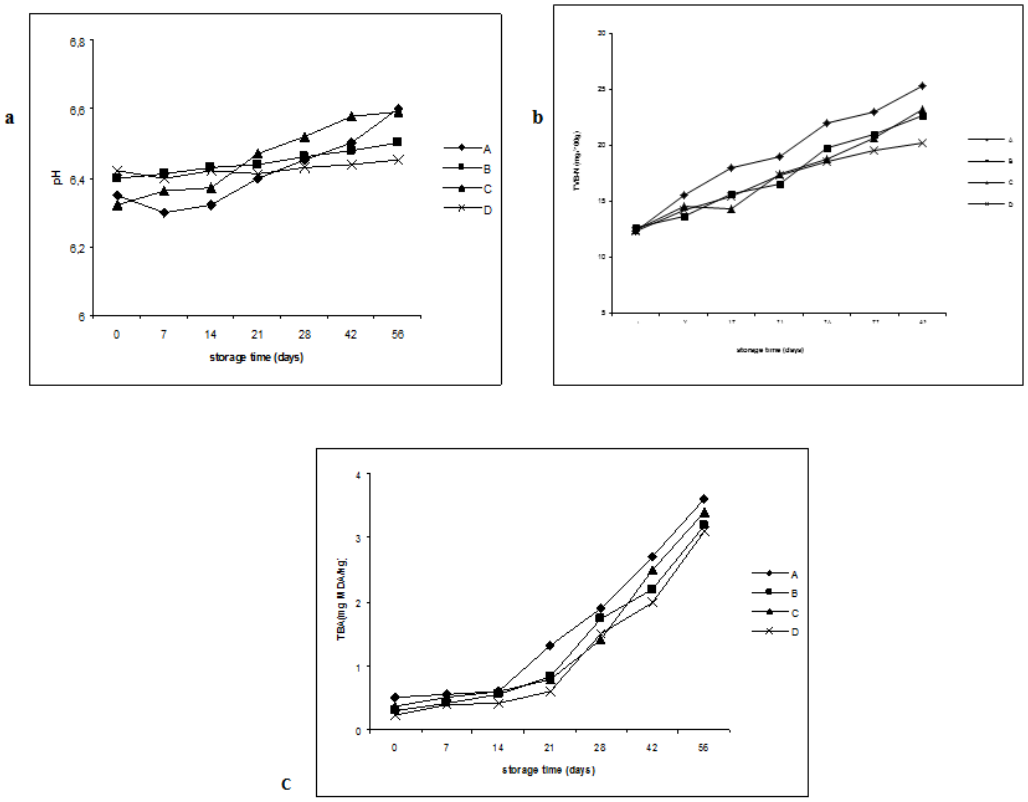

Figure 2: Changes pH (a), TVB-N (b), TBA (c) in *Capoeta umbla* sausages as affected by smoked and phosphate pretreatment during storage at 4±1°C: control (without sodium polyphosphate and smoked) A; smoked without sodium polyphosphate B; nosmoked with sodium polyphosphate C; with smoked and sodium polyphosphate D.

At the beginning of the storage, the TVB-N average value was 12mg/100g for fish sausages. The TVB-N increased up to 25.32±1.02 mg/100g for group A, 22.65±1.04 mg/100g for sausages in group B, 23.2±1.24 mg/100g for group C and 20.2±1.08 mg/100g for group D on the last day of sensory acceptability for each storage condition. The statistical analysis of the TVB-N data showed that significant differences (p<0.05) were found between smoked and phosphate pretreatment during storage. The TBA increased from an average of 0.5 on day 0 to an average of 3.5 on the 56th day for sausage samples in all group.

The pH value increased from an average of 6.3 on day 0 to an average of 6.5 on the last day of sensory acceptability for each storage condition.

Sensory quality of *Capoeta umbla* sausages were affected by smoking and phosphate pretreatment during storage (Fig. 3).

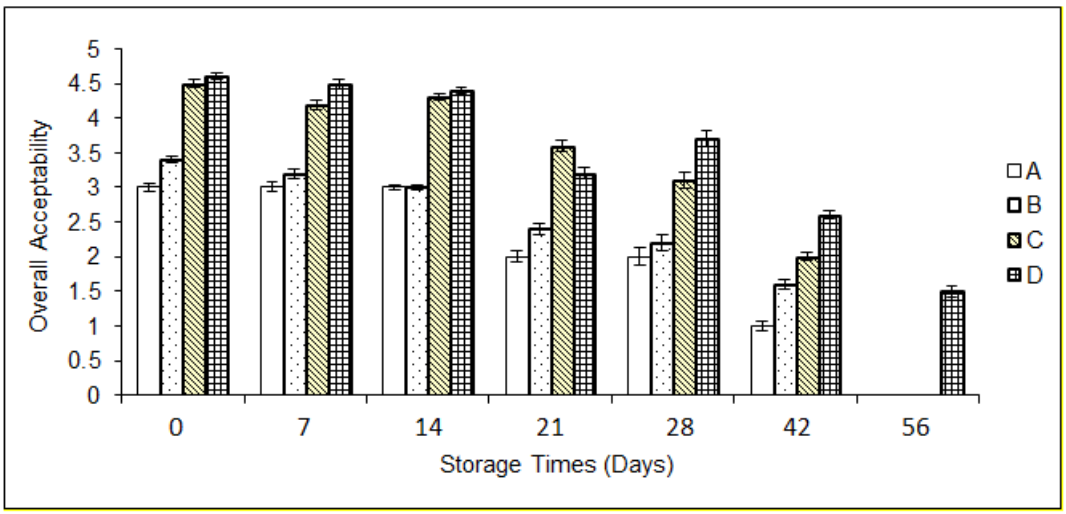

Figure 3: Changes sensory analysis in *Capoeta umbla* sausages as affected by smoked and phosphate pretreatment during storage at 4±1°C: control (without sodium polyphosphate and smoked) A; smoked without sodium polyphosphate B; nosmoked with sodium polyphosphate C; smoked and with sodium polyphosphate D.

Discussion

Microbiological assessment

Psychrotrophic and mesophilic bacterial counts of all samples increased with time of storage (p<0.05) (Fig. 1a, b). TMAB and TPAB counts in samples that were smoked and treated with polyphosphate were lower than those of other samples (p<0.05). Butsa (1985) reported that polyphosphate was more inhibiting toward microorganisms than tripolyphosphate or longer phosphates in a sausage. The effectiveness of phosphates as antimicrobial agents in meat products depends on the type of phosphate, the amount used, specific food product and conditions under which they are used (Sofos, 1986;

Masniyom *et al.*, 2005). 10^6 numbers/g was reported to be within the acceptable limit of TMAB bacteria for sausages (Adams *et al.*, 1987; Goktan, 1990). In the present study, the acceptable TMAB limit was exceeded in the control and groups A, B and C on the 42nd and in group D on 56th day.

Lactic acid bacterial counts were generally higher in samples after 28 days of storage (Fig. 1c) (p<0.05). Lactic acid bacteria counts in samples within the control group were higher than those of other samples. The lactic acid bacteria group is known to produce organic acids and ethanol as typical fermentation end products (Dondero *et al.*, 2004). Also, lactic acid bacterial counts in samples with sodium polyphosphate and smoking were lower than other samples (p<0.05).

The results revealed that phosphates and smoking inhibited the growth of lactic acid bacteria. Molins (1991) suggested that in general, Gram positive bacteria are more susceptible to inhibition by various polyphosphates than Gram negative bacteria. Polyphosphates may suppress the growth of bacteria by complexing metal ions essential for cell division (Davidson and Juneja, 1990; Masniyom *et al.*, 2005). The acceptable limit of lactic acid bacteria is 10^6 numbers/g (Baumgart, 1990). During the storage period, the number of lactic acid bacteria did not exceed the limit value.

Yeasts and molds were higher in samples after 21 days of storage (Fig. 1d) (p<0.05). Yeasts and molds in samples within the control group were higher than those of the other samples. According to the Turkish Food Codex (2009) the acceptable limit of yeasts and molds is 10^3cfu/g in food like sausage which is treated with heat. During the study period this value was not exceeded. Yeasts and molds were not considered to be of any importance for spoilage of the smoked product (Truelstrup *et al.*, 1996; Dondero *et al.*, 2004).

All bacterial counts in samples treated with both phosphate addition and smoking increased more slowly than those of other samples, which indicates that phosphates might show the synergistic effect on the retardation of bacterial growth in the smoked samples (p<0.05).

Chemical assessment

pH value of *Capoeta umbla* sausages was affected by smoking and phosphate pretreatment during storage (Fig. 2a). The initial pH of sausages was between 6.32 and 6.42. Phosphate addition significantly (p<0.05) affected pH of the sausages samples (B and D group sausages). Yapar *et al*. (2006) reported similar results in their study. During storage, pH of fish sausage increased throughout the storage time, presumably due to the production of basic amines (Debevere and Boskou, 1996).

TVB-N content of all samples are depicted in Fig. 2b. TVB-N usually includes trimethylamine and ammonia. TVB-N are products of bacterial

spoilage and the content is often used as an index to assess the keeping quality and shelf life of aquatic food products. TVB-N values of fresh and good quality fish are generally less than 0.12 mg/g. TVB-N values in the range of 0.20-0.25 mg/g and above 0.25 mg/g indicate that fish are slightly decomposed/edible and decomposed/inedible, respectively (Lannelongue *et al.*, 1982; Masniyom *et al.*, 2005). The TVB-N values for the initial storage of sausages groups were 13 mg/100g. The values of TVB-N increased during the storage period and exceeded the acceptable limit on the 56th day for all sausage groups (p<0.05).

TBA index is generally used as a measure of lipid oxidation, and results are presented in Fig. 2c. TBA values among treatments followed similar increasing trends with storage period, but values were all less than 0.4 (mg malonaldehyde/kg). Lin and Lin (2002) reported that no difference in TBA was noted at trisodium phosphate in low–fat Chinese sausages.

Sensory assessment

Sensory quality of *Capoeta umbla* sausages were affected by smoking and phosphate pretreatment during storage (Fig. 3). When sensory quality is considered, smoked sausages (C, D) gained a higher average score than sausages that were not smoked (A, B) (p<0.05). During storage, all sausage groups had decreased in sensory quality (p<0.05). The treatment group D that was treated with both smoking and sodium polyphosphate had the least decrease in sensory quality (p<0.05). It was reported that the traditional smoking increases the sensory quality and this quality decreases as the microbiological and chemical deterioration in sausages increases (Münker and Meyer, 1994; Kolsarıcı and Güven, 1998).

The shelf-life of groups A (neither smoked nor treated with sodium polyphosphate), B (smoked but not treated with sodium polyphosphate) and C (not smoked but treated with sodium polyphosphate) was 42 days, and group D (both smoked and treated with sodium polyphosphate) was 56 days according to the results of mesophilic bacteria count, total volatile base and sensory analysis. Moreover, it was found that the combined effect of smoking and sodium polyphosphate treatment had a synergistic effect on microbiological counts in sausage and more acceptable sensory results were obtained from sausages that were treated with smoke.

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