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The Effect of Storage Temperature on the Chemical and Sensorial Quality of Hot Smoked Atlantic Bonito (*Sarda sarda*, Bloch, 1838) Packed in Aluminium Foil

Serkan Koral[1,*], Sevim Köse[2], Bekir Tufan[2]

[1] Rize University, Faculty of Fisheries, 53100, Rize, Turkey.
[2] Karadeniz Technical University, Faculty of Marine Sciences, 61530 Sürmene, Trabzon, Turkey.

* Corresponding Author: Tel.: + 90 464 2233159 Fax: + 90 464 2234118;
E-mail: serkankoral@gmail.com

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Abstract

In this study, changes in chemical and sensorial quality of hot smoked Atlantic bonito (*Sarda sarda*, Bloch, 1838) during the storage at 4±1°C and 17±3°C were investigated. In addition, biochemical composition and yield after processing were determined. The values for moisture, crude protein, crude fat, ash and salt were found as 67.71, 14.55, 12.87, 1.76 and 0.70% for fresh bonito, while 57.13, 20.55, 13.97, 3.69 and 3.33% for smoked bonito, respectively. The yield after smoking was calculated as 78.02%. Total volatile basic nitrogen (TVB-N), thiobarbutiric acid (TBA) and total trimethlyamine (TMA) of smoked bonito increased significantly during storage at both temperatures while sensory scores decreased ($P<0.05$). According to sensory values, samples showed 4 days shelf life at 17±3°C and 10 days at 4±1°C. TVB-N values supported sensory analysis results and samples spoiled on 4th day of storage at 17±3°C temperature and 11th day of storage at cold storage conditions (4±1°C). TMA and TBA results were within the acceptable levels throughout the storage period for all analyzed samples. Therefore, TVB-N was found as a reliable parameter to measure chemical changes and determine quality of fish samples. This study shows that smoked bonito packed in aluminium foil can be stored at 4±1°C for 10 days.

Keywords: Hot smoking, bonito, quality changes, shelf life, aluminium foil.

Alüminyum Folyo İle Paketlenen Sıcak Tütsülenmiş Palamut Balıklarının Kimyasal ve Duyusal Kalitesine Depolama Sıcaklığının Etkisi

Özet

Bu çalışmada sıcak tütsülenen palamut balıklarının 4±1°C ve 17±3°C'de depolanmaları süresince kimyasal ve duyusal kalitesindeki değişimler araştırılmıştır. Ayrıca taze ve tütsülenmiş palamut balıklarının biyokimyasal kompozisyon ve randımanı da belirlenmiştir. Taze palamut balığında nem, ham protein, ham yağ, kül ve tuz değerleri sırası ile %67,71, 14,55, 12,87, 1,76, 0,70 bulunurken tütsülenmiş balıklarda ise bu değerler sırası ile %57,13, 20,55, 13,97, 3,69 ve 3,33 olarak bulunmuştur. Tütsülemeden sonraki randıman ise %78,02 olarak tespit edilmiştir. Her iki sıcaklıktaki depolama esnasında palamut balıklarına ait Total Volatil Bazik Azot (TVB-N), Tiyobarbütirik Asit (TBA) ve Trimetil Amin (TMA) değerlerindeki artışlar önemli bulunurken, duyusal puanlarda ise önemli düşüşler gözlenmiştir. ($P<0,05$). Duyusal analiz sonuçlarına göre 17±3°C'de depolanan örnekler 4 gün, 4±1°C'de depolananlar ise 10 günlük raf ömrüne sahip olmuştur. TVB-N analizine göre 17°C'de depolanan örnekler 4. günde bozulurken 4±1°C'de depolananlar ise 11. günde bozulmuş olup duyusal analizlerden elde edilen sonuçlar bu kritere göre elde edilen raf ömrü süresini desteklemiştir. Analiz edilen tüm örneklerdeki TMA ve TBA değerleri depolama süresince, kabul edilebilir limit değerleri altında kalmıştır. TVB-N kriterinin tütsülenmiş palamut balıklarının kalitesinin belirlenmesinde ve kimyasal değişimlerin ölçülmesinde güvenilir bir parametre olduğu belirlenmiştir. Bu çalışma, sıcak tütsülenmiş palamut balıklarının 4±1°C'de 10 gün boyunca depolanabileceğini göstermektedir.

Anahtar Kelimeler: sıcak tütsüleme, palamut, kalite değişimleri, raf ömrü, alüminyum folyo.

Introduction

Smoking is a traditional preserving method used for both fish and meat products around the world. Smoked fish products have wide acceptance today due to their accustomed taste and aroma as well as longer shelf life as a result of the combined effects of dehydration, antimicrobial and antioxidant activities of several smoke constituents mainly: formaldehyde, carboxylic acids and phenols (Doe, 1998). Salt also

provides additional preservative effect which comprises the first step of the fish smoking process. However, smoking is not an absolute preserving method. Several factors contribute to the quality and safety of such products. These factors are the quality of raw material, salt concentration used, water activity of the final product, heat through the smoking process, the quantity of smoke, packaging methods, hygienic circumstances and storage conditions (Frazier, 1967; Deng *et al*., 1974; Mills, 1978; Kaya and Erkoyuncu, 1999).

Bonito (*Sarda sarda* Bloch, 1838) used in this study is an important pelagic fish caught in the Black Sea region and other seas with high economic value (Akşiray, 1983). According to fisheries statistics of 2005, 70,797 tonnes of bonito were caught nation-wide in Turkey. Generally, it is sold freshly and frozen, processed by caning, curing or smoking (TUİK, 2005).

Varying studies were carried out on the quality changes of different types of smoked fish around the world (Buhiyan *et al*., 1986; Kaya and Erkoyuncu, 1999; Kolodziejska *et al*., 2002; Goulas and Kontominos, 2005; Yanar *et al*., 2006; Duyar *et al*., 2008; Koral *et al*., 2009). Smoked bonito exists commercially as vacuum packed or packed with other types of packaging materials or without packing at retail markets. However, packed and marketed fish in aluminium foil is not common in the world or in Turkey. Therefore, this study aimed at investigating the quality changes of smoked bonito packed in aluminium foil at two different temperatures.

Materials and Methods

Raw Material

Bonito (*Sarda sarda,* Bloch, 1838) samples were purchased from fish market in Trabzon, Turkey in September 2005. Totally eighteen fish samples weighing 10.5 kg in total were packed in polystyrene boxes equally with crushed ice and then transferred to the laboratory in forty minutes. The average length of the whole fish was 37.78±2.37 cm and average weight was 592.77±121.34 g.

Methods

Fish samples were gutted, washed and then separated into two groups after draining the excess water for 30 min. Both groups were brined and hot smoked, then one group of them (total amount 5.5 kg) was stored at 4±1°C (called as SBR), the other group (total amount 2.5 kg) was kept at 17±3°C (called as SBA).

Brining and Smoking Process

Each group of bonito was brined in 18% brine solution that was prepared from lake salt (Salina, Konya, Turkey) stored for 8 h in cold storage (4±1°C). The brine ratio was used as 1.5/1 (fish/brine, w/v). After salting, they were kept in chilled water for 10 min for homogen distribution of salt. After that, the water was drained for 30 min. before smoking. The fish samples were placed into smoking trays for further process.

Smoking process was modified from Anonymous (1987). Smoke was produced from beech sawdust. The kiln, made of chrome consisted of two parts as smoke unit and smoking and cooking unit with 10 kg capacity (Kermak, Trabzon, Turkey). Smoking was controlled by a heat resistance and humidity measuring systems placed on smoking and cooking units. Smoke was transferred to cooking unit using 13 cm (ø) pipe. The processing time in the kiln was divided into three stages: (1) preliminary drying period 20 min. at 30°C; (2) a smoking and partial cooking period 90 min. at 50°C; and (3) a cooking period 40 min. at 80°C. Total smoking process took 150 min. After cooking, fish samples were cooled at ambient temperature for 60 min. Each group was packed in aluminium foil since it was reported as a packaging material providing excellent protection from evaporation, loss of aroma and contamination (Anonymous, 1992). Such packing system is known to be used in packaging of wide range of fish and fisheries products. Then the samples were stored at 4±1°C and 17±3°C during the analyses.

Analysis

Moisture content was determined by oven drying of 5 g of fish muscle at 105°C until a constant weight was obtained (AOAC, 1995, Method 985.14). Results were expressed as g water/100 g muscle. Ash was determined by the AOAC (1980) Method 7.009. Crude fat content was determined using a solvent extractor Velp SER 148/6 (Velp Scientifica, Milano, Italy) with petroleum ether (130°C) and protein content was determined by AOAC (1980) Method 2.507. Mohr method was used to determine salt content (NaCl) in fish muscle as described in Keskin (1982). The method of Lücke and Geidel was used to determine TVB-N content as described by İnal (1992). TBA values, expressed in mg malonaldehyde/kg, were estimated by using the method of Tarladgis *et al*. (1960) described by Smith *et al*. (1992) and Varlık *et al*. (2003); the method of Boland and Paige (1971) was used for TMA analysis. All chemical and sensory analyses were carried out daily and chemical analyses were performed in triplicate. Sensory analyses were performed by using the methods of Amerina *et al*. (1965). Smoked fish samples were assessed on the basis of appearance, odour, taste and texture characteristics. Eight trained panellists judged the overall acceptability of the samples using ten point descriptive scales. A score of 10.0-9.0 indicated very good quality, 8.9-7.0 is good, 6.9-5.0 medium quality, 4.9-1.0 denoted as spoiled.

The data obtained were analyzed by analysis of variance (ANOVA) and when significant differences were found, comparisons among means were carried out by using Tukey test ($P<0.05$) by JMP 5.0.1 (SAS Institute. Inc. USA) (Sokal and Rohlf, 1987).

Results and Discussion

Table 1 demonstrates biochemical properties of smoked and unsmoked bonito samples. Statistical differences were obtained in biochemical values as well as spoilage parameters (TVB-N, TBA and TMA-N) ($P<0.05$). The differences could be attributed to the decrease in moisture content due to salting and smoking period. Similar observation was also found for hot smoked bonito by Kaya and Erkoyuncu (1999), Duyar *et al*. (2008) and for smoked mackerel by Bhuiyan *et al*. (1986). Cardinal *et al*. (2001) suggested moisture content of smoked fish below 65%. Our result for moisture content was 57.13% which was lower than suggested value. Goulas and Kontominos (2005) observed slightly higher moisture content as 58.1% for chum mackerel and Kolodziejska *et al*. (2002) also reported that moisture content of smoked mackerel was 56.7%.

Yield after cleaning, salting and smoking was found as 78.02%. Duyar *et al*. (2008) reported that yield of hot smoked bonito was 76.17% which was the same as the value for smoked eel observed by Ünlüsayın *et al*. (2001), but higher than values for smoked rainbow trout, pike perch reported by the same authors and found in our earlier study for anchovies (Koral and Köse, 2005), as 75.0%, 65.0% and 51.5%, respectively.

Table 2 demonstrates the quality changes of smoked bonito packed in aluminium foil and stored at 4±1°C and 17±3°C. The samples were analyzed until the day when they spoilt according to TVB-N a value and then for analysis, samples were stored for two more following days. Therefore, all parameters were evaluated for 13 days for samples stored at 4±1°C (SBR) and for 6 days for samples stored at 17±3°C (SBA).

Different TVB-N values were for the freshness of fish and fish products are suggested in literature; however, maximum limit 35 mg/100 g is generally

Table 1. Biochemical composition of smoked and raw bonito samples

Parameters	Raw fish	Smoked fish
Moisture %	67.71±0.40[a]	57.13±0.15[b]
Crude fat %	12.87 ±0.32[a]	13.97 ± 0.53[b]
Ash %	1.76±0.15[a]	3.69±0.80[b]
Crude protein %	14.55±0.69[a]	20.55±0.99[b]
Salt %	0.70±0.03[a]	3.33±0.18[b]
TVB-N mg/100 g	11.58±0.32[a]	13.13±0.50[b]
TBA mg malonaldehyde/kg	0.365±0.005[a]	0.385±0.005[b]
TMA-N mg/100 g	2.35±0.015[a]	2.90±0.03[b]

(n: 3±SD).
The different letters (a, b) in the same line represents statistical differences for the relating parameters between two groups ($P<0.05$).

Table 2. The changes in TVB-N, TBA, TMA-N values of smoked bonito packed in aluminium foil and stored at 4±1°C (SBR) and 17±3°C (SBA)

Days	TVB-N (mg /100 g)		TBA (mg malonaldehyde/kg)		TMA-N (mg/100g)	
	SBR	SBA	SBR	SBA	SBR	SBA
1	14.00±0.00[a]	16.11±1.00[b]	0.42±0.04[a]	1.42±0.24[b]	2.96±0.08[a]	3.20±0.04[b]
2	14.70±0.70[a]	21.36±0.15[b]	0.49±0.09[a]	1.82±0.14[b]	3.18±0.01[a]	4.32±0.23[b]
3	16.11±0.10[a]	27.32±0.00[b]	0.59±0.02[a]	2.40±0.02[b]	3.65±0.13[a]	5.65±0.28[b]
4	17.51±1.00[a]	35.37±1.25[b]	0.60±0.07[a]	3.01±0.04[b]	4.04±0.04[a]	8.84±.0.01[b]
5	19.61±0.00[a]	41.67±0.35[b]	0.78±0.02[a]	4.13±0.01[b]	4.32±0.19[a]	11.01±0.99[b]
6	21.71±1.40[a]	48.32±0.80[b]	0.88±0.04[a]	5.55±0.49[b]	4.86±0.03[a]	12.69±0.06[b]
7	23.81±0.81	-	0.95±0.07	-	5.44±0.40	-
8	26.26±1.05	-	1.00±0.03	-	6.26±0.12	-
9	28.46±1.45	-	1.08±0.01	-	8.30±0.01	-
10	31.52±1.40	-	1.18±0.07	-	9.10±0.09	-
11	35.32±0.30	-	1.26±0.02	-	9.69±0.08	-
12	37.82±0.00	-	1.37±0.17	-	10.37±0.21	-
13	41.82±1.20	-	1.50±0.03	-	11.19±0.11	-

Each value represents triplicated results, ± SD, (-) means samples were not analysed for the relating parameter.
SBR: Smoked bonito stored at 4±1°C, SBA: Smoked bonito stored at 17±3°C.
Different letters (a, b) represents statistical differences between two groups (stored at different temperatures) ($P<0.05$).

acceptable (Connell, 1990; Lopez-Caballero *et al*., 2000; Kim *et al*., 2002; Huss, 1988). Unprocessed fresh bonito contained 11.58 mg/100 g TVB-N, after smoking, the value increased to 13.13 mg/100 g. TVB-N values increased significantly at both temperature for smoked products ($P<0.05$). According to TVB-N values, products stored at 17±3°C spoiled at 4th day with a value of 35.37 mg/100g. TVB-N values of samples stored at 4±1°C were just over the maximum value at 11th day as 35.32 mg/100 g. Kaya and Erkoyuncu (1999) observed 35.5 mg/100 g TVB-N for smoked bonito stored at ambient temperature on the 4th day which agreed with our results. They observed 32.9 mg/100 g TVB-N for their smoked bonito samples stored at refrigerator on the 13th day. Therefore, packing in aluminium foil had no improvement in terms of quality relating to TVB-N values. In our earlier study, hot smoked anchovies packed in aluminium foil spoilt on the 9th day according to TVB-N values at 4±1°C despite 4 days sensory shelf life (Koral and Köse, 2005).

TMA-N is used to determine the quality of products and the maximum allowed level is accepted as <10–15 mg/100 g (Varlık *et al*., 1993). TMA value of fresh bonito was found as 2.35 mg/100 g, after smoking the value increased to 2.90 mg/100 g. The amount of TMA-N increased significantly during the storage at both temperatures. TMA-N values did agree with TVB-N results for the accepted quality criteria. For all analyzed samples stored at both temperatures, TMA values were within the acceptable levels. Goulas and Kontominos (2005) found that vacuum packed smoked chum mackerel had very low levels of TMA around 3.64 mg/100 g at 2.0±0.5 °C on 30th day.

One of the other quality parameters is known as TBA and maximum allowed level is accepted as 8 mg malonaldehyde/kg (Schormüller, 1969). Fresh fish and smoked fish contained 0.365 and 0.385 mg malonaldehyde/kg, respectively. The values increased significantly for the samples stored at both temperatures ($P<0.05$) although samples were within acceptable levels for this parameters. Similar findings were observed by Göktepe and Moody (1998), Beltran and Moral (1989), Yanar (2007), and Goulas and Kontominos (2005) for different smoked fish products. The highest value was found as 1.5 mg malonaldehyde/kg for 4±1°C cold storage on the 13th day and 5.55 mg malonaldehyde/kg for 17±3 °C on the 6th day.

Figure 1 represents overall sensory values (appearance, texture, odour and taste). Sensory test results showed that shelf life of samples were 4 days at 17±3°C while it was 10 days at 4±1°C. TVB-N values closely supported the sensory test results. Therefore, TVB-N can be accepted as reliable quality parameter for smoked samples. Hot smoked bonito packed in aluminium foil had an extended shelf life at 4±1°C compared to 17±3°C temperature according to both sensory and chemical analysis results as expected.

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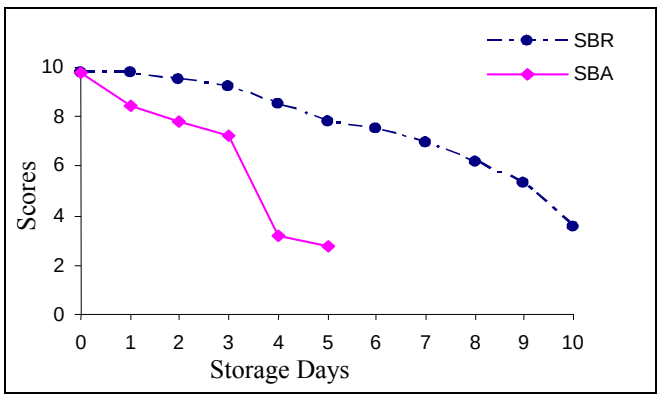

Figure 1. Overall sensory results of smoked bonito in aluminium foil stored at 4±1°C (SBR) and 17±3°C (SBA).

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