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Investigating the Quality Changes of Raw and Hot Smoked Garfish (*Belone belone euxini*, Günther, 1866) at Ambient and Refrigerated Temperatures

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Abstract

The objective of this study is to determine quality changes and shelf life of hot-smoked garfish (*Belone belone euxini*, Günther, 1866) in terms of chemical and sensory analyses at refrigerated and ambient conditions. For this purpose, total volatile basic nitrogen (TVB-N), thiobarbituric acid (TBA), trimethylamine (TMA) and sensory analyses were carried out daily during storage period. Proximate composition of raw and smoked garfish and the percentage of yield for smoking process were also determined. Unsmoked fish samples were used as control groups. According to TVB-N results, the samples of control groups, spoilt on the 3rd and 6th days at ambient and refrigerated temperatures, respectively. Whereas the smoked samples stored ambient and refrigerated temperatures, spoiled on 9th and the 25th days, respectively. TMA and TBA results did not support these results and values were still found within acceptable range on the mentioned days. According to sensory analyses, the smoked samples had shelf-life for one week at ambient temperatures and three weeks for refrigerated storage conditions.

Keywords: garfish, hot smoking, quality changes, ambient temperatures, refrigerated temperatures.

Introduction

Smoking is a traditional method used to preserve fish in the world, although today, its acceptance in developed countries is primarily based upon the sensory characteristics it imparts to the product. Furthermore, smoking increases the shelf life of fish as a result of the combined effect of dehydration, antimicrobial and antioxidant activities of several smoke constituents mainly: formaldehyde, carboxylic acids and phenols (Doe, 1998). An additional preservative effect is owed to salting which comprises the first step of the fish smoking process. However, smoking is not an absolute preserving method. For this reason, the quality of raw material, the concentration of salt, water activity of the fish, heat through the smoking process, the quantity of smoke, the way of packaging, hygienic circumstances and heat of storage have the most important effects to reduce the risk of deterioration (Kaya and Erkoyuncu, 1999). Garfish (*Belone belone euxini*, Günther, 1866) used in the present study, is an important pelagic fish caught in the Black sea region (Zaitsev and Mamaev, 1997). According to fisheries statistics of 2005, 577 tonnes of garfish was caught nation-wide in Turkey and almost all of them was consumed freshly (TURKSTAT, 2005). In literature, there is almost no research on garfish processing, especially on hot smoked garfish and its quality changes during storage. Therefore, the purpose of this study was to investigate the quality changes of hot smoked garfish at ambient and cold storage conditions.

Materials and Methods

Raw Material

Garfish (*Belone belone euxini*, Günther, 1866) were purchased from fish market in Trabzon, Turkey in December 2005. Hundred and fifty fresh fish samples were packed in five polystyrene boxes equally with crushed ice and then transferred to the laboratory in forty minutes. The average weight of the whole fish was 158.44±14.55 g and average length was 39.72±5.71 cm.

Methods

Fish were gutted, washed and then separated into four groups. Each group was packed in aluminum foil since it was reported as providing excellent protection from evaporation, loss of aroma and contamination. Such packing system is known to be used in packaging of wide range of fish and fisheries products (Anonymous, 1992). Two of these groups were brined, and hot smoked, then one of them was stored under refrigerated condition (4°C) (SSR), the other was kept under ambient condition (17±3°C) (SSA). The other two groups were unsalted, non-smoked and used as control groups. One of them was stored under refrigerated conditions (USNSR) and the other was kept under ambient (USNSA).

Brining and Smoking Process

Fish were brined in solution of 10% NaCl under

refrigerated conditions for 3 h, the ratio of brine and fish 1:1.5 (w/w). 10% salt was chosen for brining after our earlier preliminary sensory studies with smoked garfish (brined salt concentration as 5, 8, 10, 15%) showed most liked products according to taste values of 33 panelists (unpublished results). The unsalted fish were used as control groups and kept under refrigerated and ambient conditions after being washed. Smoke was produced from beech sawdust. The kiln made of chrome contained two parts as smoke unit and smoking and cooking unit with 10 kg capacity (made by Kermak, Trabzon, Turkey). Smoking was controlled by a heat resistance and humidity measuring system placed on smoking and cooking unit. Smoke was transferred to cooking unit by 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 (40 min) at 50°C; and (3) a cooking period (40 min) at 80°C. After cooking, fish were cooled at ambient temperature for 30 min and packed in aluminum foil and then stored under refrigerator (4°C) and ambient (17±3°C) conditions during the analysis period.

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 are expressed as g water/100 g muscle. Ash was determined by the AOAC (1980) Method 7.009. Lipid 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). 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 were assessed on the basis of appearance, odour, taste and texture characteristics. Eight trained panelists judged the overall acceptability of the samples using nine point descriptive scale. A score of 9-7 indicated very good quality, a score of 6.9-4 good quality, a score of 3.9-1 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 shows the percentage of proximate composition (w/w) and chemical analyses of raw and smoked garfish before storage. In the corresponding smoked garfish, the percentage of total protein, lipid and ash contents increased due to water loss during smoking. Similar findings were reported by Aminullah Bhuiyan *et al*. (1986) in Atlantic mackerel and Ünlüsayın *et al*. (2001) in European eel, pike perch and rainbow trout. The proximate composition data for raw garfish also agreed well with data presented by Vlieg (1998) for moisture, protein, ash content of New Zeland garfish. Industrial specifications for ‘‘smoked finished products’’ generally is recommended a water content in the fish flesh of less than 65% (Cardinal *et al*., 2001). Goulas and Kontominos (2005) reported that the moisture contents of smoked chum mackerel samples were 58.1 and 59%. Kolodziejska *et al*. (2002) also reported that moisture content of smoked mackerel was 56.7%. This is in agreement with our result of 60.5% moisture content.

Table 2 shows the percentage of yield after gutted and smoking processing steps. As a result of gutting and smoking, the percentage of yield was calculated as 60.1%. Koral and Köse (2005) found that the yield of smoked anchovy was 51.5%. Furthermore, Ünlüsayın *et al*. (2001) reported that yields of the smoked eel, rainbow trout and pike perch

Table 1. Proximate composition (w/w %) and chemical analyses* of raw and smoked garfish before storage trials

Sample component	Raw garfish	Smoked garfish
Water	72.05±0.47[a]	60.56±0.09[b]
Lipid	2.96±0.32[a]	5.08±0.53[b]
Ash	2.37±0.19[a]	4.02±0.32[b]
Protein	21.53±0.33[a]	26.29±0.42[b]
Salt	1.05±0.08[a]	4.01±0.09[b]
TVB-N (Total volatile basic nitrogen)	9.81±0.12[a]	10.48±0.07[b]
TBA (Thiobarbituric acid)	0.66±0.04[a]	0.84±0.04[b]
TMA (Trimethylamine)	0.98±0.03 [a]	1.22±0.03 [b]

*Results are mean values of three replicates ±SE

a-b Values in the same line followed by different letter are significantly different ($p<0.05$)

Table 2. Percentage of yield smoked garfish

Processing steps	Rate (%)
Yield control group (1000 g)	100
Waste of after gutting (284 g)	28.4
Loss after smoking (116 g)	11.6
Final yield (601 g) for smoked fish	60.1

were 78, 75 and 65%, respectively. The TVB-N value of raw garfish sample was measured as 9.81±0.12 mg/100 g (Table 3). This is a freshness indicator of raw fish material. This value is in good agreement with that of Metin *et al*. (2001), who reported that the initial TVB-N content in raw chub mackerel was 9.96 mg /100 g and similar TVB-N value was also reported for fresh hake 10.44 mg N/100 g (Ruiz-Capillas *et al*., 2001). As expected, a significant increase of TVB-N values (10.48±0.07 mg/100 g) was observed in the smoked garfish ($P<0.05$). An increase of TVB-N after smoking was most likely caused by an autolytic process which produces volatile amine compounds and bacterial spoilage. Various authors have reported different acceptability levels for TVB-N value: 35–40 mg /100 g (Connell, 1990); 25–30 mg /100 g (Lopez-Caballero *et al*., 2000); 20–25 mg/100 g (Kim *et al*., 2002); 35 mg/100g (Huss, 1988). Such differences reflect different products, specific treatments and processing conditions. Whereas the value of TVB-N in the USNSA group was 36.67 mg/100g on the 3rd day, this value for SSA group was found 26.96 mg/100 g on the same day, then reached to 38.87 mg/100 g on the 9th day. While it was found as 38.87 mg/100 g for the USNSR group on the 6th, it was only 15.06 mg/100g for the SSR group for the same day. At the end of storage period (25th day), this value for the SSR group was determined as 37.47 mg/100g. Yanar (2007) reported that the TVB-N value of fresh catfish was 15.47 mg/100g and initial TVB-N value of hot smoked catfish was 17.67 mg/100 g, and this value increased to 29.16 mg/100 g during refrigerated storage of 24 days. Kolsarici and Özkaya (1998) reported that the initial TVB-N value of hot smoked rainbow trout was 18.55 mg/100 g, and this value increased to 32.72 mg/100 g during refrigerated storage of 48 days.

TBA values represent the degree of the rancidity in the products and fresh fish is much lower than the acceptable upper limits of 8 mg malonaldehyde/kg (Schormüller, 1969). The TBA value of raw garfish samples was measured as 0.66±0.04 mg malondialdehyde/kg. During hot smoking, fish were exposed to heating and atmospheric oxygen. These factors can accelerate the oxidation of fish lipids, resulting in the increase of TBA. The significant increase ($P<0.05$) of TBA values (0.84±0.04 mg malondialdehyde/kg) was observed in the smoked garfish (Table 3). This observation is in agreement with results reported by Göktepe and Moody (1998), Beltran and Moral (1989), Yanar (2007), and Goulas and Kontominos (2005). Whereas TBA value for the USNSA was found as 5.20 mg malonaldehyde/kg on the 4th day. This value for the SSA was 2.14 mg malonaldehyde/kg on the same day. While TBA value for the USNSR group was 4.78 mg malonaldehyde/kg on the 6th day, it reached to 1.29 mg malonaldehyde/kg for the SSR group on the relating day. At the end of storage period, this value for SSR samples was determined as 2.98 mg malonaldehyde/kg. This value did not exceed the value of 3–4 mg malondialdehyde/kg, which is usually regarded as the good quality limit (Schormüller, 1969). Similar results were reported by Cuppet *et al*. (1989), Yanar (2007), and Goulas and Kontominos, (2005).

Trimethylamine is generally present in sea water fish and product of decomposition of Trimethylamine oxide (TMAO) used for assessment of fish quality, commonly as an indicator for fish quality. It is reported that 10–15 mg TMA-N/100 g is usually regarded as the upper limit of acceptability for human consumption (Huss, 1988). The TMA content of raw garfish was 0.98±0.03 mg/100 g, as the freshness indicator of the samples (Table 3). According to Connell (1990), a value of 15 mg /100 g of product has been recommended as an upper limit for very good quality cod. However TMA content depends on species, muscle type and diet of fish. Initial TMA content for smoked garfish samples was measured 1.22±0.03 mg/100 g which agreed with data presented for TMA value of chum mackerel by Goulas and Kontominos (2005). TMA value for the USNSA group was 12.47 mg/100 g on the 4th day, but it was found as 4.67 mg/100 g for the SSA samples. TMA value for the USNSR group was 8.40 mg/100 g on 6th day, while it was 2.10 for the SSR samples on the same day. At the end of storage period, this value for the SSR samples was determined as 13.07 mg/100 g and it did not exceed the limit values.

The sensory attributes of quality and the shelf-life of smoked fish are mainly affected by the initial microbial contamination, processing conditions, handling of the product after processing, and storage temperature (Shiau and Chai, 1985; Scott *et al*., 1986; Eyabi- Eyabi *et al*., 1988; Dodds *et al*., 1992; Sikorski *et al*., 1998). The results of the sensory evaluation of smoked samples (SSR, SSA) are given in Figure 1. The overall acceptability scores decreased while storage times increased for both groups. After the 5th day, the difference between the given scores (appearance, odour, taste and texture characteristics) for both groups was found significant ($P<0.05$). The scores of SSR samples were found to be below 4 (spoiled) on the 22nd day, and SSA samples spoiled (3.9-1) on the 8th day. The SSR samples had 'very good' (9-7) quality up to 12 days and 3 days for SSA samples. According to sensory analysis, smoked and refrigerated anchovy samples were unfit for human consumption at on the 11th day reported by Koral and

Table 3. TVB-N, TBA, TMA contents♠ of smoked and control groups of garfish during refrigerated (4°C) and ambient (17±3°C) storage temperatures

Days	TVB-N (mg /100 g)				TBA (mg malondialdehyde/kg)				TMA (mg /100 g)			
	SSR	USNSR	SSA	USNSA	SSR	USNSR	SSA	USNSA	SSR	USNSR	SSA	USNSA
1	11.21±0.40 [a]	14.71±0.25[b]	17.86±0.08[c]	19.61±0.08[d]	0.90±0.02[a]	1.27±0.05[b]	1.27±0.03[b]	1.42±0.05[c]	1.37±0.02[a]	1.70±0.05[b]	1.68±0.02[b]	2.92±0.03[c]
2	12.26±0.35 [a]	21.36±0.85[b]	22.06±0.20[b]	28.37±0.25[c]	0.95±0.03[a]	1.68±0.03[b]	1.56±0.02[b]	2.83±0.09[c]	1.50±0.03[a]	2.14±0.02[c]	1.82±0.07[b]	5.29±0.06[d]
3	13.66±1.05 [a]	24.86±0.70[b]	24.51±0.70[b]	36.67±0.70[c]	1.03±0.02[a]	2.13±0.02[c]	1.85±0.02[b]	3.53±0.04[d]	1.62±0.06[a]	2.88±0.01[b]	3.15±0.03[c]	8.92±0.05[d]
4	14.36±0.35 [a]	30.47±0.35[c]	26.96±0.95[b]	43.27±0.15[d]	1.09±0.04[a]	2.69±0.03[c]	2.14±0.03[b]	5.20±0.03[d]	1.80±0.05[a]	3.80±0.06[b]	4.67±0.06[c]	12.47±0.06 [d]
5	14.71±0.70 [a]	34.32±0.10[c]	29.77±0.35[b]	*	1.16±0.05[a]	3.12±0.03[c]	2.44±0.04[b]	*	1.95±0.03[a]	5.61±0.04[b]	6.22±0.05[c]	*
6	15.06±1.05 [a]	38.87±0.08[c]	31.52±0.70[b]	*	1.29±0.03[a]	4.78±0.05[c]	3.07±0.03[b]	*	2.10±0.02[a]	8.40±0.03 [b]	8.48±0.08[b]	*
7	15.76±1.05 [a]	*	33.27±0.30[b]	*	1.37±0.02[a]	*	3.73±0.04[b]	*	2.20±0.03[a]	*	10.42±0.51[b]	*
8	17.16±0.35 [a]	*	34.67±0.42[b]	*	1.48±0.02[a]	*	4.20±0.02[b]	*	2.39±0.02[a]	*	14.72±0.05[b]	*
9	17.86±0.35 [a]	*	38.87±1.02[b]	*	1.59±0.01[a]	*	5.16±0.04[b]	*	2.50±0.03[a]	*	18.90±0.01[b]	*
10	18.56±0.35	*	*	*	1.67±0.03	*	*	*	2.69±0.08	*	*	*
11	18.91±0.00	*	*	*	1.75±0.02	*	*	*	2.90±0.04	*	*	*
12	19.96±0.35	*	*	*	1.83±0.04	*	*	*	3.05±0.08	*	*	*
13	21.36±0.35	*	*	*	1.96±0.02	*	*	*	3.29±0.04	*	*	*
14	22.06±1.05	*	*	*	2.05±0.02	*	*	*	3.62±0.06	*	*	*
15	22.56±0.35	*	*	*	2.11±0.06	*	*	*	3.85±0.03	*	*	*
16	23.46±1.05	*	*	*	2.17±0.02	*	*	*	4.08±0.05	*	*	*
17	24.51±0.70	*	*	*	2.25±0.03	*	*	*	4.50±0.07	*	*	*
18	25.21±0.70	*	*	*	2.31±0.02	*	*	*	4.78±0.05	*	*	*
19	26.62±0.00	*	*	*	2.47±0.02	*	*	*	5.53±0.09	*	*	*
20	28.02±0.70	*	*	*	2.58±0.03	*	*	*	6.44±0.12	*	*	*
21	29.77±0.35	*	*	*	2.66±0.03	*	*	*	8.33±0.11	*	*	*
22	30.47±0.35	*	*	*	2.74±0.04	*	*	*	9.49±0.06	*	*	*
23	32.22±0.00	*	*	*	2.82±0.03	*	*	*	10.85±0.13	*	*	*
24	34.32±0.70	*	*	*	2.90±0.02	*	*	*	11.91±0.06	*	*	*
25	37.47±0.35	*	*	*	2.98±0.05	*	*	*	13.07±0.04	*	*	*

SSR (salted, smoked and stored at refrigerator conditions),
USNSR (unsalted, non-smoked and stored at refrigerator conditions),
SSA (salted, smoked and stored at ambient conditions),
USNSA (unsalted, un-smoked and stored ambient conditions)
a,b,c,d Values in the same line (same analysis type) followed by different letter are significantly different ($p < 0.05$).
♠Values represent the mean of three determinations (n:3) ± SE,* Not analyzed

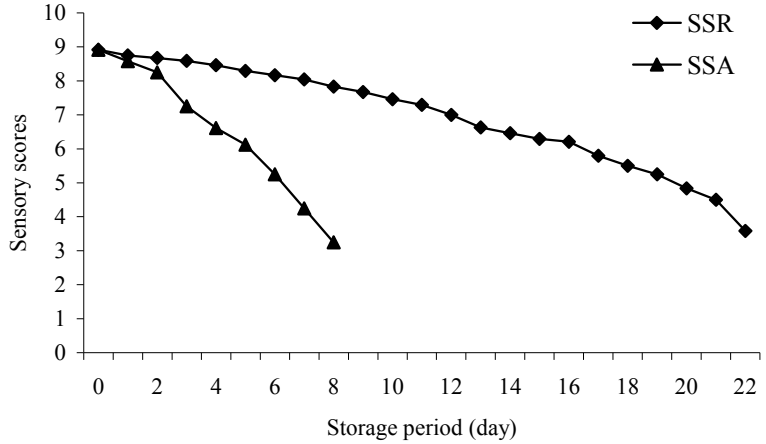

Figure 1. Sensory scores of SSR (salted, smoked and stored at refrigerator (4°C) conditions) and SSA (salted, smoked and stored at ambient (17±3°C) conditions) samples during storage.

Kose (2005). Yanar (2007) reported that catfish samples smoked and stored in refrigerator (4°C) were unfit for human consumption on the 24th day. Hot smoked mackerel stored at 2 and 8°C became unfit for human consumption on the 24th day of storage (Kolodziejska *et al*., 2002).

Conclusion

Quality changes of raw and hot smoked garfish were studied during the storage for 25 days. TVB-N, TBA, TMA values increased during storage. According to TVB-N from chemical analysis, SSA and SSR samples exceeded the limit value of 35 mg/100 g, and spoiled on the 9th, 25th days, respectively. However, according to other chemical parameters (TBA, TMA) their values did not reach the maximum limits for acceptability of fish. The sensory analyses results showed that SSR and SSA samples can be consumed in 21 and 7 days respectively.

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