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Influence of Smoking Methods and Refrigeration Storage on Physiochemical Quality Parameters of Catfish (*Clarias Gariepinus*) Fillets

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Abstract

The current study was carried out to investigate the effect of smoking methods (Hot&cold) and refrigeration storage for 40days on physiochemical quality parameters of Catfish (*Clarias gariepinus*) fillets. Chemical quality analysis of Catfish fillets indicated that TVB-N and TBA significantly (P<0.05) increased in the smoked Catfish samples in comparison with fresh unsmoked fish while pH value of smoked fillets slightly decreased. At the end of 40 days storage, TVB-N values of hot and cold smoked samples were determined by 30.17±0.479 and 32.2±0.173 mg/100g, respectively while TBA values of hot and cold smoked fillets increased up to 2.41±0.173 and 2.26±0.115mg malonaldhyde/kg, respectively. The pH values slightly increased up to 6.22±0.034 and 6.44 0.046 for hot and cold smoked samples, respectively at the end of 40 days of refrigeration storage.

Keywords: Catfish; TVB-N; TBA; Smoking methods; Refrigeration storage

Abbreviations: TVB-N: Total Volatile Basic Nitrogen; TBA: Thiobarbituric Acids; NIOF: National Institute of Oceanography and Fisheries

Introduction

Fish and fishery products have long been recognized as healthy foods with excellent nutritional value, providing high-quality protein, minerals, vitamins, essential fatty acids and trace elements. Fish is widely consumed in many parts of the world by humans due to its high content of good protein that characterizes by an excellent amino acid composition and easily digestibility [1]. Smoking is a traditional preservation technology that combines the effect of salting, deposition of smoke components and drying. It produces the characteristic taste and color that is much appreciated by consumers. Smoke contains many different components, such as aldehydes, ketones, alcohols, acids, hydrocarbons, esters, phenols, ethers, etc. [2]. The drying effect during smoking, along with the antioxidant and antimicrobial effects of the smoke, allow smoked products to have extended shelf-life [3]. Smoking has become a mean of offering diversified, high value-added products as an additional marketing option for certain fish species where fresh consumption becomes limited [4].

Total volatile basic nitrogen (TVB-N) is one of the most important criteria in the quality evaluation of fish products. Thiobarbituric acids (TBA) represent the degree of rancidity in the fresh and processed fish products and usually determined as the concentration of malonaldhyed in the products. Several studies were carried out to follow up quality changes in smokes fish products during storage Abd El- Mageed [5], Kolsarici and Ozkaya [6], Yanar [7], Bilgin et al. [8], Daramola et al. [9], Koral et al. [10], Abo-Taleb et al. [11] and Frank et al. [12]. Huss [13] reported that the acceptable limit of total volatile basic nitrogen (TVB-N) value in fresh fish flesh was 35 mg/100g.Similarly, Connell [14] observed that the acceptable levels of total volatile basic nitrogen (TVB-N) value in raw fish were ranged from 35 to 40 mg /100g. Shen [15] suggested the standards of TVB-N values for freshness of fish as follows; fresh fish: < 15mg/ 100g, sub fresh: 15-25 mg/100g and deteriorated fish <25 mg/ 100g. While, Lopez Caballero et al. [16] found that the acceptable levels of total volatile basic nitrogen (TVB-N) value of fresh fish ranged from 25 to 30 mg /100 g. The TBA value should be less than 3.0 mg malonaldhyde/kg in the perfect quality material and not be more than 5.0 mg malonaldhyde /kg in good quality material and consumption limits were from 7.0 to 8.0 mg malonaldhyde/kg [17]. pH value has been used for the evaluation of fish freshness and as an index of the quality of fish products [18]. In general, pH value of living fish is in the range of 6.3 to 7.0 [19,20].

Materials and Methods

Materials

Fish sample

I. **Catfish (Clarias gariepinus):** Fresh Catfish (Clarias gariepinus) samples were obtained from Wadi EI-Rayan Lake, Fayoum Governorate, Egypt, during August 2015. Averages of weight and length ranged between 1.8-2.3kg and 56-60cm, respectively. The fish samples were transported in ice-box to the laboratory of Fish Processing Technology, Shakshouk Station for Fish Research, National Institute of Oceanography and Fisheries (NIOF), Fayoum Governorate, Egypt. Fish samples were beheaded, gutted and washed gently with tap water then skinned and filleted manually. The edible part (fillets) of Catfish was about 48%.

Processing methods

Smoking methods: Smoked Catfish fillets were produced by following the traditional methods of cold and hot smoking using smoking oven at Shakshouk Fish Research Station (NIOF). The conditions of smoking are described in Table 1 as reported by Abd El-Mageed [5] (Table 1).

Table 1: Conditions of smoking

Smoking Parameters	Cold Smoking	Hot Smoking
Brining (%Nacl)	10%	10%
Brining Period (h)	1	1
Air Drying Period (h)	3	3
Temperature (^{0}C)	30 - 40	50 - 90
Smoking Period (h)	11-12	5-6
The Source of Fuel	sawdust	sawdust

Physiochemical quality parameters

Total volatile basic- nitrogen (TVB-N): Total volatile basic-nitrogen was determined by macro-distillation method as described by Pearson [21] and the results obtained were expressed as mg TVB-N/100g fresh sample.

Thiobarbituric acid (TBA): Malonaldehyde content was calorimetrically determined as described by Pearson [21] and the results were expressed as mg malonaldhye/kg of sample.

pH: The pH value was measured according to A.O.A.C. [22] as the follows: 10 g of the minced sample were homogenized with 100 ml of distilled water and the mixture was filtered by using filter paper. The pH value of the filtrate was measured using pH meter with combined electrode.

Effect of smoking methods on Catfish fillets

Physiochemical Quality Parameters: The effect of smoking methods on the physicochemical quality parameters was studied. Total volatile basic nitrogen (TVB-N), Thiobarbituric acid (TBA) as well as pH of Catfish smoked by hot and cold smoking methods was determined and the results obtained are shown in Table 2.

Total Volatile Basic Nitrogen (TVB-N): The results showed that TVB-N significantly ($P<0.05$) increased in the smoked Catfish samples in comparison with fresh unsmoked fish. It was found that TVB-N values in hot and cold smoked samples were 17.80±0.173 and 18.95±0.202 mg/100 g, respectively. Similar results reported by Yanar [7] and Koral et al. [10]. Increasing TVB-N after smoking process most likely caused by an autolytic process which produces volatile amine compounds. The higher value of TVB-N in cold smoked fillets might be attributed to the action of protein hydrolysis caused by enzymes during the longer time and lower temperature used in cold smoking [5] (Table 2).

Thiobarbaturic acid (TBA): During smoking process, Catfish fillets were exposed to heating and atmospheric oxygen. These factors can accelerate the oxidation of fish lipids, resulting in the increase of TBA. As shown in Table 2, TBA values for raw Catfish fillets significantly ($P<0.05$) increased from 0.23±0.017 to 0.44±0.023 and 0.29±0.011 mg malonaldehyde/kg in hot and cold smoked samples, respectively. However, the thiobarbituric acid values in the smoked samples were less than the levels reported for the rejected samples and were still acceptable. This observation is in agreement with the results reported by El-Akeel [23], Yanar [7] and Goulas and Kontominos [24]. The higher TBA value observed in hot smoked sample may be attributed to partial dehydration of fish and more oxidation of the unsaturated fatty acids as a result of smoking at relatively high temperatures (up to 70˚C). This observation is in agreement with the results reported by Goktepe and Moody [25] who observed a two-fold increase in TBA value of raw Catfish after hot smoking at temperature of 82˚C.

Table 2: Physicochemical quality characteristics of fresh and smoked Catfish fillets.

Parameters	Catfish Fillets			Sig.	LSD
	Fresh	Hot Smoked	Cold Smoked		
TVB-N (mg/100g)	13.7±0.09	17.80±0.17	18.95±0.20	0	0.23
TBA (mg malonaldhyde/ kg)	0.23±0.01	0.44±0.02	0.29±0.01	0	0.048
pH	6.4±0.08	6.10±0.04	6.20±0.01	0.026	0.154

pH: As shown in Table 2, pH value of raw Catfish fillets was 6.4±0.086 while hot and cold Catfish fillets showed pH values of 6.10±0.046 and 6.20±0.011, respectively. The lower pH values of smoked samples might be attributed to the absorption of some organic acids from the smoke by the flesh during smoking processing. Similar results were reported by Yanar [7].

Physiochemical Quality Parameters: The chemical quality attributes commonly used to determine the quality as well as the shelf life of fish and fish products are total volatile basic nitrogen (TVB-N), thiobarbituric acid (TBA) and pH value. These quality attributes of smoked fish fillets are the major factors which affect the overall acceptability of these products for human

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consumption. The influence of storage conditions on these parameters of hot and cold smoked Catfish fillets was studied during refrigeration storage at 4±1˚C.

Total Volatile Basic Nitrogen (TVB-N): Total volatile basic nitrogen of fish and fish products is an index to the degree of putrefaction, decomposition and degree of the breakdown of proteinases constituents. TVB-N contents of hot and cold smoked Catfish fillets were determined periodically at intervals of 5 days during refrigeration storage for 40 days. The results obtained are shown in Table 3. The initial values of TVB-N contents of hot and cold smoked Catfish fillets were determined by 16.8±0.173 and 18.95±0.202 mg/100g (on wet weight basis), respectively. During storage, it was observed that TVB-N values of the samples gradually increased as the storage periods extended. At the end of 40 days storage, TVB-N values of hot and cold smoked samples was determined by 30.17±0.479 and 32.2±0.173 mg/100g (wet weight basis), respectively.

Increasing TVB-N values during storage was attributed to the activity of endogenous and microbial protolytic enzymes which results in breakdown of proteins to volatile nitrogenous compounds [26,27] correlated between the quality of fish products and limits of TVBN as very good up to 25 mg/100g, good up to 30 mg/100g, marketable up to 35mg/100mg and spoilt more than 35 mg/100g. Accordingly, it could be concluded the good quality of the smoked catfish fillets products even after 35 days of refrigeration storage. These results are in agreement with those reported by Abd El-Mageed [5] on smoked Silver Carp fillets and El-Akeel [23] on Catfish Yanar [7] on Catfish and Koral et al. [10] on Garfish (Table 3).

Table 3: Changes in TVB-N content (mg/100g) of smoked Catfish fillets during refrigeration storage at 4.0 ± 1˚C.

Storage Time (Days)	TVB-N Content (mg/100g)		Sig.	L.S.D
	Hot smoked fillets	Cold smoked fillets		
0	16.8±0.173	18.95±0.202	0.001	0.531
5	17.36±0.173	19.76±0.288	0.002	0.673
10	21.28±0.161	22.58±0.420	0.02	0.901
15	22.54±0.138	23.98±0.277	0.01	0.619
20	22.55±0.317	23.42±0.115	0.062	0.675
25	24.82±0.577	26.77±0.444	0.055	1.45
30	25±0.288	26.98±0.230	0.006	0.739
35	27.44±0.230	29.22±0.127	0.003	0.526
40	30.17±0.479	32.2±0.173	0.016	1.01
Sig.	0	0	-	-
L.S.D	0.897	0.781	-	-

-Data are presented as mean ±SE of 3 replicates. -SE: standard error. -Significant difference at $P < 0.05$.

Thiobarbituric (TBA): Thiobarbituric (TBA) is widely used as an indicator for the degree of lipid oxidation and the presence of TBA reactive substances is due to the second stage of autoxidation. TBA values for hot and cold smoked Catfish fillets during refrigeration storage were determined as malonaldhyde (mg/kg) and data obtained are presented in Table 4. Initially, TBA values of hot and cold smoked Catfish fillets samples were 0.44±0.023 and 0.29±0.011 mg malonaldhyde/kg, respectively. During refrigeration storage of the smoked samples, TBA values showed a gradual increase as the storage time prolonged. At the end of storage period (40 days), TBA values of hot and cold smoked fillets increased up to 2.41±0.173 and 2.26±0.115 mg malonaldhyde/kg, respectively. It is clearly observed that storage time had the pronounced effect on the production and concentration of the lipid oxidation products that were determined as malonaldhyde.

Table 4: Changes in TBA content (mg malonaldhyde/kg) of smoked Catfish fillets during refrigeration storage at 4.0 ± 1˚C.

Storage Time (Days)	TBA Value (mg/malonalhyade/kg)		Sig.	L.S.D
	Hot Smoked Fillets	Cold Smoked Fillets		
0	0.44±0.023	0.29±0.011	0.004	0.051
5	0.60±0.028	0.36±0.017	0.002	0.073
10	0.88±0.103	0.63±0.404	0.088	0.225
15	1.06±0.173	1.04±0.080	0.013	0.35
20	1.54±0.080	1.80±0.029	0.012	0.23
25	2.04±0.080	1.89±0.115	0.347	0.282
30	2.21±0.121	1.93±0.144	0.212	0.375
35	2.39±0.202	2.02±0.196	0.259	0.563
40	2.41±0.173	2.26±0.115	0.511	0.416

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Sig.	0	0	-	-
L.S.D	0.354	0.292	-	-

-Data are presented as mean ±SE of 3 replicates. -SE: standard error. -Significant difference at P < 0.05.

The observed increase in TBA values for hot and cold smoked Catfish fillets were mainly because of both the autoxidation of fish fat and the formation of some TBA-reaction substances during storage [23]. The TBA value should be less than 3.0mg malonaldhyde/kg in the perfect quality material and not be more than 5.0 mg malonaldhyde /kg in good quality material and consumption limits were from 7.0 to 8.0 mg malonaldhyde/kg [17]. In the present study, the highest value of TBA was determined by 2.41±0.173 mg malonaldhyde/kg for hot smoked Catfish fillets sample indicating the good quality of the different samples of smoked Catfish fillets even after 40 days of refrigeration storage. It was observed that TBA values for cold smoked Catfish samples were lower than those determined in the hot smoked samples and after 40 days storage the maximum value determined was 2.26 mg malonaldhyde / kg. This observation could be attributed to the effectiveness of the smoke antioxidants which may be more concentrated in cold smoking than in hot smoking. Similar results were reported with hot and cold smoked Silver Carp fillets, smoked Catfish and smoked Garfish [5,7,10] (Table 4).

pH: The pH is among the most critical factors affecting microbial growth and spoilage of foods. pH value was measured in smoked Catfish fillets during refrigeration storage and the results obtained are illustrated in Table 5. As shown in Table 5, the initial pH values for hot and cold smoked samples were almost the same (6.1±0.046 and 6.2±0.011). These initial values slightly increased up to 6.22±0.034 and 6.44±0.046 for hot and cold smoked samples, respectively at the end of 40 days of refrigeration storage. which could be due to the enzymatic degradation of fish muscle components [28]. Rising pH during storage also may be due to formation of dimethyl amine from trimethylamine oxide [29]. pH values between 6.8 - 7.0 were proposed as acceptance limit of fish, while values above 7.0 indicate the spoilage [30,31]. These results are coincided with those obtained by [5,7] Daramola et al. [9] and Frank et al, [12] who reported that the pH value of smoked fish was slightly elevated during storage [32] (Table 5).

Table 5: Changes in pH value of smoked Catfish fillets during refrigeration storage at 4.0 ± 1˚C.

Storage Time (Days)	pH Value		Sig.	L.S.D
	Hot Smoked Fillets	Cold Smoked Fillets		
0	6.10±0.046	6.20±0.011	0.104	0.089
5	6.11±0.034	6.20±0.005	0.062	0.073
10	6.13±0.040	6.22±0.017	0.11	0.089
15	6.14±0.028	6.24±0.074	0.127	0.163
20	6.16±0.011	6.26±0.028	0.032	0.051
25	6.17±0.017	6.31±0.034	0.022	0.073
30	6.19±0.051	6.35±0.023	0.048	0.115
35	6.19±0.040	6.42±0.005	0.005	0.073
40	6.22±0.034	6.44±0.046	0.019	0.115
Sig.	0.34	0	-	-
L.S.D	0.103	0.103	-	-

-Data are presented as mean ±SE of 3 replicates. -SE: standard error. -Significant difference at P < 0.05.

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