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Quality of Smoked Tilapia Fillets (*Oreochromis niloticus*) Treated by Traditional and Liquid Smoke

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ABSTRACT

The purpose of this study was to treat tilapia fillets by traditional smoke (hot and cold smoking) and liquid smoke (watery smoke and oily smoke), and examined the effects of these treatments on the fillets quality. The proximate composition and nutritional values were determined. The cold smoked fillets had the highest percentage, 43.97%; 8.3%; 6.05% and 274.78 Kcal, of protein, fat, carbohydrates and nutritional value, respectively. Salt percentage was less than 3.5% in all smoked tilapia fillets treatments and compiled with EOS standards (2005). TVB-N and TBA values were lower (<25mg/ 100g; <1.5mg *Malondialdehyde*/ kg) in all smoked tilapia fillets. TPC and Yeasts and molds counts ranged between 2.54×102 and 2.49×103 cfu/g; 1.26×102 and 0.23×102 cfu/g, in all smoked tilapia fillets treatments respectively, were complied with EOS standards. The organoleptic properties showed excellent and very good scores for traditional and liquid smoking fillets, respectively. Smoked tilapia fillets (*Oreochromis niloticus*) treated by Liquid Smoke can be considered a good alternative to traditional smoking.

1. Introduction

Egypt has the largest aquaculture industry in Africa and the third largest after China and Indonesia in Nile tilapia production (Moffitt, et al., 2014, FAO, 2018). Nile tilapia (*Oreochromis niloticus*), is the dominant fish species produced in Egypt. It accounts more than million ton of the aquaculture production in Egypt.

During the last two decades, the fish farming sector suffers from fluctuation and low prices of Tilapia fish compared to the high prices of feed in Egypt. Therefore, the tendency has been to work to raise the added value of these fish through the production of fish fillets to increase the marketing value and use them in production of other desired products in Egypt. Fish fillets are widely accepted because of their suitable price, good nutritional value and texture, and absence of intramuscular thorns (Bonilla & De la Pava, 2013).

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Nile tilapia is being increasingly exported as fillets around the world (Merino, Bonilla, & Bages, 2013). Fish smoking is a very relevant activity in the fish processing sector in Egypt. It is based on the traditional method of smoking fish to enhance flavor (Saed, et al., 2020), increase the utilization of fish and thereby reducing wastage that might result from fish spoilage which will in turn influence protein availability in the country (Kumolu-Johnson and Ndimele, 2011). Many polycyclic aromatic hydrocarbons (PAHs) especially benzo(a)pyrene produced during traditional smoking can influence smoked fish safety (El-Naggar et al., 2019). Smoking with smoking liquids resulting from destructive distillation of wood is currently used in fish smoking process to enhance the smoked fish acceptability, play an antioxidant and bacteriostatic role and control the quality of smoke components and make them safer from a health opinion.

As a tilapia fish is the most valued fish species in Egypt, therefore its processing and raising its value require more attention to possibility of exporting it abroad. This study carried out smoking fish by traditional (hot and cold smoking) vs. liquid smoking (watery smoke and oily smoke) as an alternative method to traditional one. The effect of these treatments on the quality of smoked tilapia fillets was studied. Organoleptic properties, some chemical parameters and microbial counts used to evaluate whether liquid smoking could replace traditional smoking of *Oreochromis niloticus* Fillets or not.

2. Materials and methods

2.1. Raw material

Iced fresh Tilapia fish (Oreochromis niloticus) (25 kg with average weight 300 ± 50g) were purchased from local fish market in Al Mothalth zone, Suez governorate, North eastern of Egypt. They were transferred to Fish Processing unit in faculty of fish resources, Suez University. Tilapia fish fillets was prepared according to Codex Alimentarius (2013) as the fish were washed and hand filleted then salted by using brine containing an 10% NaCl at a 2:1 (v/w) brine /fresh fillet ratio for 5min. Before smoking starts, brined fillets left on racks for 10min to drainage excess water.

2.2. Smoking technology and treatments

Smoking procedures for tilapia fillets were performed according to Egyptian standards (EOS) for smoked fish (2005) with modification for liquid smoking (Fig. 1). Four treatments were prepared as the following:
a) Two traditional smoking treatments was performed in electrical smoking kiln using beech sawdust. Cold smoking (TC) carried out on 30 ±3°C for 5h; while hot smoking (TH) was the other treatment which achieved at 28 ±3°; 50 ±5° and 80 ±5°C for 1h to each stage.
b) Two Liquid smoking treatments; one was watery smoke (WS) and another was oily smoke (OS) which were prepared by condensate of beech sawdust smoke in 200ml distilled water or 200ml soybean oil for 3h. The WS and OS treatments were conducted by wiping one of them with a clean brush on the surface of fillets five times every 20min at 30°C then raising the final temperature to 80°C for 40 min.
Each treatment was cooled at ambient temperature (23 ±3°C) for 15min then it was vacuum packaged after frozen quickly at -40 °C in air blast freezer until analysis performed.

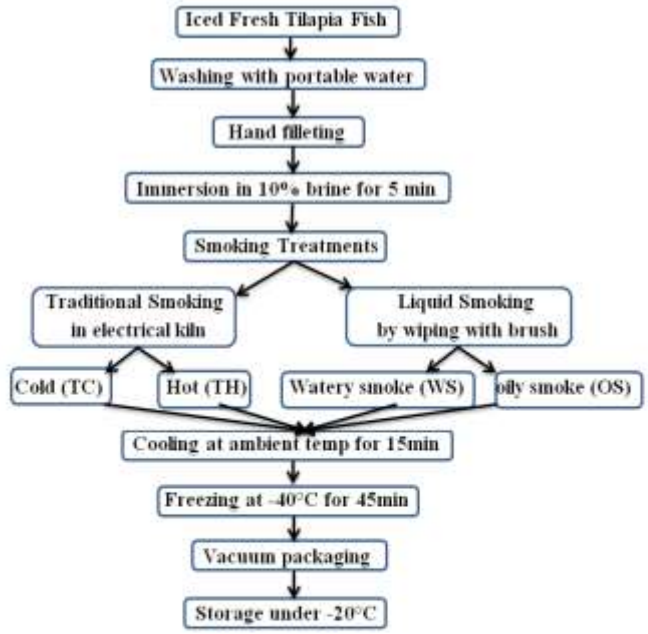

Fig.1: Flow diagram of preparation of smoked tilapia fish fillets

2.3 Proximate analysis and nutritional value

Proximate compositions of Untreated (UF) and treated fillets were determined by AOAC method, (2000). Moisture content was determined via loss on drying at 65 °C for 72 h. The crude protein was determined by using Kjeldahl method. Fat content was estimated using the Soxhlet method. The ash was determined by heating in furnace at 550 °C for 24 h. The total carbohydrate content was determined by subtracting the sum of the percentage moisture, ash, crude lipid, and crude protein from 100%. Nutritional value was calculated depending on protein, carbohydrates and fat content in each treatment.

2.4 pH

According to Martinez et al. (2011), pH was measured by adding 90 ml of distilled water to 10 g of sample and homogenizing the mixture in the homogenizer at 3000 rpm for 3min. 5 Measurements for each sample were made with a pH-meter from Hanna (AD8000 Multi-Parameter) calibrated at 25 ◦C.

2.5 Salt content

Salt content in the Untreated and treated fillets was objected by the volumetric method of Volhard (AOAC, 2000). The salt content was calculated as percentage of the sample.

2.6 Total Volatile Base Nitrogen (TVBN) and Thiobarbituric acid (TBA)

The Total Volatile Base Nitrogen (TVBN) was determined following the method of Pearson (1982).

Fat oxidative stability was assessed by measuring changes in thiobarbituric acid (TBA) formed during treatments. TBA was extracted by distillation according to Goulas and Kontominas (2007). 10 g of fish was mixed with 97 ml of distilled water, 3 ml of 4 N HCl and two drops of antifoaming agent in a 500 ml distillation flask. The mixture was distilled for 10 min to collect 50 ml of distillate; a 5 ml aliquot of which was mixed with 5 ml of 0.02 M 2-thiobarbituric acid in a test tube, that was heated in a water bath at 100 ◦C for 35 min, prior to measuring the absorbance at 538 nm on a V-503 UV/Vis spectrophotometer from Jasco (Tokyo, Japan). TBA for the Untreated and treated fillets were calculated in milligrams of malonaldehyde per kilogram of sample (MAD/kg).

2.7 Organoleptic properties

The various smoked fillets were subjected to sensory quality evaluation using descriptive test based on 5-point hedonic scale modified from Tobor (1994) and Eyo (2001). Colour, Taste, Flavour, texture and acceptability were sensory attributes examined, the following grades were allotted depending on their qualities: 8 ≤ 10 = Excellent, 6 ≤ 8 =Very good, 4 ≤6 = good, 2 ≤ 4 = bad and ≤2 =worst. Twenty trained panelists from Department of fish processing technology were used for the assessment.

2.8 Microbiological methods:

Total plate count (TPC) was determined by using nutrient agar medium (AOAC, 1998). Yeasts and molds counts were enumerated on malt agar as mentioned by APHA (1976).

2.9 Statistical analysis

Means and Standard Deviation (SD) were calculated for untreated and treated tilapia filets.

3. Results and discussion

3.1. Chemical composition and nutritional value

The results of the chemical composition and nutritional value analyses of fresh untreated and smoked treated fillets were showed in Table1. The composition of fresh tilapia fillets was 77.78; 15.92; 2.8; 2.5 and 2% for moisture; protein; fat; ash and carbohydrate; respectively. These results were similar to those founded by Chaijan (2011) and Rizo et al. (2016). The compositions of smoked treated fillets were varied based on the processing method used. The obviously changes was showed in cold smoking fillets. The highest moisture content was found in treated fillet with oily smoke (OS) (70.15%) where the treated fillet by cold smoking (TC) was showed the lowest content (36.76%). Rizo et al., (2016) stated that moisture content was the main factor that affects the stability and shelf-life of smoked fish. The fat; protein; carbohydrate were increased as moisture content decrease. The fat content in cold smoking treatment was increased more than three times while treated fillet with oily smoke was increased about double and this may be due to wipe the fillet by oily smoke during processing. The nutritional values were increased as the processing treatments were applied and the highest value was in cold smoking treatment. Using liquid smoking (WS & OS) improved the nutritional value in comparing with hot smoking (TH).

Table 1. Proximate composition and nutritional value (Kcal) of Untreated (UF) and smoked treated Tilapia fish fillets

Treatments / Parameters	Untreated	Smoked Treatment			
	Fresh fillet	Traditional Smoking		Liquid Smoking	
	UF	TC	TH	WS	OS
Moisture	77.78 ± 0.30	36.76 ± 0.60	68.93 ± 0.3	65.42 ± 0.29	70.15 ± 0.41
Protein	15.92 ± 0.22	43.97 ± 0.09	19.84 ± 0.15	22.67 ± 0.17	19.0 ± 0.21
Fat	2.8 ± 0.20	8.3 ± 0.34	4.33 ± 0.14	4.03 ± 0.21	4.95 ± 0.24
Ash	2.5 ± 0.15	4.92 ± 0.26	3.02 ± 0.14	2.94 ± 0.30	2.78 ± 0.31
Carbohydrate	2.0 ± 0.03	6.05 ± 0.23	3.88 ± 0.13	4.94 ± 0.07	3.12 ± 0.44
Nutritional value Kcal	96.88	274.78	118.33	146.71	133.03

3.2 Biochemical properties

Table2 presented the results of some Biochemical quality of Untreated (UF) and treated Tilapia fish fillets. Upon the maximum value of total nitrogen bases (TVB-N), the fresh fillet and all smoked treated fillets were "high-quality" where all (TVB-N) contents were lower than 25 mg/100 g according to Sernapesca, (2018) and Icontec, (2016). Similarly, TBA values were less than set by EOS (2005) (4.5 mg Malondialdehyde/ kg). The TBA values were not more than 1.5mg Malondialdehyde/ kg and they increased than in fresh fillets as a result of increasing the time of treatment such in cold smoking treatment (TC) and when oil adding during wiping the fillets by oily smoke treatment (OS). The pH of liquid smoking treatments (WS; and OS) were lightly increased than fresh fillets while traditional smoking treatments (TC and TH) were lightly decreased than fresh one. Salt is important as the preservative effect. The salt contents were increased in all smoking treatments. The cold smoking treatment increased the salt content than in hot smoking. Comparison of different liquid smoking treatments, WS treatment was slightly had more salt than OS treatment. All treatments had salt content agreed with that set in EOS (2005). Previous studies have been showed that smoked fish affected by brine concentration. Fuentes, et al., (2010) reported that salt content in smoked fish ranged from slightly (1.3–5%) to strongly salted (20%). The inclined in moisture content influenced the increasing of salt content after smoking treatments. The smoke components (Stolyhwo et al., 2006), extent of moisture loss, and the duration and temperature of heating may also be important (Swastawati et al.; 2014). Ruiz-Alonso et al., (2021) investigate some physical-chemical parameters of Nile tilapia and they found that the values of TVB-N; TBA and pH were 11.8 mg/100g; 0.11 mg MAD/Kg and 6.43, respectively which in consistent with the results in this study.

Table 2. Biochemical quality of Untreated (UF) and smoked treated Tilapia fish fillets

Treatments	Untreated	Smoked Treatments			
	Fresh fillet	Traditional Smoking		Liquid Smoking	
	UF	TC	TH	WS	OS
TVB-N (mg/100g)	14.38 ± 0.22	17.76 ± 0.31	23.53 ± 0.17	18.31 ± 0.19	22.43 ± 0.25
TBA (mg MAD/Kg)	0.52 ± 0.05	1.32 ± 0.09	1.01 ± 0.15	0.95 ± 0.11	1.50 ± 0.17
pH	6.52 ± 0.20	6.30 ±0.14	6.44 ± 0.12	6.66 ± 0.21	6.83 ± 0.24
Salt (%)	0.12 ± 0.05	3.22 ± 0.12	1.81 ± 0.14	1.73 ± 0.17	1.58 ± 0.07

3.3 Organoleptic Properties

The panelists' scores allotted for the organoleptic properties of all smoked fillet treatments (Table3), where they accepted all. The traditional smoking samples were excellent and their scores were ranged between 8.33 to 8.87. The liquid smoking samples were very good and their scores were ranged between 6.53 to 7.55. A lighter colour and moderate flavor and taste were found in liquid smoking tilapia fillets. These results indicate a decrease in the concentrations of watery smoke (WS) and oily smoke (OS) that used in liquid smoking treatments thus high liquid smoke concentration was required. Martinez et al., (2012) indicated that the colour changes of outer surface of smoked product caused by salting and smoking. In liquid smoke there were many chemical substances such as phenols, ketones, acids, alcohols and esters (Montazeri, et al., 2013) that responsible for the colour changes of smoked fish (Rozum, 2014).

Table 3. Organoleptic quality of smoked treated Tilapia fish fillets

Treatments	Smoked Treatments			
	Traditional Smoking		Liquid Smoking	
	TC	TH	WS	OS
Colour	8.33 ± 0.35	8.73 ± 0.31	7.55 ± 0.19	6.95 ± 0.25
Flavour	8.53 ± 0.17	8.87 ± 0.13	6.73 ± 0.11	6.95 ± 0.17
Taste	8.80 ± 0.43	8.98 ± 0.47	6.53 ± 0.12	6.73 ± 0.17
Texture	8.33 ± 0.35	8.73 ± 0.31	6.63 ± 0.11	6.68 ± 0.07
Acceptability	8.53 ± 0.17	8.87 ± 0.13	6.83 ± 0.11	6.95 ± 0.24

3.4 Microbial counts

The total plate counts (TPC) and yeasts and molds counts showed in Table4. As can be seen, the fresh fillets had the highest counts (2.05×10^4 ± 0.45; 5.32×10^2 ± 0.57 cfu/ g) in comparing with all smoked treated fillets which decreased according to their treatments. TPC was decreased by about 2 logs in TH, WS and OS samples where the temperature used in these samples was high (80°C). Yeasts and molds counts were specially influenced by high temperature and oil used in **OS** treatment. All smoked treatments complied with the standards for smoked fish (EOS, 2005) and smoke-flavoured fish (Codex Alimentarius, 2013; Icontec, 2016). The small microbial counts mean that processing procedures were carried out under hygienic conditions.

Table 4. Microbiological examination of untreated and smoked treated Tilapia fish fillets

Treatments	Untreated	Smoked Treatments			
	Fresh fillet UF	Traditional Smoking		Liquid Smoking	
		TC	TH	WS	OS
TPC counts (cfu/ g)	2.05×10^4 ± 0.45	2.49×10^3 ± 0.64	2.54×10^2 ± 0.22	4.98×10^2 ± 0.54	3.41×10^2 ± 0.36
Yeasts and molds counts(cfu/g)	5.32×10^2 ± 0.57	1.26×10^2 ± 0.51	0.42×10^2 ± 0.23	0.45×10^2 ± 0.37	0.23×10^2 ± 0.61

4. Conclusion

The treating of tilapia fillets by traditional smoke or liquid smoke produced smoked fillets, whose biochemical and microbial counts complied with EOS standards. Taste panel tasting in all smoked treatments showed high scores for all sensory properties. Liquid smoking as alternative method to traditional method will not need a smoke generator and the time of production is decreased. Further study needed to investigate the shelf-life of these products and determine the concentration of these liquid smokes and their composition.

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