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Effects of processing on bacteriological, proximate, hydrocarbon content and organoleptic indices of *Scomber scombrus*

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Abstract

Effects of boiling, smoking and frying on the organoleptic quality, bacteriological count, proximate composition and total hydrocarbon contents of *Scomber scombrus* fish sold in Ikot Ekpene Metropolis were investigated. Fillets of fresh *S. scombrus* were made, and processed by smoking, boiling and frying methods. Portions of the fish sample were aliquoted, and used to carry out sensory evaluation, plating aliquots of diluents onto nutrient agar plates (for total viable count (TVC), and on Manitol Salt agar (for total staphylococcal count (TSC). Standard methods were used to determine moisture, ash, total lipids and crude protein contents. Total hydrocarbon content was determined by toluene extraction and measurement of absorbance of filtrate spectrophotometrically. Sensory quality obtained using smoke-drying and frying methods scored significantly higher than that of boiling and the control ($p<0.05$). TVC of samples were lower than in the control fish sample after processing, increasing over the 4-day period, although negligible when compared to the control. TVC were lowest in samples processed by frying. TSC decreased in all fish samples after processing, except in the control fish sample. Fried *Scomber scombrus* samples also showed no trace of *S. aureus*. Moisture, lipid, crude protein and ash contents of control *S. scombrus* were 68.78±1.02, 2.03±0.11, 20.14±0.06 and 0.09±0.32 respectively. The changes in moisture, lipid, crude protein and ash contents were statistically significant ($P<0.05$) in processed fish samples. Total hydrocarbon content also increased in processed fish; 2.914±0.005 for smoke-dried, 2.168±0.001 for fried and 1.538±0.009 for boiled, as against 1.412±0.011 in the control sample. Overall bacteriological quality indices, the proximate content and total hydrocarbon contents of samples demonstrated frying and smoking as preferable processing methods for *Scomber scombrus*.

Keywords: *Scomber scombrus*, total hydrocarbon content, fish processing, smoking, boiling, frying

Introduction

Fish is an important food source, valued for its high protein content. (Ojutiku *et al*., 2009). In comparison to meat, fish contains higher amounts of protein, amino acids, vitamins and essential minerals. (Osibona *et al*., 2011). The high-quality nutritional contents of fish however provide a conducive environment for microbial proliferation after capture and/or death, making it perishable (Oparaku and Mgbenka, 2012). Avoiding deterioration after capture therefore becomes an important objective if fish must be fully utilized. Processing of fish leads to inactivation of pathogenic microorganisms, or unfavourable conditions for their proliferation, and enhances flavor and taste (Nader *et al*., 2014).

Various processing techniques have been utilized to improve the microbial quality of fish and thereby extend its shelf life, these include smoking, salting, cooking, frying in oil, sun drying, solar drying and canning among others (Kumolu-Johnson *et al*., 2010). Globally, between 25 to 30% of fish catch consumed have been processed by drying, salting, smoking or combinations of these processes (Aliya *et al*., 2012). These processing methods though useful in preservation however influences the physical and nutritional quality of fish producing variations in nutritional and organoleptic parameters of fish (Pourishamsian *et al*., 2012).

Smoking, salting, frying and drying are the traditional methods of fish processing available in Nigeria, as well as in many developing countries. These methods are common, as they do not involve sophisticated equipment or operations (Olayemi *et al*., 2011). Other methods including canning, lyophillization, and freezing may be too expensive to deploy in developing economies. Most processing methods that involve heat reduce the water activity of the fish and extend the shelf-life of processed fish products. Depending on the type and degree of such methods, processing produces varying effects on microbial stability (Huss *et al*., 1997).

Studies have reported that heating of fish accelerates drying, preventing microbial activities. Heating treatments, however, alters the nutritional content of the fish in addition to dehydrating fish. Idah and Nwankwo, (2013) reported variation in protein content of fish with intensity of applied heat during processing. (Eyo, 2001) reported decreases and/or loss in lysine in fish processed by smoking, proportional to the temperature and duration of the smoking process. Clifford *et al*. (1980) has reported decreases in available lysine on the surface, and interior of fish processed by smoking. (Eyo, 2001) has reported 6.6% decreases of basic amino acids at the surface of fish processed by heating. Alipour *et al*. (2010), reported that boiling reduces protein digestibility due to complex chemical reactions (cross linking). Porishamsian *et al*. (2012), noted that frying alters proximate composition and fatty acids of fish. Oku and Amakoromo, (2013), have however reported enhancement of flavour in fish by smoking.

One of the most affordable fish available throughout Nigeria, are the Atlantic mackerel (*Scomber scombrus*) (Osibona *et al*., 2011). The Atlantic mackerel, a fat fish species belonging to the Scombridae family is rich in protein (18-20 %), fat (6-23%), omega-3 fatty acids and an excellent source of selenium, niacin, and vitamins B6 and B12 (FAO, 2014). The present study now seeks to investigate the effects of traditional processing methods; smoking, frying and boiling on quality parameters (organoleptic, bacteriological, proximate composition and total hydrocarbon contents) of *Scomber scombrus* fish.

Materials and Methods

Sample collection

Fish samples *(Scomber scombrus*) were obtained from "Otor" Market in Ikot Ekpene Local Government Area of Akwa Ibom State, into ice boxes and transferred to the laboratory for further analysis. Identification was made at the Department of Zoology, University of Uyo, Uyo, Akwa Ibom State.

Sample processing

Fresh fish samples were washed, eviscerated, beheaded and then rinsed. Four fillets were then prepared from each sample. Each fillet was subjected to a different processing treatment; boiling in water for 20 minutes at 98°C; deep-frying in vegetable oil in a frying pan and smoking using firewood in a fire stand for 7 hours. Temperatures of the smoking process was adjusted following the methods of Djopnang *et al*. (2018); with burning wood was adjusted continuously to sustain the required temperature ranges, which was between 32 and 50 °C for 2 h, initially, 60 and 80 °C for the next 2h30 minutes and 50 and 60 ° C finally for 2h30 minutes to smoke-dry. The last filet was analyzed raw.

Post processing preparation

After processing, fishes were handled for analysis according to Djopnang *et al*. (2018). Portions of raw, and processed fish samples were then allotted for analysis, from which their moisture content was first evaluated. Portions of the aliquots were then dried at 50 °C and ground into flour for the determination of proximate contents.

Sensory evaluation

Sensory evaluation of fish samples was performed by a test panel of students selected from the Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osurua, who were asked to evaluate appearance, odour, texture, taste, flavour and general acceptability. Questionnaires were used by the panelists and presented in a random sequence in a 9-point Hedonic scale (Poste *et al*., 1991).

Microbiological analysis

Fish samples were homogenized in a food blender, and 10g serially diluted up to dilution factor 10^{-4} with 1ml of the diluent aseptically inoculated into about 15mls of molten sterile nutrient agar in sterile pre-labeled Petri plates by the pour plate method. Enumeration of total *Staphylococcus* count was done by plating on Manitol Salt Agar plates. Inoculated Petri plates were incubated at 37^{O}C for 24-48 hours. Visible colonies of bacteria developed on the plate were enumerated.

Proximate Composition Analysis

The moisture content of fish samples was evaluated by obtaining a constant weight after drying in an electric air-dried oven at 105°C (AOAC, 1990). Crude protein content was obtained by conversion of the determined nitrogen content (Kjeldahl, 1983). Ash content was measured gravimetrically in a furnace at 550°C for 24 h (AOAC, 1990). Total lipid was obtained by extraction using chloroform and methanol solvents in the Soxhlet system, (Bligh and Dyer, 1959).

Total Hydrocarbon Analysis

Fish samples (*Scomber scombrus*), were ground in a teflon mortar, macerated and sieved through a 1 µm sieve. Exactly 5.0g each of the sieved samples were shaken in 50 ml of toluene on a Stuart flask shaker for 10mins. The extracts were later filtered into 100 ml volumetric flasks and made up the 50 ml mark with toluene. This step was done in triplicate. The absorbance of the supernatant of the filtrate after settling for 15 minutes was measured at 420nm using a spectrophotometer (Spectrumlab). Appropriate blanks of pure toluene were run throughout the procedure.

Statistical Analysis

Mean and standard deviation were computed, and the results reported in the form mean ± SD and significant difference in means were examined using ANOVA followed by the Duncan test. Data analysis was facilitated using the Statistical Package for Social Sciences (SPSS version 20.0) and statistical significance was established at the 0.05 level of significance with p-value less than 0.05 considered statistically significant.

Results

Table 1: Effects of processing methods on the sensory parameters of *Scomber scombrus* samples

Processing method	Appearance	Odour	Texture	Taste	Flavour	General acceptability
Control	6.18±1.74[a]	4.46±1.85[a]	6.98±1.39[a]	4.16±1.45[a]	3.28±1.14[a]	5.07±1.76[a]
Smoke-drying	7.67±1.01[b]	6.97±1.06[b]	7.47±0.61[a]	6.82±4.55[b]	8.78±0.76[c]	8.28±0.41[b]
Boiling	6.90±0.73[a]	6.29±1.85[b]	6.72±0.96[a]	5.00±2.30[a]	6.74±2.23[b]	6.41±2.13[a]
Frying	8.71±0.60[b]	7.96±0.27[b]	8.17±0.50[a]	9.13±0.34[b]	9.15±0.70[c]	9.05±0.55[b]

Similar superscript means not significantly different (p>0.05), different superscript means significantly different (p<0.05),

Table 2: Total viable count (TVC) of *Scomber scombrus* samples

Fish sample	**Total viable count (TVC) (Cfu/g)**			
	Day 1	**Day 2**	**Day 3**	**Day 4**
Control	3.1×10^5	9.9×10^5	1.6×10^6	3.2×10^6
Smoke-dried	1.2×10^5	2.5×10^3	4.8×10^3	7.3×10^3
Boiled	1.3×10^5	3.8×10^3	2.4×10^4	5.2×10^4
Fried	1.3×10^5	1.1×10^1	3.3×10^1	1.5×10^2

Table 3: Total Staphylococcus Count (TSC) of *Scomber scombrus samples*

Fish sample	**Total Staphylococcus Count (TSC) (Cfu/g)**			
	Day 1	**Day 2**	**Day 3**	**Day 4**
Control	4.0×10^2	1.8×10^3	2.8×10^3	5.8×10^3
Smoke-dried	2.2×10^4	4.0×10^2	9.0×10^2	2.1×10^3
Boiled	1.3×10^4	1.3×10^3	9.3×10^3	1.2×10^4
Fried	2.3×10^3	< 100	< 100	<100

Table 4: Effects of processing methods on bacterial counts of fish of *Scomber scombrus* samples

Processing method	**Total Viable Counts ($\times 10^5$)**	**Total Staphylococcal Counts($\times 10^3$)**
Control	18.41±11.69[b]	4.51±7.31[a]
Smoke-drying	0.42±0.66[a]	3.64±7.46[a]
Boiling	1.12±2.05[a]	59.13±137.82[a]
Frying	0.23±0.47[a]	0.40±0.77[a]

Similar superscript means not significantly different (p>0.05), different superscript means significantly different (p<0.05).

Table 5. Effects of processing methods on the proximate composition of *Scomber scombrus*

Processing method	Moisture content	Lipid content	Crude protein	Ash
Control	68.78±1.02^{b}	2.03±0.11^{a}	20.14±0.06a	0.09±0.32^{a}
Smoke-drying	16.44±0.002^{a}	20.00±0.065^{b}	52.44±0.22^{c}	3.71±1.67^{b}
Boiling	59.92±0.08^{b}	14.75±0.35^{b}	60.00±0.21^{c}	1.22±0.12^{a}
Frying	15.04±0.60^{a}	16.44±0.45^{b}	32.22±1.02^{b}	1.75±0.05^{a}

Table 6: Correlation between moisture content, lipid content, crude protein and ash

	Moisture content	Lipid content	Crude protein	Ash
Moisture content	1			
Lipid content	-.648	1		
Crude protein	-.457	.603	1	
Ash	-.680	.767*	.462	1

*Correlation is significant at 5% (p<0.05).

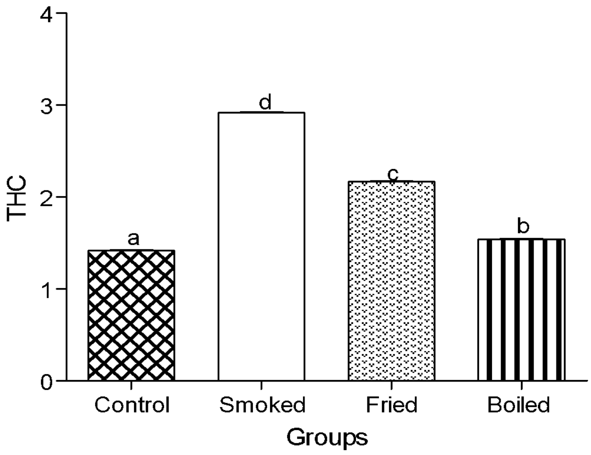

Fig 1: Total hydrocarbon content (THC) of *Scomber scombrus* samples

Table 7: Comparison of the THC of *Scomber scombrus* samples

Groups	Mean±SD
Control	1.412±0.011^{a}
Smoked	2.914±0.005^{d}
Boiled	1.538±0.009^{b}
Fried	2.168±0.001^{c}

Similar superscript letters mean not significantly different at 5% (p>0.05), different superscript letters means significantly different at 5% (p<0.05), **significant at 1% (p<0.01).

Discussion

Result in Table 1 reveals that the appearance of smoking, drying and frying fish scored significantly higher than that of the control and boiling (p<0.05) while odour obtained using smoking-drying, boiling and frying scored significantly higher than that of the control ($p<0.05$). There was no significant effect of processing methods on the texture ($p>0.05$) while taste was scored significantly higher using smoke-drying and frying than other processing methods ($p<0.05$). The flavour obtained using smoking- drying and frying scored significantly higher than boiling, while between smoking-drying and frying, there was no significant difference in flavour ($p>0.05$). Generally, acceptability obtained using smoke-drying and frying methods scored significantly higher than that of other processing methods and the control ($p<0.05$). Idah and Nwankwo, (2013) have opined that organoleptic parameters are one of the major quality parameters used by consumers in accepting or rejecting fish products, hence its value in quality evaluation. In their study Idah and Nwankwo, (2013) reported that smoking at $60^{O}C$ for 15 hrs increased the sensory qualities of fish (*O. niloticus*). Aberoumand, (2014) has however reported higher flavour and palatability scores for boiled *Nemipterus japonicas, Carangoides malabaricus* and *Saurida undosquamis* as well as best appearance and texture scores, compared to those processed using frying and roasting methods.

Total viable bacterial counts (TVC) were shown to increase within the four days period as shown on table 2. TVC increased the control fish sample from 3.1 x 10^5 by day 1 to 32 x 10^6 by day 4. TVC of samples were lower in processed samples than in the control, but increased over the 4-days period, although they were negligible when compared to that of the control. TVC were lowest in samples processed by frying. The fried *Scomber scombrus* samples also showed no trace of *S. aureus*. Agbolgba and Iyera (1998), have reported varying bacterial loads in processed fish samples.

Staphylococcus aureus is commonly used as an index of hazardous conditions during fish processing (Huss *et al.,* 1997). From table 3, total staphylococcal counts (TSC) decreased in all fish samples after processing, except in the control fish sample. Over the 4-day period after processing, TSC increased gradually. TSC remained lowest in samples processed using frying (<100). Okonko *et al*. (2008) have suggested the presence of *Staphylococcus aureus* in fish samples to be through contamination by handling. Okareh and Erhahon, (2015) have reported pathogenic strains with heat stable enterotoxin resistant to gastrointestinal enzymes which could potentially cause food poisonings. Result in Table 4 show that there is no significant difference in TSC between the groups while TVCs of the control were significantly higher than that of smoke-drying, boiling and frying ($p<0.05$).

Result in Table 5 indicates that moisture content in the control sample were significantly higher than that of processed fish. Moisture content was significantly decreased in fried *S. scombrus* (15.04±0.60), followed by that of smoke-dried sample (16.44±0.002). Aberoumand, (2014) has also reported decreased moisture content of *N. japonicus* processed by roasting (smoking), compared to frying, boiling and unprocessed control. Lipid content of the fish processed using smoke-drying (20.00±0.065), frying (16.44±0.45) and boiling (14.75±0.35) were significantly higher than that of the control (2.03±0.11), ($p<0.05$). Unlusayin *et al*. (2001) has suggested higher lipid and ash content in the processed seafood to be due to decrease in moisture contents, which subsequently increases all other nutrients. Other researchers have reported increases in the fat, lipid or oil contents in the fried fish fillets (Saguy and Dana, 2003; Rosa *et al*. 2007). The crude protein in smoked and boiled was significantly higher than in the control sample and that processed using frying ($p<0.05$). Ash content in smoke-dried samples was significantly higher than that of the control, boiling and frying ($p<0.05$). The differences found in proximates after processing has been suggested by Kubow, (1992) to be due to water and oil reactions with items in the fish, especially, at increased temperatures such as that involved in processing, which affect the nutritional content of the fish by altering the oil structure, and thereby denature available nutrients

Result in table 6 reveals that Lipid content has a significant positive relationship with Ash ($p<0.05$) which implies that Lipid content increases as Ash increases while the relationship obtained between other variables was not significant ($p>0.05$).

Results in Table 7 above show significant difference in THC between the controlled, smoked, fried and boiled fish (F-cal. = 27012. 08, p =0.000, $p<0.01$). Result reveals that THC in the control fish sample was significantly less than that of the smoked, fried and boiled fish. THC of the smoked fish was significantly higher than that of the samples processed using other methods ($p<0.05$). THC obtained in fried fish was significantly higher than that of the boiled fish ($p<0.05$). THC content of all processed fish samples was specifically increased by frying. Miculis *et al*. (2011) reported higher levels of PAH4 in traditionally smoked fish products in comparison with industrially smoked fish products. Silva *et al*. (2011) also reported general increase in PAHs levels with various smoking methods at varying degrees Candella *et al*. (1998) have previously reported an indirect relationship between fat content of seafood and frying.

Conclusions

In this research, the highest protein content was obtained in fish samples processed by boiling. The organoleptic quality of smoke-dried *Scomber scombrus* scored higher. Moisture contents were also significantly decreased in smoke-dried samples. However, smoke-drying has also been shown to increase the total hydrocarbon content of *Scomber scombrus.* Fried

Scomber scombrus samples had lower moisture contents and presented decreased total viable and total staphylococcal counts over the 4-day holding period, compared to samples processed by other methods as well as the control. Ash and lipid contents for fried *Scomber scombrus* were not significantly increased compared to smoking method. However, THC was lower in fried *Scomber sombrus* samples than in smoke-dried samples, although higher than in the control and boiled samples. Aberoumand, (2013) has previously recommended smoking as the best cooking method for fish (*N. japonicas*) for healthy diet. Overall bacteriological quality indices, the proximate content and total hydrocarbon contents of samples demonstrated frying and smoking as the best processing methods for *Scomber scombrus*.

Conflict of interests

Authors declared that no conflict of interests exist

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