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PROXIMATE COMPOSITION AND SENSORY PROPERTIES OF SMOKED *Gymnaruchus niloticus* (ABA KNIFE FISH)

Paul T[1*], Nwakuba NR[2], Simonyan KJ[3]

[1,3] Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, P.M.B 7267, Umudike, Nigeria.
[2] Department of Agricultural and Bioresources Engineering, Federal University of Technology, P.M.B. 1526 Owerri, Nigeria.

***Author for Correspondence:** ptosin106@gmail.com

ABSTRACT

Fish products require proper processing techniques to preserve their sensory qualities for a substantial period. This study presents the quality composition of a local fish species (Aba knife fish) predominant in Aba, South-eastern Nigeria. The objective of the study was to investigate the effect of smoking process on the proximate and sensory qualities of Aba knife fish *(Gymnaruchus niloticus)*. The studied fresh fish fillets were rinsed in clean water, brined and spread in trays before taken for smoke drying. A modified smoking kiln was used for the smoke-drying process. Analyses of proximate compositions (moisture content, crude protein, crude lipid, crude fiber, and ash content) were conducted on both the fresh and smoked fish samples. The study revealed that smoke drying decreases the moisture content to a mean safe level of 36.64 ± 0.01% dry basis (d.b), and increase the crude protein content (17.35 ± 0.02), ash content (3.61± 0.01), fat content (4.04 ± 0.01), carbohydrate content (38.36 ± 0.01) of the studied fish samples. There was no crude fibre content (0.00) in the fresh fish samples. Hence, the smoking process had no noticeable effect on the fibre content. The smoked fish samples were rated high in terms of aroma, taste, texture, colour, and general acceptability by the panel of quality assessors. Significance of the results obtained as well as recommendations for future studies were offered.

Keywords: Fish, drying, proximate, sensory, smoking.

INTRODUCTION

Fish and its products is now a key food commodity for man's future survival (Effiong and Fakunle, 2011). It is one of the world's most important sources of animal protein preferred by most people (Chukwu, 2009). Due to the added non fish based nutrient it has which are all vital for human health and growth (Centre of Excellence Science Seafood Health, 2011). Aside protein, fish has nutrients such as omega-3 long chain polyunsaturated fatty acids (n-3 LC-PUFAs), iodine, calcium, and vitamin D, zinc and iron (McManus and Newton, 2011).

Fishes are the cheapest source of animal protein and play an important role in the diet of many people in both developed and developing countries but freshly caught fishes spoil easily and therefore require adequate preservation and storage (Mojisola, 2014; Nwakuba et al. 2018). Fish smoking is a process of treating fish by exposing it to smoke from smoldering wood or plant materials (Akinneye et al. 2010). This process is usually characterized by a combination of salting, drying, heating and smoking in a smoking chamber (Kumolu-Johnson et al. 2010).

Fish smoking is the simplest method of preservation of fish as it does not require sophisticated equipment or highly skilled workers (Eyo, 2001). Smoking as a method of preservation produces commonly acceptable products since it imparts desirable colour and flavor (Olayemi et al. 2011). Smoked seafood products vary widely in microbial stability, but this depends on the nature and degree of severity of smoking. There is a growing demand across Africa, Europe, United State of

America and Canada for smoked fish due to its nutritious and sensory properties (Egbal et al. 2010).

Smoking has been known to affect the weight, texture, colour, flavour, aroma and general acceptability of the finished products (Cardinal et al.. 2001; Abolagba and Osifo, 2008;Tawari and Abowei, 2011; Nwakuba et al. 2018).

Aba knife fish (Gymnarchus niloticus) is normally found in slow-moving streams and densely vegetated swamps and marshes (Eyo, 2001; Akinneye, 2010; Emere and Dibal, 2013). *Gymnaruchus niloticus* is rich in protein which commands a very high price in Nigerian market. It has an average price of $30 per fish, due to its high value and relished when smoked (Effiong and Fakunle, 2011).This study therefore, aims to determine the effect of smoking on the proximate composition (moisture content, crude protein, fat, crude fibre, ash, carbohydrate, energy content) and organoleptic quality (texture, aroma, colour, taste, and general acceptability) of Aba knife fish.

MATERIALS AND METHODS

Sample collection and preparation

Fresh Aba knife fish (*Gymnarchus niloticus*) were collected from local fishermen at Atani fish market in Anambra State of Nigeria. Fresh samples were preserved in ice to prevent post capture digestion, some sample were taken to the smoking kiln for smoke-drying. The samples (fresh and smoke dried) were taken for proximate composition analysis at the Biochemistry Laboratory of the National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria.

Materials and Reagents

The instruments used for this research study are soxhlet reflux flask, muslin cloth, electronic balance (model XY200L), digital thermometer, modified smoking kiln, measuring cylinders (100ml boro-silicate glass), trays, Whatman 43 filter paper, kjeldahl distillation apparatus, petri dish (pyrex), porcelain crucible, muffle furnace and thimble. The reagents used are concentrated sulphuric acid (H_2SO_4), selenium powder, sodium hydroxide (NaOH), boric acid, hydrogen chloride (HCl), petroleum ether and distilled water (H_2O).

Experimental Procedure

The methodology used for the production of smoke-dried Aba fish was as prescribed by Akintola et al. (2013). The fresh fish samples were measured in length and mass. The average length of the fresh samples was 61.85cm with a range of 58.9 - 64.8cmwhile the average mass was 12.9kg with a range of 7.8 – 10.2kg. The dimensions of the dressed fish fillets were taken as follows. The average yield length of the dressed fish fillet was 12.37cm with a range of 11.78– 12.96cm while the average yield mass of fish fillet was 1.77kg with a range of 1.1 – 2.4kgand was cut into twenty-one fillets. Clean water was used to wash the prepared fish fillets. Brining was carried out by dipping the fish fillets into 75% saturated brine solution which was made by dissolving 27g of salt solution (NaCl) in 100ml of water for one minute. The fish fillets were rinsed in fresh water and were sprayed in trays and seven fillets were taken to the laboratory for proximate analysis of the fresh sample while the other fourteen fillets were taken for smoke drying. The modified smoking kiln of 2kg charcoal and a mean temperature of 62^{o}C were used during the smoke-drying process. The fish fillets were loaded on the smoking tray and the temperature was taken hourly until a constant weight was achieved and the fish was properly smoked. The smoke-dried sample was divided into two, seven fillets were used for the sensory analysis and the other seven were taken to the laboratory to conduct the proximate analysis of the smoke-dried samples. The smoke drying process of the fish sample is shown below in Fig. 1.

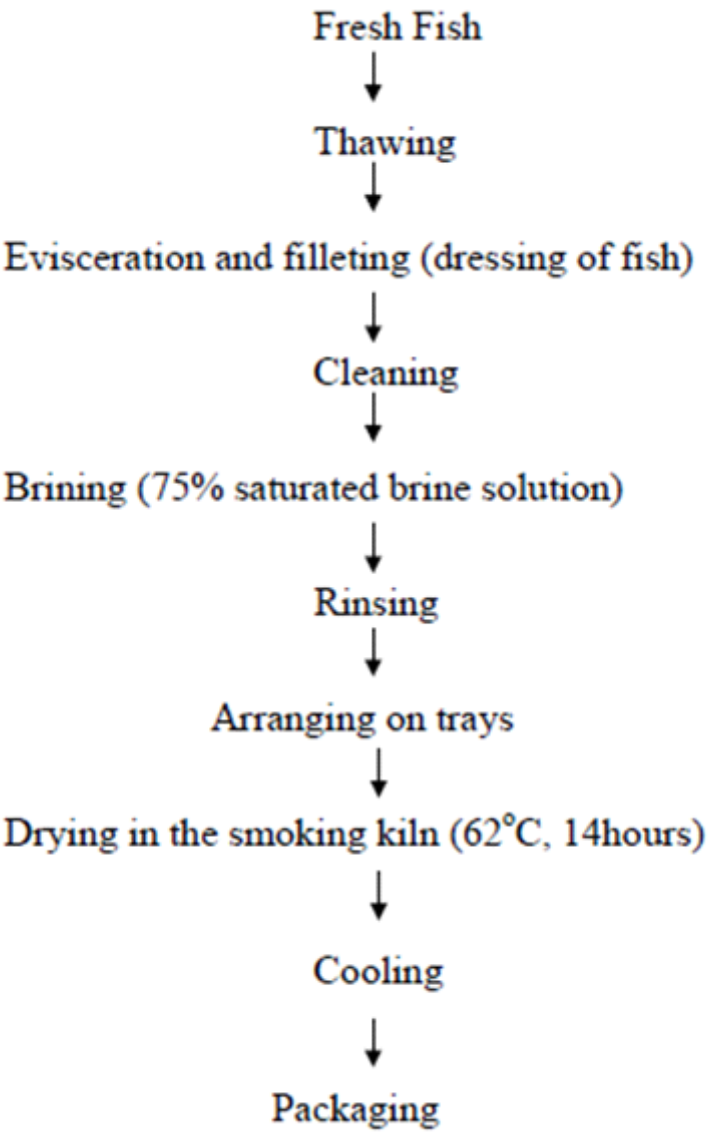

Fig. 1: Flow chart of *Gymnaruchus niloticus* smoke drying process

Proximate Analysis

The proximate composition of the fresh and smoke-dried samples was determined using the prescribed method described by Association of Official Analytical Chemists (AOAC, 2000). The procedures for the determination of the proximate properties of the fresh and smoke-dried fillet samples are as follows:

Determination of moisture content

A mass of 10g of the sample was poured into a previously weighed moisture can. The sample in the can was dried in the oven at 105^{0}C for three hours. It was cooled in desiccators and weighed, returned to the oven for further drying after which it was left to cool and weighed repeatedly at hour intervals until a constant weight was obtained (AOAC, 2000). The weight of the moisture lost was calculated as a percentage of the mass of the sample analyzed. It was given by the expression as shown in Equation (1):

$$\text{Moisture content} = \frac{100}{1} \text{ X} \frac{W_1 - W_3}{W_2 - W_3} \qquad (1)$$

Where: W_1= mass of empty moisture can, W_2= mass of moisture can + weight of sample before drying, and W_3= mass of moisture can + weight of sample dried to constant mass (g).

Determination of ash content

A mass of 3g of the processed sample was poured into a previously weighed porcelain crucible. The sample was burnt to ashes in a muffle furnace at 550°C. When it was completely ashed, it was cooled in desiccators and weighed (AOAC, 2000). The weight of the ash was expressed in percentage of mass of sample analyzed as shown in the Equation (2):

$$\%\,\text{ash} = \frac{100}{1} \text{ X } \frac{W_2 - W_1}{\text{Mass of sample}} \qquad (2)$$

Where: W_1 = mass of empty crucible (g), W_2= mass of crucible + ash (g).

Determination of crude fiber content

A mass of 3g of the processed sample was boiled in 150mls of 1.25% H_2SO_4 solution for 30mins under reflux. The boiled sample was washed in several portions of hot water using a two-fold muslin cloth to trip the particles which were returned back to the flask and boiled again in 150ml of 1.25% NaOH for another 30mins under the same condition. After washing in several portions of hot water, the sample was allowed to drain dry before being transferred to a weighed crucible where it was dried in an oven at 105°C to a constant mass (AOAC, 2000). It was burnt to ashes in a muffle furnace. The mass of fiber was calculated as a percentage of weight of sample analyzed. It was given by the expression as shown in Equation (3):

$$\%_{\text{crude fiber}} = \frac{100}{1} \text{ X } \frac{W_2 - W_2}{\text{Mass of sample}} \qquad (3)$$

Where: W_2= mass of crucible + sample after boiling, washing, and drying (g); W_3=mass of crucible +sample as ash (g).

Determination of fat content

The solvent extraction method was used (AOAC 2000). A mass of 3g of the processed sample was wrapped in a porous paper (Whatman 43 filter paper) and put in a thimble. The thimble was placed in a soxhlet reflux flask and mounted in a weighed extraction flask containing 200mls of petroleum ether. The upper end of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated. It boiled, vaporized and condensed into the reflux flask. The reflux flask filled up and symphonized over carrying its oil extract down to the boiling flask. The process was allowed to go on repeatedly for 4hours before the defatted sample was removed, the sample recovered and the oil extract was left in the flask. The flask containing the oil extract was dried in the oven at 60°C for 30minutes (to remove the residue solvent) cooled in desiccators and weighed (AOAC, 2000). By difference the weight of fat extract was determined and expressed as a percentage of the weight of the analyzed sample and is given by Equation (4):

$$\%\,\text{Fat} = \frac{100}{1} \text{ X } \frac{W_2 - W_1}{\text{weight of sample}} \qquad (4)$$

Where: W_1= mass of empty extraction flask and

W_2= mass of extraction flask + fat extract (g).

Determination of protein content

This was done by the Kjeldahl method. The total N_2 was determined and multiplied with a factor of 6.25 to obtain the protein content.1.0g of processed sample was mixed with 10ml of concentrated H_2SO_4 in a digestion flask. A tablet of selenium catalyst was added to it before it was heated in a fume cupboard until a clear solution was obtained (i.e., the digest) which was diluted to 100ml in a volumetric flask(AOAC, 2000).10mls of the digest was mixed with an equal volume of 45% NaOH solution in a Kjeldahl distillation apparatus. The mixture was distilled into 10mls of 4% boric acid containing 3 drops of mixed indicator (bromocresol green/methyl red). A total of 50mls of distillates was collected and titrated against 0.02N. The N_2 content and hence the protein content was calculated using Equation (5):

$$\%\,\text{Protein} = \%\,N_2 \times 6.25$$

$$\%\,N_2 = \frac{100}{w} * \text{ N } * \frac{14}{1000} * \frac{V\mathbf{t}}{Va}$$

Where: W= mass of sample (g), N= normality of titrant (0.02 H_2So_4), Vt=Total digest volume (100ml)
Va=Volume of digest analyzed (10ml), T=Titre value of sample (40ml) and B=Titre value of blank (50ml).

Determination of carbohydrate content

It was estimated using the Equations (6) – (8):
% carbohydrate = 100%(protein+ lipid + ash + crude fibre + moisture content + dry matter)(6)

Table 1: Indexes adopted by the panel for accessing the characteristics of the smoke-dried *Gymnaruchus niloticus* fish.

Colour	Rating	Taste/Aroma	Rating	Texture	Rating
Dark golden lustre	5	Excellent	5	Very dry	5
Golden lustre	4	Very good	4	Dry	4
Normal brown	3	Good	3	Fairly dry	3
Slightly brown	2	Fair	2	Spongy	2
Silvery	1	Poor	1	Wet	1
Mean value					

Figure 2: Fresh *Gymnaruchus niloticus* fish

Figure 3: Smoke-dried *Gymnaruchus niloticus* fish

RESULTS AND DISCUSSION

Proximate analysis

The result of the proximate analysis carried out on the fresh and smoked-dried fish samples is presented in Table 2.The mean crude protein content of the smoked samples increased 2.7% when smoke-dried, whereas moisture content was grossly reduced to a mean safe level of 36.64% d.b for storage. Similar results were obtained by Effiong and Fakunle (2011). The crude fiber value remained 0.0% after smoking because there was no crude fiber content in the fresh fish sample (Adebowale et al. 2008). The mean ash and carbohydrate content of the smoke-dried sample increased 2.38% and 33.92% respectively. More so, the mean fat content and energy increased 2.72 and 170.91%, respectively.

The result obtained from the study indicated weight loss as presented in Table 2, this shows that the fresh fish sample lost moisture content due to dehydration during smoke-drying which took between 14-16 hours before the final weight was obtained, these findings is in line with Chukwu (2009) and Egbal et al.. (2010). The loss in moisture of smoked fish samples is as a result of the application of heat which decreases water activity in fish tissue, while high moisture content provides a conducive environment for

spoilage by microbes (Akintola et al. 2013). The lowest moisture content recorded in smoked fish samples entails a longer shelf life of the product. It has been reported by Abolagba and Osifo (2008) that the principle of fish smoking is the removal of moisture content as a result of heat application from smoking.

The quality of fish protein is superior to that which could be obtained from milk, meat and eggs. The increase in protein content of smoke-dried sample as shown in Table 2 may be due to product dehydration which concentrated the protein during smoke-drying thereby increasing the nutritive value of the fish. A Similar finding was reported by Adebowale et al. (2008) who compared the crude protein level of *Clarias gariepinus* to the processed smoke-dried sample.

The result obtained in Table 2 shows that Fresh *Gymnaruchus niloticus* has a high moisture content (78.34%) with a low fat content (1.32%) after drying there was a significant increase in fat (lipid) content. Eyo (2001) reported that as the water content decrease in a fish, the fat increases and vice-versa. The increase in fat content could also be as a result of the heat generated by the smoking kiln which increases the concentration of nutrient in the mass of fat due to lipid oxidation. This finding is in line with Olayemi et al. (2011) who reported that during smoking fish losses its moisture content which result in increase in the concentration of nutrient in the remaining mass of fats.

Ash is the inorganic residue that remains after matter has been burnt off which was found in little non-significant traces in the fish sample. Ash is the measure of the mineral content of any food including fish (Omotosho et al. 2001). Smoke drying increase significantly (≤ 0.05) in Table 3, the ash content of Aba knife fish which could be attributed to the fish species, season and food availability. Similar findings was reported by Kumolu-Johnson et al. (2010) who observed significant difference in ash content of some smoked *Clarias gariepinus*. The ash content of the smoked dried sample increased to 3.61% (Table 2) which is similar to the works of Akinmeye et al. (2010) on *Bonga* Spp, *Sardinella* Spp and *Heterotis niloticus*.

Carbohydrate content in the fish fresh sample is 4.44% which is minimal and practically minute (Osibiona et al. 2009). From Table 2, after drying it was observed that the carbohydrate value of the smoked fish sample increased to 38.36%. Fresh fish generally do have very low levels of carbohydrates because glycogen does not contribute much to the reserves in the fish body tissue (USDA, 2010). Chukwu (2009) also observed that increase in carbohydrate of smoke-dried fish could be due to the fish consumption, absorption capacity and conversion potentials of essential nutrients from their diet or local environment into such biochemical attributes needed by the organism.

Table 2: Mean proximate composition (mean ± SD) n=3 of the fresh and smoke dried Aba Knife Fish.

Proximate Property	Fresh Sample	Smoke dried Sample
Moisture Content (%)	78.34 ± 0.03	36.64 ± 0.01
Protein Content (%)	14.68 ± 0.01	17.35 ± 0.02.
Fat (%)	1.32 ± 0.02	4.02 ± 0.01
Crude Fibre (%)	0.00	0.00
Ash Content (%)	1.23 ±0.01	3.61 ± 0.01
Carbohydrate (%)	4.44 ±0.005	38.36 ± 0.01
Energy (Cal/100g) (%)	88.29 ±0.08	259.20 ± 0.03

Table 3: Analysis of Variance (ANOVA) of the Mean proximate composition of Smoke Dried Fish Sample.

Parameters	Source of Variation	Sum of Squares	Df	Mean Square	-value	Sig.
Moisture content	Between groups	234.99	2	2607.084	1738056	0.0005
	Within groups	109.92	1	0.00015		
Protein content	Between groups	44.04	2	10.6934	225116	0.0001
	Within groups	52.05	1	0.0002		
Fat content	Between groups	5.36	2	10.935	185128	0.0010
	Within groups	12.06	1	0.0013		
Ash content	Between groups	4.84	2	8.4966	42483	0.0020
	Within groups	3.69	1	0.0002		
Carbohydrate	Between groups	43.12	2	1738.082	804667	0.0004
	Within groups	13.29	1	0.0182		
Energy	Between Groups	347.49	2	43815.12	219828	0.0001
	Within Groups	264.87	1	0.0002		

Sensory characteristics of smoke-dried *Gymnaruchus niloticus* fish fillet

The result of the sensory analysis carried out on the smoke-dried fish samples is presented in Table 4. The mean texture and aroma of the smoke-dried samples increased by3.2 and 2.2, also there was increase in the mean colour, taste and general acceptability of the smoked samples which is 3.3, 3.5 and 2.4 respectively. Similar results were obtained by Abolagba and Osifo (2008). The sensory qualities of a processed fish sample are of great importance due to the fact that every consumer wants good qualities from fish consumption. The sensory qualities of a fish are what normally attract consumers to it (Adebowale et al. 2008). The high temperature in the modified smoking kiln (62^{o}C) contributes to the loss of amino acids as a result of millard reaction which involves amino group of amino acids with sugars and carbonyis. It is this reaction that necessitates the characteristic golden brown colour of smoked fish. The concentration of nutrients and the denaturation affect of smoking

increase the taste of smoke-dried fish. There are chemical compounds in wood smoke with aromatic hydrocarbons in smoke which are important in chemical reactions leading to the production of the flavour, colour, and other properties of smoked fish (Abolagba and Osifo, 2008).

Results from Table 5 show the statistical analysis carried out to ascertain the level of significance of the sensory qualities of the smoke-dried fish sample. The texture mean score of 4.4 shows that the smoked fish sample was dry (Table 1) and statistically significant (≤ 0.05) with P-value of 0.010. It can also be seen that the mean aroma score of 4.6 indicates excellent taste (Table 1) is statistically significant (≤ 0.05) with P-value of 0.005. A mean score of 4.8 rating was given by the respondents on colour of the samples. This implies that the colour of the smoked samples is equated to a dark golden lustre (Table 1). In terms of taste and general acceptability, the respondents rated a mean score of 4.5 and 4.6 indicating very good taste and general acceptance, more so they are both statistically significant (Table 5).

Table 4: Mean scores of the ratings of respondents on fresh and smoke dried *Gymnaruchus niloticus* sample.

Sensory Property	Mean Score of Fresh Sample	Mean Score of Smokedried Sample
Texture	.2	4.4
Aroma	.4	4.6
Colour	1.5	4.8
Taste	.0	4.5
General Acceptability	2.2	4.6

Table 5: Analysis of variance (ANOVA) of the mean scores of respondents rating on smoked *Gymnaruchus niloticus*.

Parameters	Source of Variation	Sumof Squares	Df	Mean Square	F-value	Sig.
Texture	Between groups	36.45	1	36.45	46.532	0.010
	Within groups	14.10	8	0.783		
Flavo	Between groups	12.80	1	12.80	12.659	0.005
	Within groups	18.20	9	1.011		
Colou	Between groups	4.05	1	4.05	2.632	0.100
	Within groups	27.70	8	1.539		
Taste	Between groups	22.05	1	22.05	22.424	0.010
	Within groups	17.70	8	0.983		
General acceptability	Between groups	8.45	1	8.45	24.934	0.002
	Within groups	6.10	8	0.339		

CONCLUSION

In this experimental study, the proximate composition and sensory qualities of smoked local fish species, Aba knife fish *(Gymnaruchus niloticus)* were explored. Considering the results established from this work, the following conclusions are drawn:

Smoke drying increases the crude protein content, ash content, fat content, and carbohydrate content of *Gymnaruchus niloticus* and there was no crude fiber content in the fresh fish. Hence, smoking did not affect the fiber content. The smoked *Gymnaruchus niloticus* was rated high in texture, aroma, colour, taste, and general acceptability.

RECOMMENDATIONS

The result of the current study may be useful in determining the effect of smoke drying on the proximate and sensory characteristics of local fish species.Future empirical studies will consider the optimization of the proximate composition and sensory qualities at varying pretreatment conditions and smoking techniques. It will be expedient to establish prediction relations for the smoking energy demand and shrinkage influence of the different sizes of the Aba knife fish species.

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