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Comparative Study of the Proximate Composition and Sensory Evaluation of Fresh and Smoke-dried Fish Species from Omambala River, Anambra State, Nigeria

Anthonia Ujunwa Oli[1*], Patrick Amaechi. Okeke[2], Christian Chukwuemeka Oli[3], Franklin Nnanna Ibe[4] and John Dozie Okogwu[5]

[1,2]Department of Fisheries and Aquaculture Management, Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka
[3]Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka
[4,5]Department of Chemistry, Nwafor Orizu College of Education, Nzugbe
*Corresponding Author's Email: ujunwaanthonia@gmail.com

ABSTRACT

This study investigates the proximate composition and organoleptic properties of fish species from the Omambala River in Anambra State. A total of 40 fresh fish samples, specifically *Clarias gariepinus* and *Heterotis niloticus*, with a mean length of 25 cm and mean weight of 380 g, were analyzed. The fish samples, initially scaled, had their viscera removed and were washed in clean water before undergoing brining. This involved immersing the fish in a 75% saturated brine solution, prepared by dissolving 27 g of NaCl in 100 ml of water for 30 seconds. The samples were then smoke-dried in a smoking kiln. Proximate composition was assessed using standard methods from the Association of Analytical Chemists (AOAC), while organoleptic properties were evaluated using a 9-point hedonic scale. Data were collated and analyzed using a two-way analysis of variance (ANOVA) with GENSTAT version 4 software, and mean separation was performed using the Least Significant Difference at a 5% probability level. Results indicated that the proximate analyses revealed an increase in all nutrient compositions after smoke-drying, except for moisture and carbohydrates, which significantly decreased from 44.58% to 14.15% and from 37.10% to 7.88%, respectively, for *C. gariepinus.* In the case of *H. niloticus*, increases were noted in ash, fiber, fat, and protein, while moisture decreased significantly ($p<0.05$) from 44.87% to 17.89%. Organoleptic evaluation showed a preference for *C. gariepinus*, which had a significantly higher overall acceptability mean score of 8.40±0.66 compared to 6.70±2.26 for *H. niloticus.* This research demonstrates that smoke-drying fish effectively reduces moisture content, enhances nutrient composition, and improves organoleptic properties, thereby increasing shelf life. It is recommended that both *C. gariepinus* and *H. niloticus* be hygienically smoke-dried to maximize organoleptic qualities, nutrient composition, and shelf life, ultimately yielding better economic returns.
Keywords: Nutrient composition, organoleptic properties, Smoking kiln, Fish species

INTRODUCTION

Fishes are good source of human food that promotes growth and protect the body from a variety of health diseases such as cardiovascular and coronary heart diseases and prevents rickets and mental diseases in children [1, 2, 3]. The nutritional content can be used to rank different fish species based on their nutritional and functional benefits, allowing consumers to make better decisions according to their requirements. Generally, fish is made up of 70 – 84 % water, 15 – 24 % protein, 0.1 – 22 % fat and 1 – 2 % mineral and 0.1 – 1 % carbohydrate [4]. Fish has high nutritional value due to having rich contents of protein, water, amino acid composition and fatty acids [5, 6, 7, 8]. The nutritional value of fish has shown some beneficial effects on human health with efficient protective measures against cardiovascular diseases, cancer and Alzheimer's disease [9]. The nutritional value of fish used as a source of food is obtained from its chemical composition, which varies widely from species to species and within the same species. The feeding habit, sex and seasonal variations are among the main factors which can affect the nutrient composition in fish [10]. Proximate composition of fish includes determination of moisture, protein, fat and ash contents, which constitutes about 96%–98% of the total constituents of the fish body [11]. Fish is extremely

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perishable because it provides conducive environment for the development of microorganisms immediately after its death. Preservation means keeping the fish, after it has landed, in a condition wholesome and fit for human consumption for a short period to few days or for longer periods of over few months [12]. During the period of preservation, the fish is kept as near as possible, with minimum losses in flavour. Fish is highly susceptible to deteriorate immediately they are captured or harvested. Once the fish dies, a number of physiological and microbial activities commence, which reduces the quality of the fish [13]. Smoke dried products are considered a delicacy in many African countries and a good proportion of fish is consumed smoked. It is said that after you have tested smoked fish, you will be well and truly hooked" [14]. The original basis for fish processing by smoking is to add flavour. During smoking, the component of wood smoke deposited on the fish not only imparts good flavour and colour, but also increases fish stability due to its bactericidal and antioxidant properties. Phenolic compounds, acids and carbonyl present in wood smoke are believed to be responsible for these favourable changes [15]. Any fish can be smoked, however, fatter fish will absorb more smoke flavour, so fish like, mackerel, salmon and trout are perfect for smoking [16, 17, 18, 20] According to [17], smoked products are known to possess an increased resistance to oxidative changes in fatty foods such as fish. There are four basic methods used for preserving the final products of fish such as heating, freezing, controlling water activity, irradiation. These methods help to prevent fish from spoilage and degradation [21, 22, 23, 24]. Smoking as a process in addition to preservation, also provides unique sensory features with a partial dehydration of fish tissue and alternation of the texture. Fish contain a lot of water. Prior to smoking fish, the fish must be brined, or salted. The primary purpose of this process is not actually for flavour, since the finished product actually contains very little salt, but rather for pulling much of the excess moisture out of the fish [25, 26, 27, 28]. Organoleptic properties are otherwise known as sensory evaluation is simply how consumers react to a particular product. Consumer can either accept this product or not due to one reason on the other. This can be measured using either 5 hadonic or 9 hadonic scale measurement. It helps to measures the freshness of fish and fish products with respect to the five distinct senses including taste, smell, feel and appearance. Sensory evaluation of freshness is widely used attributes for ensuring quality of fish. Sensory evaluation is a crucial part in food development because it determines how consumers will react towards a product [29, 30, 31, 32, 33, 34]. It is generally assumed that consumers' primary consideration when selecting and consuming a new food *commodity* is the product's palatability and quality, with nutritional attributes taking a secondary role [35, 36, 37, 38, 39]. The fish samples used for this research consists of two fish species: *Clarias gariepinus* and *Heterotis niloticus.* These fish species were chosen because they are readily available, preferred by consumers, affordable, and within the reach of an average Nigerian. This research was carried out to determine the nutrient composition and sensory evaluation of fresh and smoke-dried fishes from Omambala river.

Materials and Methods

Sample Collection

A total of 40 fresh fish (*Clarias gariepinus* and *Heterotis niloticus*) samples with mean length of 25±7.07 cm and mean weight of 380±169.71 g were procured from fishermen at landing sites. The fish species were collected inside a sterile cooler containing ice park and transported to the Laboratory for analysis.

Sample Preparation

Fish samples were thoroughly washed with clean water several times to remove adhering blood and excessive mucus and then beheaded. Salt was employed in the ratio 1:10 (salt: fish ratio) for about thirty minutes to kill the fish and also used to reduce the bacterial load on the skin of the fish. The fish was eviscerated, washed and covered with a muslin cloth to prevent flies from perching on it prior to smoking process, as described by[6].

Fish processing and smoking

The smoking kiln was cleaned with clean water and towel and allowed to dry before placing the fresh fish sample on it. The fish samples placed on the smoking kiln was left for the first 10 hour at a temperature of 140 ^oC to allow effective smoking, after which it was left for the next 12 hours at 60 ^oC till the fish is completely dried. It was closely monitored to avoid being burnt. A collection of the fresh and smoked–dried fish were taken to Docchey Laboratory for determination of proximate composition.

Proximate Analysis

Determination of Moisture content [8]

A petri-dish was washed and dried in the oven. Approximately 2 g of the sample was weighed into petri dish. The weight of the petri dish and sample was noted before drying. The petri dish and sample was put in the oven and heated at 105 ^oC for 2 hour. The result noted and heated another 1 hour until a steady result is obtained and the weight was noted. The drying procedure was continued until a constant weight was obtained.

$$\% \, Moisture = \frac{W_1 - W_2}{Weight \, of \, sample} \times 100 \qquad (1)$$

Where:
W_1 = weight of petri dish and sample before drying
W_2 = weigh of petri dish and sample after drying.

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Determination of Ash content [8]

Empty platinum crucible was washed, dried and the weight was noted. Approximately 2 g of sample was weighed into the platinum crucible and placed in a muffle furnace at 550°C for 3 hours. The sample was cooled in a dessicator after burning and weighed.

Calculations:

$$\%\,Ash\ content = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

Where:

W_1 = weight of empty platinum crucible

W_2 = weight of platinum crucible and sample before burning

W_3 = weight of platinum and ash

Determination of Crude Fibre [8]

About 2 g of fish sample was defatted with petroleum ether (if the fat content if more than 10 %). Boil under reflux for 30 minutes with 200 mL of a solution containing 1.25 g of H_2SO_4 per 100 mL of solution. Filter the solution through linen. Wash with boiling water until the washings are no longer acid. Transfer the residue to a beaker and boil for 30 minutes with 200 mL of a solution containing 1.25 g of carbonate free NaOH per 100 mL. Filter the final residue through a thin but close pad of washed and ignited asbestos in a Gooch crucible. Dry in an electric oven and weigh. Incinerate, cool and weigh. The loss in weight after incineration x 100 is the percentage of crude fibre.

$$\%\ \text{crude fibre} = \frac{\text{weight of fibre}}{Weight\ of\ sample} \times 100 \quad (3)$$

Determination of Crude fat [33]

250 mL clean boiling flasks was placed in oven at 105 – 110 °C for about 30 minutes, and then transferred into a desiccator and allow to cool. Correspondingly labeled, cooled boiling flasks wash weighed. The boiling flask was filled with about 300 mL of petroleum ether (boiling point 40 – 60 °C. The extraction thimble was plugged lightly with cotton wool. The soxhlet apparatus was assembled and allowed to reflux for about 6 hours. Thimble was removed with care and petroleum ether in the top container of the set – up collected and drained into a container for re – use. The flask which is almost free of petroleum ether, was removed and dried at 105 – 110 °C for 1 hour. This was transfered from the oven into a dessicator and allow to cool and then weighed.

$$\%\ \text{Fat} = \frac{(\text{Weight of flask } + \text{oil}) - (\text{weight of flask})}{Weight\ of\ sample} \times 100 \quad (4)$$

Determination of Crude Proteins [8]

Exactly 0.5 g of sample was weighed into a 30 mL kjehdal flask (gently to prevent the sample from touching the walls of the side of each and then the flasks were stoppered and shaken. Then 0.5 g of the kjedahl catalyst mixture was added. The mixture was heated cautiously in a digestion rack under fire until a clear solution appeared. The clear solution was then allowed to stand for 30 minutes and allowed to cool. After cooling, it was made up to 100 mL with distilled. Water was added to avoid caking and then 5 mL was transferred to the kjedahl dstillation apparatus followed by 5 mL of 40 % sodium hydroxide. A 100 mL receiver flask containing 5 mL of 2 % boric acid and indicator mixture containing 5 drops of Bromocresol blue and 1 drop of methlene blue was placed added under a condenser of the distillation apparatus so that the tap was about 20 cm inside the solution and distillation commenced immediately until 50 drops gets into the receiver flask, after which it was titrated to pink colour using 0.01 N hydrochloric acid.

Calculations:

% Nitrogen =Titre value × 0.01 x 14 × 4 (5)

% Protein = % Nitrogen × 6.25 (6)

Determination of carbohydrate

In the determination, the carbohydrate content of a sample was regarded as the nitrogen free extract and this was determined by adding up the percentage of moisture, Ash, protein, Fat and subtracting the sum from 100.

% carbohydrate = 100- (% Protein + % Ash+ Moisture + % Fat + %Fibre) (7)

Organoleptic Characteristics Method

Organoleptic characteristics analysis, as outlined by [31], employed a subjective analysis approach. Twenty consumers of the fish were recruited for the tests. Members of the panel were selected and trained for each parameter like odour, texture, flavour, palatability and appearance aspects of organoleptic characteristics and how to allocate mark for each parameter [4, 32]. Both genders were equally represented to avoid errors due to gender [1]. Fish products samples were unwrapped served in clean petri-dishes alongside questionnaires to the panelists. Panelists were instructed to assess the fish by feeling and tasting it, assigning scores based on appearance, texture, aroma/flavor, taste, and acceptability/palatability. The Organoleptic characteristics were assigned numeric values

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on the hedonic scale of 1-5. Where 1=Poor, 2=Fairly good, 3=Averagely good, 4=Good, 5=Excellent. The questionnaires were returned and analysed for each parameter.

Statistical Analysis

The data obtained from the study was collated and a two-way analysis of variance (ANOVA) was employed to reveal significant difference using the GENSTAT version 4 analytical software. Mean separation was done using the Least Significant Difference at 5 % probability level.

RESULTS

The proximate composition and organoleptic properties of each of the two species of fish: *Clarias gariapenus (C. garienpinus)* and *Heterotis niloticus* (*H. niloticus*) from Omambala River, Aguleri, Anambra State were investigated, and results displayed in Tables 1 and Table 2 as well as in Figures 1 and 2 respectively.

Table 1: Proximate Composition of Fresh and Smoke–dried Fish Samples

Fish Species	Exp fish	Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	CHO (%)
C. garienpinus	Fresh	44.87±0.80	2.38±1.34	3.16±0.30	8.39±0.15	23.92±0.20	17.28±0.44
	Smoked	17.89±0.84	7.39±0.49	6.32±0.18	23.41±1.31	37.10±0.20	7.88±1.44
H. niloticus	Fresh	44.58±0.68	4.88±0.60	2.24±0.16	6.54±0.35	26.83±0.12	14.93±1.09
	Smoked	14.15±0.19	5.68±0.21	6.24±0.28	15.3±0.30	33.72±0.12	24.91±0.76
$LSD_{0.05}$		2.22	1.33	0.77	2.28	0.47	3.28

M±SE = Mean±Standarad Error, Exp Fish: Experimental fish, M: Mean of triplicate analysis

Table 2: Mean Score of Organoleptic Evaluation of *Clarias gariepinus* and *Heterotis niloticus*

Fish species	Appearance	Taste	Aroma	Texture	Overall Acceptability
C. gariepinus	8.20±0.92	8.10±0.88	7.10 ±1.29	7.30 ±1.25	8.40 ±0.70
H. niloticus	8.10 ±0.88	5.40±1.90	5.20±2.53	7.10 ±2.33	6.7±2.26

M±SD = Mean±Standarad deviation, M: Mean of triplicate analysis

DISCUSSION

It was found that the moisture content varied among the examined species, ranging from 44.58 to 44.87 % for fresh fish and 14.15 to 17.89 % for smoke-dried fish. In both fresh and smoked fish, *C. gariapenus* has the highest moisture content. The moisture content of fresh *C. gariapinus* is higher than that of fresh *H. niloticus.* However, there was no significance difference in the values obtained. The variation in moisture content among species may be attributed to differences in season or feeding habits [30]. Moisture is the principal constituent of fish, quantity-wise. Moisture content in many fish varies between 60–80%. Moisture content is also found to vary considerably within the same species of fish depending on the age, fat content, feeding condition etc. Fatty fish exhibit an inverse relationship between fat and moisture contents [10], which is agrees with the results obtained in this study. The moisture content of *C. gariepinus* and *H. niloticus* samples indicates that both fish species are composed of water rendering them highly perishable. The moisture contents of the fresh fish species were significantly ($p<0.05$) higher than those of the smoked fish. The reduction in the moisture content of the smoked samples is as a result of water loss during the smoking process. This reduction in moisture content is of advantage as it safeguards fish samples from microbial attack and rapid spoilage due to lipid dehydrogenation. The main principle involved in fish processing by smoking is the creating of an unfavourable environment for microbial growth by reducing the fish moisture content through heating, thereby prolonging shelf life [5]. The moisture content of the fresh fish samples were not consistent with the findings of [20]. This study shows that fresh *C. gariapinus* and *H. niloticus* have the ash contents of 2.37 % and 4.88 % respectively while the smoke-dried *C. gariapinus* and *H. niloticus* were found to possess ash content of 7.39 % and 5.67 % respectively. In both species studied, there was an increase in the percentage ash content after smoke-drying: *C. gariapinus* showed 68 % increase while *H. niloticus* increased by 14 %. Significant difference ($p<0.05$) was observed between the ash content of the fresh and smoke-dried *C. gariapinus.* Similarly, the ash in fresh *H. niloticus* differed significantly from that in the smoke-dried sample. Also, there was significance difference between the ash content of the fresh *H. niloticus* and fresh *C. gariepinus.* Ash is a measure of the mineral content of a food item. The range of the ash content in the present study is an indication that the fish samples may be sources of minerals such as calcium, potassium, zinc, iron and magnesium [14]. High ash content has been reported to lower bacterial and fungal activities leading to better shelf life in fishes [17]. It was observed from the results presented in Table 1 that the fibre content in both *C. gariapinus* and *H. ninoticus* showed a progression after smoke-drying. While the fibre content in *C. gariapinus* increased from 3.16 to 6.32 %, *H. niloticus* increased from 2.24 to 6.24 % leading to 50 percent and 64 percent rise in fibre of *C. gariapinus* and *H. niloticus* respectively after smoke-drying of the fish. Fresh *C. gariapinus* and *H. niloticus* gave percentage fat of 8.39 % and 6.54 % while the smoke-dried samples gave 23.41 % and 15.30 % respectively. Again, there was an increase in %Fat in each of the two species studied after smoke – drying. The difference between the values obtained for fresh and smoke-dried samples of each species was significantly high ($p<0.05$). Fat or lipid serves as source of energy during starvation and fasting [14]. The lipid level in the fish tissues is under direct influence of their food and feeding habits [9]. According to [18], fishes are often classified on the basis of their fat contents, that is, lean fish (fat < 5 %), medium fat fish (fat 5 –10 %) and fatty fish (fat > 10 % by weight). Based on this classification, fish species under the present study were classified as medium fat fish. [23], also reported that the fat level in the fish could have been due to the impact of the feed. There was a difference in the fat content of all the fresh samples because the lipid content of the samples increased as the fish dried. These similar values of the fat content in the fish samples may be because they were obtained from the same source and were subjected to the same conditions. This could be the result of evaporation of moisture contents which is in agreement with the previous work by [26]. These findings, is in line with the result obtained by [29] who reported that during fish smoking, fish loses its moisture content, which results in increase in the fats. The result of the fat content obtained in this study was slightly different from the report of [30], who recorded a range of 14.47 – 15.53 % for smoked dried *C. gariepinus* in Lapai, Niger state, Nigeria.

Apart from moisture which showed the highest value, protein is the next parameter that has high values as indicated in Table 1 and Figure 1, where protein content was slightly higher in the muscle of fresh *H. niloticus* than in *C. gariepinus*. Proten in fresh *C. gariapinus* (23.90 %) and *H. niloticus* (26.83 %) increased to 37.10 % in *C. gariapinus* and 33.72 % in *H. niloticus* after the samples have been smoke-dried. Nutritionally, protein content is the most essential constituent which defines the wholesomeness and quality of fish meat. Generally, protein is important for proper functioning of antibodies resisting infections, regulation of enzymes and hormones, growth and repair of body tissues [16, 19]. The significant increase in protein of *C. gariepinus* from 23.90 to 37.10 % and *H. niloticus* from 26.83 to 37.72 % makes the smoked samples of *C. gariepinus* and *H. niloticus* good sources of dietary protein for human consumption. The result shows that the crude protein increased as the moisture reduces. Also, the range of the values recorded for protein in this study agreed with the observation (33.66 – 66.04 %) of [1]. The value of the crude protein content also shows the inverse relationship between the protein and moisture contents. [26], opined that the protein content of fish may be influenced by size, sexual maturation, water quality as well as feeding ration and frequency. The observed protein levels of fish species indicated that they belonged to the high-protein (18–23 %) category [4]. The highest protein content of *H. niloticus* may be attributed to its carnivorous nature. The high tissue protein content of the fish species in this study may be related to the high protein contents of their common diets as they fed mostly on fish items, crustaceans, molluscs, algae and diatoms [4]. The findings of the present study are in line with what was recorded by Neeru *et al.* (2017) who also observed increase in protein after smoking. Table 2 shows that the values obtained for appearance and texture in *Clarias gariepinus* and *Heterotis niloticus* were not significantly different ($p>0.05$) indicating that they were at about the same range. However, the consumers preferred the appearance and texture of *Clarias gariepinus* to that of *Heterotis niloticus*. There was a significant difference ($p<0.05$) between the taste of the two smoke-dried fish species under study; the panelists preferred the taste of *Clarias gariepinus*. Also, there was preference for the aroma of *Clarias gariepinus* over that of *Heterotis niloticus*. The result of this analysis shows the overall acceptability of *Clarias gariepinus* and *Heterotis niloticus* to be 8.40 and 6.7 respectively which is 93% and 74% respectively. Organoleptic evaluation is a crucial part in food development because it determines how consumers will react towards a product [5]. It is generally assumed that consumers' primary consideration when selecting and consuming a new food commodity is the product's palatability and quality, with nutritional attributes taking a secondary role [27]. The appearance, texture, aroma/flavour, taste and overall acceptability of *Clarias geriepinus* were most preferred. The texture probably may be due to relatively low water-holding capacity and low resistance to mechanical stress (compression, extrusion) when smoked, thus contributing to the tenderness, juiciness and better taste of the flesh. This is similar to the observation of [30] who compared the proximate composition and sensory attributes of different *Claris* catfish species. Taste and aroma/flavour play a significant role in food choices, appetite and nutrient intake because chemosensory signals prepare the body to digest food by triggering salivary, pancreatic, intestinal and gastric secretions (cephalic phase responses) which enable the detection and discrimination of foods in the face of fluctuating nutritional requirements. There is an association between a food's taste and aroma/flavour and its postingestive effects because taste enables the consumer to modulate food intake in anticipation of its nutritional consequences. Thus, 33] concluded that taste and aroma/flavour indicates the nutritional value of food while they (taste and aroma) both initiate, sustain and terminate ingestion, therefore playing a major role in the volume of consumed food. It has also been reported that aroma/flavour and appearance may be affected by the composition of fatty acid and resultant effects of lipid oxidation [24] while the overall palatability or acceptability is a reflection of the cognitive and qualitative sensor.

CONCLUSION

This study has established that fresh smoked *Clarias gariepinus and Heterotis niloticus* are more nutritious than the fresh fish samples. This is because they had higher nutrient composition. The study revealed that *Clarias gariepinus* was more accepted because according to the panelists, it possessed better taste, aroma, appearance and texture. This study also revealed that smoking of fish helps to reduce the moisture content thereby increasing the shelf life as well as the nutritional values.

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