p-ISSN. 2406-9825
e-ISSN. 2614-3178

Acta Aquatica: Aquatic Sciences Journal, 11:1 (April, 2024.): 49-55

Acta Aquatica
Aquatic Sciences Journal

Quality assessment of smoked catfishes (*Clarias gariepinus*, *Heterobranchus longifilis* and *Synodontis clarias*) from selected fish markets in Benue State, Nigeria

Received: 18 January 2023, Revised: 31 January 2024, Accepted: 09 February 2024
DOI: 10.29103/aa.v11i1.10076

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Abstract

The quality assessment of smoked catfish from selected fish markets in Benue state was carried out. *Clarias gariepinus*, *Heterobranchus* spp. and *Synodontis* spp. each weighing 500g were collected from Abinsi and Wadata markets. The proximate composition, mineral composition and organoleptic assessment were carried out. Association of Official Analytical Chemists (AOAC) methods were adopted for the determination of proximate and mineral composition while a 9-point Hedonic scale ranging from 1(dislike extremely) to 9(like extremely) was a procedure for organoleptic quality determination. Results for proximate and mineral compositions showed good standard but varied from market to market. Abinsi fish markets showed that *Heterobranchus* spp. had 10.16%, 12.74%, 58.98%, 16.42%, 1.71%. *Clarias gariepinus* had 9.09%, 10.10%, 66.11%, 13.94%, 0.76%. *Synodontis* spp. had 8.19%, 11.07%, 55.80%, 22.68%, and 2.27% as values for moisture content, ash content, protein content, lipid content and carbohydrates content while Wadata fish market *Heterobranchus* spp. had 10.34%, 11.89%, 59.48%, 15.71%, and 2.59%. *Clarias gariepinus* had 8.88%, 11.37%, 68.97%, 10.37%, 0.38%. *Synodontis* spp. had 8.36%, 12.19%, 56.35%, 21.30%, and 1.81% for moisture content, ash content, protein content, lipid content and carbohydrates content respectively. The mineral composition for Abinsi fish showed that *Heterobranchus* spp. had 240.33 mg/100g, 395.48 mg/100g, 32.44 mg/100g, 0.03 mg/100g, 0.80 mg/100g, 5.37 mg/100g; *Clarias gariepinus* had 270.30 mg/100g, 278.05 mg/100g, 32.14 mg/100g, 0.21 mg/100g, 0.30 mg/100g, 5.06 mg/100g; *Synodontis* spp. had 330.05 mg/100g, 257.78 mg/100g, 34.24 mg/100g, 0.24 mg/100g, 0.40 mg/100g, 6.98 mg/100g; for Potassium, Calcium, Sodium, Copper, Zinc and Iron while in Wadata fish market *Heterobranchus* spp. had 250.30 mg/100g, 127.88 mg/100g, 39.84 mg/100g, 0.39 mg/100g, 0.68 mg/100g, 4.95 mg/100g; *Clarias gariepinus* had 410.15 mg/100g, 159.33 mg/100g, 33.03 mg/100g, 0.22 mg/100g, 0.60 mg/100g, 5.96 mg/100g; *Synodontis* spp. had 300.45 mg/100g, 295.48 mg/100g, 33.93 mg/100g, 0.30 mg/100g, 0.71 mg/100g, 12.0 mg/100g; for Potassium, Calcium, Sodium, Copper, Zinc and Iron. The sensory evaluation revealed that taste, appearance, texture and odour were accepted by the panellist and significant difference occurred ($P<0.05$) among samples from both markets. The three catfish species from this study were found to be rich in protein content, Potassium, Calcium, and Sodium with low presence of Copper, Zinc, Iron, lipid and carbohydrate contents.

Keywords: Catfishes; markets; quality assessment; smoked

1. Introduction

Fish and fishery products constitute an important food commodity in international trade due to its ever-increasing consumption demand. Fish is a good source of quality protein, minerals, vitamins and omega 3-fatty acids (Rhea, 2009; Pal, 2010). It contributes about 60% of the world's supply of protein, and 60% of the developing world derives more than 30% of its animal protein from fish (Emikpe *et al*., 2011). In Nigeria, fish constitutes 40% of animal protein intake and is highly accepted for its quality, availability and affordability (Kabaherda *et al.*, 2009).

The nutritional quality of fish has been adjudged as first class. However, this status becomes short-lived soon after the fish dies. Normal micro-flora which was once helpful turns harmful. They graduate to becoming pathogenic when environmental factors like temperature and relative humidity in association with bad handling, poor hygiene, and delayed processing and preservation set in. The contamination often occurs from human and animal sources, and thus, fish and seafood can be involved in the transmission of pathogenic microorganisms and toxins (Pal, 2012).

Food processing and preservation aim to inhibit microbial growth, improve acceptability and above all extend the shelf-life of the products either by way of using

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preservatives, refrigerating or traditionally by either salt-curing or smoking. In Nigeria, the socioeconomic status of rural fish farmers and consumers makes smoking the most preferred choice of processing. The preservation technique of smoking has been a method dated back to civilization as a means of preserving fish. According to Ali *et al.* (2011), smoking reduces the moisture content of fish to the point that it impairs the activities of spoilage microbes. It gives special colour and flavour to the fish (Alasalvar *et al*, 2011) and extends its shelf-life via the effects of dehydration, anti-microbial and anti-oxidant of the smoke compounds (Eyo, 2001; Kumolu *et al*., 2013).

The quality of smoked fish could be degraded through a complex process, in which the physical, chemical and microbiological forms of deterioration are involved. The enzymatic and chemical reactions are usually responsible for the initial loss of freshness whereas microbial activity is responsible for the obvious spoilage, and thereby establishes product shelf life (Huss, 1997). Sensory methods are the most satisfactory for assessing the spoilage and freshness of fish and fishery products (Pal, 2010).

According to the International Organization for Standardization (ISO), quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated needs. For fish products, this refers to the purity, nutritive safety, consistency in value and excellence of the fish product which is difficult to obtain when fish is smoked and dried because the processing of the fish product is not done under a better controlled environment. Control of microorganisms exerted through, a high level of hygiene efficient cleaning, and disinfection practices during the processing and preservation procedures are essential to enhance safe wholesome and acceptable fish products reaching the consumer. Therefore, this study aimed to assess the quality of smoked *Clarias gariepinus*, *Heterobranchus longifilis* and *Synodontis clarias* from selected fish markets in Benue state, Nigeria.

2. Materials and Methods

2.1. Sample collection

Smoked dried fish samples were randomly purchased from three different locations at Abinsi and Wadata markets in Benue State. Samples of smoked *Clarias gariepinus*, *Heterobranchus longifilis* and *Synodontis clarias* each weighing approximately 500g were sourced. The samples were collected and packaged separately using foil paper and polythene bags and were taken for laboratory analysis.

2.2. Proximate composition analysis

The proximate composition of the samples was determined according to the Association of Official Analytical Chemists methods (AOAC, 2010). The moisture, crude protein, ash, fat and carbohydrate, analyses were conducted in Nigeria Stored Product Research Institutes (NSPRI) Ilorin Kwara State.

2.2.1. Moisture content

The uncovered dish was placed with its lid open in a well-ventilated oven maintained at 103^{o}C for 3 hours the dish was transferred to a desiccator at room temperature to cool for 30 minutes, and five grams (5g) of the smoked fish sample was weighed into a pre-weighed, clean and dry dish provided with an easily removable lid, then a dish with the sample was placed in the oven for 2 hours. The step was repeated until decreases in mass between successive weighs which do not exceed 0.5 per g (fresh weight basis). The loss in weight was reported as the moisture content (AOAC, 2010).

$$\%\ \text{Moisture content} = \frac{w1 - w2}{w1 - w0} \times 100$$

$w0 =$ Initial weight of sample before drying
$w1 =$ Weight of the sample after drying
$w2 =$ Weight of the dish, lid and the sample

2.2.2. Crude protein

Two grams (2g) of the fish sample was weighed into a digestion tube and 15mL of concentrated H_2SO_4 was added to dissolve the sample. Kjedhal tablets were added to start up the digestion process in a fume cupboard preset at 410^{o}C for 45 minutes until it gives a clear solution. 75 mL of distilled water was added to prevent it from solidifying after digestion. The tube was placed in a distilling unit and 50mls of 40% NaOH was dispensed into the diluted solution, and the digested distillate into 25 ml of 40% boric acid for 5 minutes. The distillate was titrated against Hcl until the first grey colour was seen with 55.92 recorded as titre value. A blank was first run and the titre value was recorded (AOAC, 2010).

$$\%\ \text{Crude protein} = \frac{T \times N \times D \times 14 \times C.F \times 100}{M \times 100}$$

T = Volume of HCl used
N = Molarity of the HCl solution
D = Dilution factor
C.F = Factor used in converting Nitrogen into protein
M = Mass of the sample

2.2.3. Ash content determination

Five grams (5g) of the fish sample was weighed into an empty porcelain crucible that had been previously ignited and weighed. The sample and crucible were thereafter placed in the muffle furnace maintained at a temperature of 600^{o}C for 6 hrs. After ashing, it was then transferred directly to a desiccator and weighed immediately (AOAC, 2010). The % ash was calculated from the expression.

$$\%\ \text{Ash} = \frac{(\text{Weight of the crucible} + \text{Ash}) - (\text{Weight of empty crucible}) \times 100}{\text{Weight of sample}}$$

2.2.4. Lipid determination

Crude fat was also carried out using the method (AOAC, 2010) of Cleaning and weighing a dried thimble. Which was recorded as (W1) and a 5g oven-dried fish sample was added and re-weighed as (W2). The round bottom flask was filled with petroleum ether (40-60^{o}C) up to 0.75 volume of the flask. Soxhlet extractor was fixed with a reflux condenser to adjust the heat sources so that the solvent boils gently, the samples were then put inside the thimble and inserted into the Soxhlet apparatus and extraction under reflux was carried out with petroleum ether for 6 hours. After the barrel of the extractor was empty, the condenser was then removed and the thimble was removed, taken into the oven at 100^{o}C for 1 hour and later cooled in the desiccator. This was then weighed as (W3).

$$\%\ \text{Fat} = \frac{\text{Weight of fat}}{\text{weight of sample}} \times 100$$

$$\%\ \text{Fat} = \frac{w2 - w3}{w2 - w1} \times 100$$

2.2.5. Carbohydrate content determination

Carbohydrate content determination was determined by difference.

%Carbohydrate= 100 - % (Protein + Crudefat + Ash + Moisture + Crudefiber)

2.3. Organoleptic assessment

A panel of Ten (10) judges were selected from the Centre for Food Technology and Research (CEFTER) community at random to assess the smoked dried catfish samples, A 9-point hedonic scale ranging from 1(Dislike extremely) to 9 (Like extremely) was used (Olayemi *et al.*, 2011). The qualities assessed were: appearance, odour, texture, and taste.

2.4. Mineral determination

2.4.1. Wet digestion of sample

One gram (1.0 g) of the powdered sample was weighed in a digesting glass tube, twelve millilitres (12 ml) of HNO_3 was added to the fish samples and the mixture was kept overnight at room temperature. Then 4.0 ml $HClO_4$ was added to the mixture and was kept in the fumes block for digestion. The temperature was increased gradually, starting from 50°C and increasing up to 250-300°C. The digestion was completed in about 70-85 minutes as indicated by the appearance of white fumes. The mixture was left to cool and the contents of the tubes were transferred to 100 ml volumetric flasks and the volumes of the contents were made to 100 ml with distilled water. The wet digested solution was transferred to plastic bottles labelled accurately and stored. The digest was used for mineral determination.

2.4.2. Determination of mineral elements by AAS

Determination of Minerals by Atomic Absorption Spect rometry AAS) was carried out at the University of Ilorin Central Research Laboratories using model BUCK scientific ACCUSYS 211 AAS. The atoms of an element are vaporized and atomized in the flame, and then the atoms absorb the light at a characteristic wavelength. The source of the light is a hollow cathode lamp, which is made up of the same element, which has to be determined. The lamp produces radiation of an appropriate wavelength, which while passing through the flame is absorbed by the free atoms of the sample. The absorbed energy is measured by a photo-detector read-out system. The amount of energy absorbed is proportional to the concentration of the element in the sample. Standards for each element under investigation were prepared in part per million (ppm) and the limit standard concentration for each element was adhered to according to the Scientific instruction. The standard solutions were aspirated and the graph was obtained. The sample concentrations of various metals were read and calculated using the equation below.

$$= \frac{\text{concentration of sample(ppm)}}{\text{Weight of sample}} \times \text{dilution factor } (100)$$

2.5. Statistical analysis

The data were subjected to analysis of variance (ANOVA) using Genstat (Discovery version) and a significant test for differences between sample means was done using the Duncan multiple range (DMRT) test at a 5% level of significance.

3. Results and Discussion

3.1. Result

3.1.1 Proximate compositions

The moisture content, Ash content, protein content, fat content and carbohydrate content from the two markets were in the range of 8.19% to 10.16%, 10.10% to 12.74%, 55.80% to 68.97% 10.37% to 22.68% and 0.38% to 2.59% respectively. From the Abinsi market, *Heterobranchus* spp. had 10.16%, 12.74%, 58.98%, 16.42%, and 1.71%. *Clarias gariepinus* had 9.09%, 10.10%, 66.11%, 13.94%, 0.76%. *Synodontis* spp. had 8.19%, 11.07%, 55.80%, 22.68%, and 2.27% as values for moisture content, Ash content, protein content, lipid content and carbohydrate content. While in Wadata fish market *Heterobranchus* spp. had 10.34%, 11.89%, 59.48%, 15.71%, and 2.59%. *Clarias gariepinus* had 8.88%, 11.37%, 68.97%, 10.37%, 0.38%. *Synodontis* spp. had 8.36%, 12.19%, 56.35%, 21.30%, and 1.81% for moisture content, Ash content, protein content, lipid content and carbohydrates content respectively. *Heterobranchus* spp had higher values of moisture content in both markets. Significant ($P<0.05$) differences occur between the same smoked catfish species from the Abinsi and Wadata markets. The significant ($P<0.05$) differences occur between *Clarias gariepinus* for moisture contents, *Heterobranchus* spp., *Clarias gariepinus, Synodontis* spp. for Ash content, *Clarias gariepinus* for protein content, *Heterobranchus* spp., *Clarias gariepinus, Synodontis* spp. for lipid content and *Heterobranchus* spp. for carbohydrates content between the two markets. The protein content values of the *Heterobranchus* spp. *Clarias gariepinus*, *Synodontis* spp. from both markets showed high values and variation in the markets (Table 1).

3.1.2. Elemental composition of smoked catfishes from Abinsi and Wadata market

Table 2 shows the mineral composition of Heterobranchus spp. Clarias gariepinus and Synodontis spp. The mineral analysis showed the presence of potassium (K) calcium (Ca) sodium (Na) Copper (Cu) Zinc (Zn) and Iron (Fe). The values of the mineral composition varied between smoked catfish species from the two markets. The range was between 240.33 to 410.15 mg/100g, 127.88to 395.48mg/100g, 32.14 to 39.84 mg/100g, 0.03 to 0.39 mg /100g, 0.30 to 0.80 mg/100g, 4.95 to 12.00 mg/100g, for Potassium, Calcium, Sodium, Copper, Zinc and Iron Respectively. Heterobranchus spp. had 240.33 mg/100g, 395.48 mg/100g, 32.44 mg/100g, 0.03 mg/100g, 0.80 mg/100g, 5.37 mg/100g; Clarias gariepinus had 270.30 mg/100g, 278.05 mg/100g, 32.14 mg/100g, 0.21 mg/100g, 0.30 mg/100g, 5.06 mg/100g; Synodontis spp. had 330.05 mg/100g, 257.78 mg/100g, 34.24 mg/100g, 0.24 mg/100g, 0.40 mg/100g, 6.98 mg/100g; for Potassium, Calcium, Sodium, Copper, Zinc and Iron in Abinsi market while in Wadata market Heterobranchus spp. had 250.30 mg/100g, 127.88 mg/100g, 39.84 mg/100g, 0.39 mg/100g, 0.68 mg/100g, 4.95 mg/100g; Clarias gariepinus had 410.15 mg/100g, 159.33 mg/100g, 33.03 mg/100g, 0.22 mg/100g, 0.60 mg/100g, 5.96 mg/100g; Synodontis spp. had 300.45 mg/100g, 295.48 mg/100g, 33.93 mg/100g, 0.30 mg/100g, 0.71 mg/100g, 12.0 mg/100g; for Potassium, Calcium, Sodium, Copper, Zinc and Iron. There was a significant difference in the Potassium (K) content of Heterobranchus spp. Clarias gariepinus and Synodontis spp. between Abinsi and Wadata markets at ($P<0.05$) level. There was a significant difference in the values of Calcium (Ca) in Heterobranchus spp., Clarias gariepinus and Synodontis spp. between Abinsi and Wadata

markets, Sodium (Na) in Heterobranchus spp. Clarias gariepinus showed a significant difference between Abinsi and Wadata markets. There was a significant difference in the values of Copper (cu) in Heterobranchus spp. between Abinsi and Wadata markets. Zinc (Zn) showed a significant difference in Heterobranchus spp. Clarias gariepinus and Synodontis spp. between Abinsi and Wadata markets while Iron (Fe) showed a significant difference in Clarias gariepinus and Synodontis spp. between Abinsi and Wadata markets.

Table 1
Proximate compositions of smoked fish obtained from Abinsi and Wadata markets in Benue State.

Market	Sample	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Carbohydrate (%)
Abinsi	*Heterobranchus* spp.	10.16±0.07^{d}	12.74±0.30^{d}	58.98±0.12^{b}	16.42±0.31^{d}	1.71±0.04^{b}
	Clarias gariepinus	9.09±0.04^{c}	10.10±0.03^{a}	66.11±0.04^{c}	13.94±0.11^{b}	0.76±0.09^{a}
	Synodontis spp.	8.19±0.11^{a}	11.07±0.04^{b}	55.80±0.17^{a}	22.68±0.18^{f}	2.27±0.16^{cd}
Wadata	*Heterobranchus* spp.	10.34±0.06^{d}	11.89±0.11^{c}	59.48±0.59^{b}	15.71±0.06^{c}	2.59±0.47^{d}
	Clarias gariepinus	8.88±0.05^{b}	11.39±0.09^{b}	68.97±0.13^{d}	10.37±0.04^{a}	0.38±0.10^{a}
	Synodontis spp.	8.36±0.10^{a}	12.19±0.17^{c}	56.35±0.13^{a}	21.30±0.28^{e}	1.81±0.13^{bc}
LSD (0.05)		0.183	0.373	0.652	0.470	0.532
P-Value		0.001	0.001	0.001	0.001	0.001

Means±Standard Deviation on the same column with different superscript differs significantly at P<0.05 level.

Table 2
Elemental composition of smoked fish species obtained from Abinsi and Wadata Fish Markets, Benue State.

Market	Sample	Mineral Concentration in mg/100g					
		K	Ca	Na	Cu	Zn	Fe
Abinsi	*Heterobranchus* spp.	240.33±0.11^{a}	395.48±2.28^{e}	32.44±0.26^{a}	0.03±0.04^{a}	0.80±0.04^{e}	5.37±0.05^{a}
	Clarias gariepinus	270.30±1.02^{c}	278.05±4.46^{d}	32.14±0.41^{a}	0.21±0.01^{b}	0.30±0.03^{a}	5.06±0.20^{a}
	Synodontis spp.	330.05±1.91^{e}	257.78±1.9^{c}	34.24±0.09^{c}	0.24±0.01^{bc}	0.40±0.01^{b}	6.98±0.18^{c}
Wadata	*Heterobranchus* spp.	250.30±2.55^{b}	127.88±4.42^{a}	39.84±0.09^{d}	0.39±0.01^{d}	0.68±0.04^{d}	4.95±0.21^{a}
	Clarias gariepinus	410.15±3.32^{f}	159.33±3.64^{b}	33.03±0.24^{b}	0.22±0.03^{b}	0.60±0.03^{c}	5.96±0.06^{b}
	Synodontis spp.	300.45±2.76^{d}	295.48±9.10^{d}	33.93±0.18^{c}	0.30±0.04^{c}	0.71±0.04^{d}	12.0±0.28^{d}
LSD (0.05)		6.278	5.027	0.671	0.070	0.090	0.519
P-Value		0.001	0.001	0.001	0.001	0.001	0.001

Means±Standard Deviation on the same column with different superscripts differs significantly at P<0.05 level.

Table 3
Sensory evaluation of smoked-dried catfish from Abinsi and Wadata markets, Benue State.

Markets	Samples	Taste	Appearance	Texture	Odour
Abinsi	*Heterobranchus* spp.	6.23±0.07^{c}	6.67±0.07^{c}	6.97±0.07^{c}	6.43±0.07^{c}
	Clarias gariepinus	5.38±0.00^{a}	6.22±0.00^{b}	6.92±0.00^{bc}	6.23±0.07^{b}
	Synodontis spp.	8.50±0.07^{f}	7.67±0.07^{e}	7.52±0.00^{e}	6.93±0.07^{e}
Wadata	*Heterobranchus* spp.	7.63±0.00^{e}	7.33±0.07^{d}	7.43±0.07^{d}	6.92±0.00^{e}
	Clarias gariepinus	7.38±0.07^{d}	7.63±0.07^{e}	7.33±0.07^{d}	6.77±0.07^{d}
	Synodontis spp.	5.73±0.00^{b}	5.58±0.00^{a}	6.63±0.07^{a}	5.92±0.00^{a}
LSD (0.05)		0.141	0.163	0.163	0.163
P-Value		0.001	0.001	0.001	0.001

Means ± Standard Deviation on the same column with different superscripts differ significantly at P<0.05 level.

3.1.3. Organoleptic assessment

The sensory evaluation as shown in Table 3 was conducted on the Taste, appearance texture and odour of the sample of the smoked *Heterobranachus* spp. *Clarias gariepinus* and *Synodontis* spp. The means scores range for all the organoleptic indices examined was between 5.38 and 8.50; *Heterobranachus* spp. had 6.23, 6.67, 6.97, 6.43; *Clarias gariepinus* had 5.38, 6.22, 6.92, 6.23; *Synodontis* spp. had 8.50, 7.67, 7.52, 6.93; for Taste, appearance texture and odour in Abinsi market while for Wadata market *Heterobranachus* spp. 7.63, 7.33, 7.43, 6.92; *Clarias gariepinus* 7.38, 7.63, 7.33, 6.77; *Synodontis* spp. 5.73, 5.58, 6.63, 5.92; for Taste, appearance texture and odour respectively. *Heterobranchus* spp. and *Clarias gariepinus* from the Wadata market were preferred to the *Heterobranchus* spp. and *Clarias gariepinus* from Abinsi market while *Synodontis* spp. from Abinsi were preferred to the *Synodontis* spp. from Wadata market. A Significant difference (P<0.05) occurs between *Heterobranchus* spp. *Clarias gariepinus* and *Synodontis* spp. in Abinsi and Wadata for taste, appearance, texture, and odour indicating that both samples from Abinsi and Wadata market are liked by the panellist, however, a significant difference (P<0.05) was observed between them, this might be due to variations among individuals in responding to the same level of stimuli like appearance and taste.

3.2. Discussion

Proximate composition, mineral composition and organoleptic qualities of smoked fish were determined from Abinsi and Wadata fish markets in Benue state. *Heterobranchus* spp., *Clarias gariepinus* and *Synodontis* spp were the catfish species used in the study. The percentage moisture content ranged from 8.19 % to 10.34 %. *Synodontis* spp. from the Abinsi market had the lowest value of moisture content while *Heterobrauchus* spp. from the Wadata market had the highest value. The low percentage moisture content recorded in *Synodontis* spp. showed that it would have a much better keeping quality, as the study on the influence of

traditional smoke drying on the quality of fish by Ali, *et al*, (2011) showed that the percentage moisture content was least in smoked fish with acceptable keeping quality.

Generally, proteins are essential for normal function, growth, and maintenance of body tissue hence protein content is considered to be an important tool for the evaluation of biochemical and physiological standards of a given organism like fish in this case (SK Shahina *et al*., 2016). Fish protein is of high quality and contains sufficient amounts of all the essential amino acids required by the body for growth, maintenance of lean muscle tissues and active metabolism (Talabi, 1995). Protein content was slightly higher in *Clarias gariepinus* from both markets each recording 66.11% and 68.97% respectively, this values are higher than the value of 53.10% reported by (Ogbonna and Ibrahim 2009) but agree with 68.40% reported by (Olayemi *et al*, 2011). The high protein content in *Clarias gariepinus* suggests that protein was not lost during smoking. This finding is in agreement with the observation of Akinwumi (2014) and Puwastien *et al*., (1999). Similarly, Fapohunda and Ogunkoya (2OO6) reported that smoke-drying methods increased the protein ash and fat contents. Also, the high protein content of *Clarias gariepinus* in both markets may relate to the high protein contents of their common diets as they mostly feed on, crustaceans, molluscs, algae and diatom (Osibona, 2005). The smoke catfish values with the range of (10.37 to 22.68) % obtained for fat content from the Abinsi and Wadata market showed similarity to studies by Ogbonna and Ibrahim (2009); and Olayemi *et al*, (2011). The fat content values indicate that smoking had no inhibition towards the fat content of the catfish species examined for the study.

The proximate composition for ash content was between the ranges of 10.10 % to 12.74 %), this could be attributed to the high drying temperature and enclosed system of drying. Higher temperatures have often been associated with high values of ash content (Olayemi *et al*, 2011). The ash contents for all samples examined in the table were significantly different ($P < 0.05$) and the values were not above the acceptable limits except for *Heterobranchus* spp. and *Synodontis* spp. which had 12.74%, and 12.19% respectively. However, the carbohydrate content showed a deviation from the above trend with *Heterobranchus* spp. having the highest value 2.59 % and *Clarias gariepinus* 0.38% had the least value, both from Wadata markets.

The mineral composition from this study revealed significant differences ($P<0.05$) in the distribution of mineral elements among the three studied species of catfish. From the result *Clarias gariepinus* had the highest Potassium (K) value, *Heterobrauchus* spp. had the highest values for Calcium (Ca), Sodium (Na), Copper (Cu) and Zinc (Zn) while *Synodontis* spp. had the highest value for Iron (Fe). This observation agrees with the reported work by Oladimeji and Sadiku (1991) who studied the mineral constituents of three freshwater fish species. Potassium, 410.15 % was higher for *Clarias gariepinus* while Calcium 395.48 % was higher for *Heterobrauchus* spp. and Sodium 39.84 % was higher for *Heterobrauchus* spp. in the analysed three species, this observation is in agreement with Eyo (2001) who reported low iron contents but high potassium content in fish. Freshwater fish is a particularly valuable source of Calcium, Sodium as well as Iron, Copper and Zinc (FAO, 2014). Onyia *et al*. (2010) reported similar findings and observed that the dominance of mineral elements in a fish depends on the water body where the fish lives.

The variations recorded could be as a result of the rate in which these components are available in the water body (Yeannes and Almandos, 2003) and the ability of the fish to absorb and convert the essential nutrients or elements from the diet or water bodies where they live. This is supported by the findings of Prapasri *et al.* (1999) and Ricardo *et al.* (2007). Other elements such as Zinc, Iron and Copper varied in concentration among the studied species and significant differences ($P<0.05$) occurred among them. Most of these microelements like Zn, Cu, and Fe are equally important in trace amounts as observed, but they tend to become harmful when their concentrations in the tissues exceed the metabolic demands (Hogstrand and Wood, 1996; Ako and Salihu, 2004).

Generally, minerals concentration in the muscles of freshwater fish vary considerably among different studies possibly due to differences in metal concentrations and chemical characteristics of water from which fish were sampled, ecological needs, metabolism and feeding patterns of fish, and also the season in which studies were carried out (Papagianmis *et al*., 2004; Yilmaz, 2003; Ahmed *et al*., 2010; Opaluwa *et al*., 2012; Mohammed and Osman 2014). The variation in K, Na and Ca could also be due to the presence of major sources of metal pollution, intensive human activity and the discharge of municipal domestic waste and effluents.

Even If the mineral content is lower than threshold values indicated by WHO (1996), contamination of aquatic ecosystems should be expected through bioaccumulation, food from environment concern due to negligible levels of toxic elements. Although the results obtained from the concentration of K, Ca, and Na elements in selected fish species from the study area were below the permissible limit of the World Health Organization (WHO), it does not mean the fish are free from the danger posed on consumers due to their bio-accumulative nature in human and aquatic environment.

Sensory evaluation results revealed that the smoked catfishes from both markets retained very good scores for taste, appearance, texture and odour. This showed that the products were accepted or liked since the least mean scores for all the organoleptic indices examined were ≥ 5.38. There was a significant difference ($P < 0.05$) between the taste, appearance, texture and odour of the smoked catfish samples that were subjected to organoleptic assessment. The preference in taste, texture and appearance could be attributed to the smoking method. Smoke may be attributed to the chemical compound in hardwood characterized by the deposition of phenolic compounds, carbonyls, and syringic acid which add a pleasurable taste, appearance and texture in smoked products (Eyo, 2001; Ekeocha *et al*., 2010).

Smoking as a method of fish preservation may raise the mineral composition of the product to levels that are either beneficial or toxic to humans. Therefore, product quality and acceptability need to be assessed based on not only the perceivable physical properties such as texture, odour and flavour but also on microbial analysis, pest infestation investigation, and mineral and proximate composition. The method of smoking and duration of exposure to the smoke have been identified as important factors that affect product quality and acceptability (Indrasena *et al.*, 2000).

4. Conclusion

The proximate and mineral composition of smoked catfishes showed variations from market to market, however, the three catfish species from this study were found to be rich

in protein content, Potassium, Calcium, and Sodium with low presence of Copper, Zinc, Iron, lipid and carbohydrate contents. The sensory evaluation of *Hetrobraunchus* spp, *Clarias gariepinus* and *Synodontis* spp from both markets had acceptable quality and recommendation.

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