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PROXIMATE COMPOSITION AND SENSORY CHARACTERISTICS OF SILVER CATFISH *(Bagrus bajad)* SMOKED WITH DIFFERENT WOOD SPECIES

[1]Abdullahi, B.A., [2] Dasuki, A [2] Dauda ,A.B [3] Emmanuel,V.S, [4]Bello, M.N , [5]Diftuffe, M.

[1]Department of Animal Science, Federal University of Kashere, Gombe State, Nigeria
[2]Department of Fisheries and Aquaculture, Federal University, Dutsin-Ma, Katsina State, Nigeria
[3]Department of Biological Sciences, Federal University, Lokoja, Kogi State, Nigeria
[4]National Horticultural Research Institute, Ibadan , Oyo State, Nigeria
[5]Department of Agricultural Education, Federal College of Education (Technical) , Gombe, Gombe State ,Nigeria

***(Corresponding author: Abdullahi, B.A : ab933@fukashere.edu.ng, +2348039491336)**

ABSTRACT

The study examined the Proximate composition and Sensory characteristics of Silver catfish (Bagrus bajad) smoked with different wood species commonly used amongst fish processors in Dustin-Ma local government area of Katsina state. Five treatments (A-E) comprising of five wood species A= Neem tree (Azadirachta indica), B= Jackalberry tree (Diospyros mespiliformis), C= Kinkeliba tree (Combretum micranthum), D= Purple Orchid tree (Piliostigma reticulatum) and E= charcoal was used. A total of 125 silver catfish were purchased from the Garhi landing site of Zobe Reservoir in the study area. The fish were washed, gutted, brined in 5% salt solution and then divided into five treatments (A, B, C, D and E) of 3Kg each and were each assigned to a particular treatment. Fish were smoked using modified smoking kilns, smoked fish was allowed to cool for one hour and then packed in a perforated cardboard box and stored at a prevailing room temperature. Proximate analysis was conducted to determine the biochemical content of the smoked fish using the AOAC method 2012. A twenty-member semi trained panelist was used to assess the organoleptic properties of the fish using a 5 point hedonic scale initially and after eight weeks of storage period. Results showed that protein content ranged from 57.26% to 69.15%. Fish smoked with Neem tree had the highest moisture content of 5.32%. The final analysis showed that 75.64% and 5.19% were the highest protein and moisture contents, in fish smoked with Kinkeliba tree. The overall sensory assessment ranged from 20.0 to 21.35 for aroma, taste, texture, colour, and general acceptability in the initial assessment and 11.48 to 19.43 in the final assessment. Proximate analyses indicated slight variations before and after storage period. All the fish smoked with the different wood species possessed good and desirable sensory attributes and are capable of maintaining these characters up to eight weeks of storage period from the result of sensory evaluation.

Keywords: *Bagrus bajad*, Proximate, Sensory, Smoked fish, Wood types.

1.0 INTRODUCTION

Fish is one of the main sources of food for humans, especially in developing nations, and provides a significant portion of protein, fats, and fat-soluble vitamins (Fashagba *et al.,* 2020). It is also a good source of valuable medicinal, feeding, and technical products. Fish decomposes quickly, and so, needs to be properly processed and stored to prolong its shelf life and avoid postharvest losses which amount to 35 to 50% of the total catches (Abdullahi *et al.*, 2024). In Nigeria and other parts of the world, various methods have been deployed over the years to extend its shelf life, and these includes; chilling, freezing, salting, drying, canning, and smoking. (Abdullahi *et al.,* 2024). Fish smoking is one of the basic methods of fish preservation as it does not require expensive equipment or highly skilled individuals (Paul *et al.,* 2021). Smoking as a preservation method generates widely acceptable finished products because it provides ideal colour, texture, aroma, and overall acceptability to the final products (Nwakuba *et al*., 2018). The biochemical and microbiological stability of smoked fish products varies greatly depending on the method, nature, and intensity of smoking (Paul *et al.,* 2021). However, wood smoke is not the same for all tree species and can affect both the physical, organoleptic and chemical attributes of the smoked fish products (Dauda *et al*., 2020). The determination of the proximate compositions help in understanding the variations and fractions of various nutritional constituents such as proteins, crude fats, and other minerals in smoked fish products, which depends on species, age, sex and feeding habits among others (Sanni *et al.,* 2023). This became essential in ensuring that they meet the requirements of food regulations and commercial specifications. To improve the nutritional value of fish and reduce postharvest loss, this study was carried out to determine the proximate and sensory attributes of Silver catfish (*Bagrus bajad*) smoked with different wood species.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Dutsin-Ma Local Government Area of Katsina State in the Northern part of Nigeria located at latitude 12^0 27ˋ 18ˋ ˋ N and 7^0 29ˋ 29ˋ ˋ E. The Local Government is blessed with dams and the most prominent was Zobe dam which is used for supply of drinking water, irrigation purpose and fishing activities.

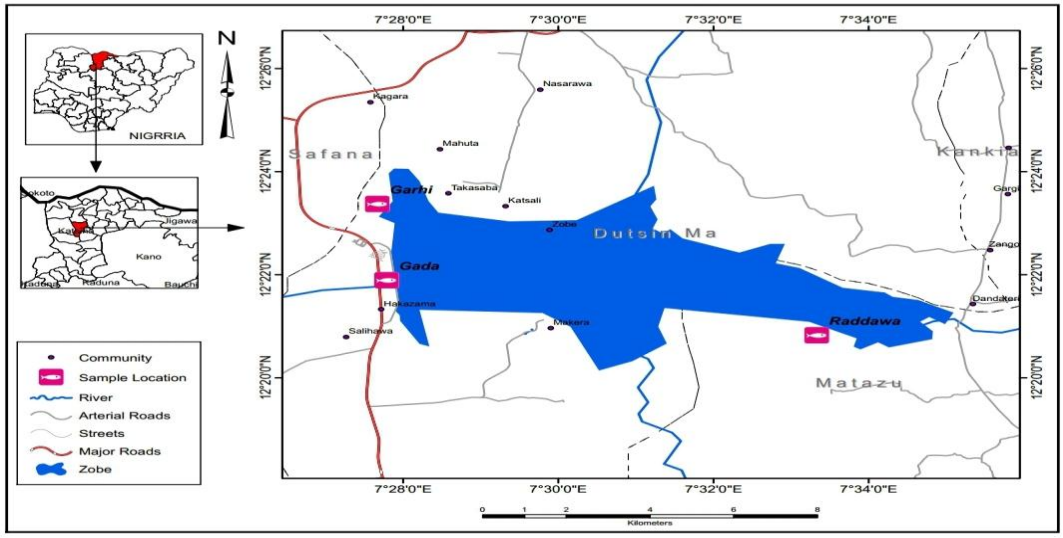

Figure 1: Map of Zobe Reservoir showing the landing sides

2.2 Samples Collection

A total of one hundred and twenty five (125) pieces of silver catfish (*Bagrus bajad*) (length range of 15 – 26 cm) were purchased randomly from fishermen from Zobe reservoir in Dutsin-Ma Local Government Area of Katsina State. The fish samples were chilled with ice and transported to the University (Federal University Dutsin-Ma) Fish Market for preparation identification and further analysis.

2.3 Samples Identification

The fish samples were identified to the species level using field guide to Nigerian freshwater fishes by Olaosebikan and Raji (2013).

2.4 Samples Preparation

The fish was then divided into 5 groups of 3kg each. Each group was allocated to particular wood type which was used for the smoking process. The fish were gutted and thoroughly washed before being immersed in a 5% brine solution for 15 minutes, drained, and air dried for an hour before smoking. Fish tails were slatted by making a small incision in them, and the fish was coiled into a horse shoe shape by securing the tail inside the mouth with clean wooden skewers for easy and uniform smoking as described by (Atanda *et al*., 2015).

2.5 Sources of Wood species

The wood species used were sourced from Dutsin-Ma weekly market and these were; Neem tree (*Azadirachta indica)*, Jackalberry tree *(Diospyros mespiliformis)*, Kinkeliba tree *(Combretum micranthum)*, Purple Orchid tree *(Piliostigma reticulatum)* and Charcoal (commercial).

2.6 Smoking Process

The smoking took place at the Federal University Dutsin-Ma Fish Market in Dutsin-Ma Local Government Area. Five modified metal drum kilns were used for the smoking process. They were built using slightly modified methods described by Idah and Nwankwo (2013). They were each made by perforating a 400L drum with 90 cm length and 58 cm diameter. The drums were cut open midway. The bases were used as the combustion chamber. An internally built damper made of perforated metal plate was installed above the combustion chamber. The smoking chamber was separated into two compartments using chicken wire mesh 10 cm above the damper. Before smoking, a 26kg average weight of each of the woods was placed in the combustion chamber of each kiln and ignited. The fire was lit for about 20 minutes before the fish were introduced. To ensure that the fish were thoroughly smoked and dried, they were first subjected to direct hot smoking for the first hour and then to a lower temperature for 6 to 8 hours by constantly adjusting/removing the burning wood to regulate the heat and avoid charring (Ubwa *et al*., 2015). Fish were occasionally turned to ensure consistent smoking. After smoking, the fish were removed from the kiln and allowed to cool at room temperature for about one hour, before being packed into perforated cardboard box. The fish were stored at the prevailing room temperature for a period of eight (8) weeks.

2.7 Proximate Analysis

Proximate Analysis of the smoked fish was carried out to determine the moisture content, crude protein, fat, crude fiber and ash content using the AOAC method (2012).

2.7.1 Determination of Energy value (Calorific Value)

The energy value was estimated using Atwater factors as described by AOAC (20112). The energy value was calculated by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel value of 4, 9, and 4 kcal/g respectively and taking the sum of their products as described by (Ubbor *et al.*, 2022). The energy value was calculated thus:

EV = (% Protein x 4) + (% Fat x 9) + (% Carbonhydrate x 4)……Equation 1.

2.8 Sensory Evaluation

Sensory evaluation was carried out to determine the taste, aroma, mouth feel (texture) and acceptability (colour) of the smoked fish products. This evaluation was conducted twice during the study period; immediately after the smoking and then subsequently at the end of the storage period. A twenty (20) member (semi-trained) taste panel (already familiar with smoked fish) were given the product to score using a 5 point hedonic scale (5 - Excellent, 4 – Very Good, 3 - Good, 2 - Fair, and 1 – Poor) (Eyo, 2001).

2.9 Data Analyses

Data obtained from Proximate compositions were subjected to analysis of variance (ANOVA) using the Statistical Packages for Social Science (SPSS Version 20). Differences between means of the data were determined using the Tukey's Honestly significance difference (HSD) at 5% significant level. While results of sensory assessment were presented as mean ± standard deviation.

3.0 RESULTS AND DISCUSSION

3.1 Results

3.1.1 Proximate Composition

The initial and final proximate compositions of smoked *B. bajad* are presented in Table 1 and 2 respectively. In the initial analysis, the protein composition ranged from 57.26% (charcoal) to 69.15% (*C. micranthum*) which were all significantly different (P>0.05) among the five treatments. Total ash contents were found to be higher in *A. indica* with 6.12% while the least was recorded in *D. mespiliformis* (4.16%). The total ash contents were significantly different (P>0.05) among the treatments except for *A. indica* and *P. reticulatum* which were not significantly different (P>0.05). Percentage fat contents ranged from 16.91% (*D. mespiliformis*) to 9.71% (*C. micranthum*). The values were significantly different (P>0.05) among *D. mespiliformis, C. micranthum* and charcoal while *A. indica* and *P. reticulatum* were not significantly different (P>0.05). The dry matter contents ranged from 97.46% (*C. micranthum*) to 94.68% (*A. indica*) with both samples significantly different (P>0.05) among them. *D. mespiliformis* had the highest Nitrogen-Free Extract (NFE) value of 14.39% while *C. micranthum* had the least value of 12.51%. There was no significant difference (P>0.05) among the five treatments with respect to total NFE

values. The fibre contents ranged from 2.59% (charcoal) to 1.05% (*P. reticulatum*) which were not significantly different (P>0.05) among *A. indica*, *D. mespiliformis*, *C. micranthum* and *P. reticulatum* while, charcoal was significantly different (P>0.05). Highest energy value was 448.85Kcal/g in *D. mespiliformis* while the least was 418.65Kcal/g in *C. micranthum*. The values were significantly different (P>0.05) except for *A. indica*, *C. micranthum* and *D. mespiliformis* which were not significantly different (P>0.05) among them. The final composition after eight weeks of storage showed a decrease in moisture content which leads to increase in the percentage protein composition. The highest protein was 75.64% in *C. micranthum* while the least was 68.94% (charcoal). The values were significantly different (P>0.05) except for *P. reticulatum* and *D. mespiliformis* which were not significantly different (P>0.05). The dry matter contents ranged from 96.68% (*A. indica*) to 94.81% (*C. micranthum*). The values for dry matter content were not significantly different (P>0.05) among them, except (*A. indica*) and (*C. micranthum*) which were significantly different (P>0.05). The highest fat content was recorded in *A. indica* (16.53%) while the least was 9.68% in *C. micranthum* and were significantly different (P>0.05) among them. The NFE values ranged from 4.69% (*D. mespiliformis*) to 1.35% (*P. reticulatum*) were significantly different (P>0.05) among them except for *A. indica* and *P. reticulatum*. Highest energy value was 450.27Kcal/g in *A. indica* while the least was 410Kcal/ in *D. mespiliformis* which were significantly different (P>0.05).

Table 1: Proximate Composition of Silver Catfish Smoked with Different Wood Species at Production

Parameters	**A**	**B**	**C**	**D**	**E**
Dry Matter (%)	94.68 ± 0.15^{d}	95.24 ± 0.33^{b}	97.46 ± 0.25^{a}	95.14 ± 0.11^{b}	95.26 ± 0.02^{b}
Protein (%)	60.21 ± 1.29^{b}	58.67 ± 1.22^{d}	69.15 ± 0.72^{a}	62.07 ± 0.92^{b}	57.26 ± 1.12^{d}
Fat (%)	13.58 ± 0.08^{b}	16.91 ± 0.54^{a}	9.71 ± 0.23^{c}	13.28 ± 0.07^{b}	16.39 ± 0.07^{a}
Ash (%)	6.12 ± 0.03^{a}	4.16 ± 0.23^{c}	4.93 ± 0.15^{b}	6.06 ± 0.09^{a}	5.51 ± 0.84^{b}
NFE (%)	13.54 ± 1.44^{a}	14.39 ± 0.40^{b}	12.51 ± 0.37^{a}	12.68 ± 0.82^{a}	13.51 ± 0.23^{a}
Fibre (%)	1.23 ± 0.06^{b}	1.12 ± 0.03^{b}	1.16 ± 0.03^{b}	1.05 ± 0.04^{b}	2.59 ± 0.52^{a}
Energy (Kcal/g)	422.17 ± 0.37^{c}	448.85 ± 1.21^{a}	418.65 ± 0.61^{c}	422.72 ± 1.01^{c}	440.93 ± 3.06^{b}

Values on the same row with the same superscripts did not differ significantly (P>0.05). (Values are means ± standard deviations)

Keys: NFE= Nitrogen-Free Extract; **A=** *Azadirachta indica*; **B=** *Diospyros mespiliformis*
C= *Combretum micranthum*; **D=** *Piliostigma reticulatum*; **E=** Commercial charcoal.

Table 2: Proximate Composition of Silver Catfish Smoked with Different Wood Species after 8 Weeks of Storage

Parameters	A	B	C	D	E
Dry matter (%)	96.68±0.16^{a}	95.41±0.28^{b}	94.81±0.10^{c}	95.74±0.13^{b}	95.61±0.25^{b}
Protein (%)	72.84±0.48^{b}	70.89±0.85^{c}	75.64±0.36^{a}	71.40±100^{c}	68.94±0.74^{d}
Fat (%)	16.53±0.37^{a}	13.32±0.60^{b}	9.68±0.48^{d}	15.46±0.29^{a}	16.47±0.29^{a}
Ash (%)	4.66±0.31^{c}	5.31±0.26^{b}	4.40±0.45^{c}	6.38±0.66^{a}	5.14±0.04^{b}
NFE (%)	1.61±0.19^{d}	4.69±0.17^{a}	3.40±0.30^{b}	1.35±0.26^{d}	2.39±0.25^{c}
Fibre (%)	1.03±0.07^{c}	1.20±0.01^{c}	1.68±0.06^{b}	1.23±0.16^{c}	2.67±0.33^{a}
Energy (Kcal/g)	450.72±2.87^{a}	427.00±3.84^{c}	410.04±4.04^{d}	434.73±1.67^{b}	444.25±4.91^{b}

Values on the same row with the same superscripts did not differ significantly (P>0.05). (Values are means ± standard deviations)

Keys: NFE= Nitrogen-Free Extract; **A=** *Azadirachta indica*; **B=** *Diospyros mespiliformis*
C= *Combretum micranthum*; **D=** *Piliostigma reticulatum*; **E=** Commercial charcoal.

3.1.2 Sensory Evaluation

The initial and final sensory attributes of smoked *B. bajad* from different wood species are shown in Table 3 and 4 respectively. The initial sensory evaluation showed that the fuel woods impacted a desirable sensory attributes to the smoked fish as the panelist scored 4.20 as the highest score for taste in fish smoked with charcoal while the least was 4.00 in fish smoked with *C. micranthum.* The score for aroma ranged from 4.30 in fish smoked with *D. mespiliformis* to 4.00 in fish smoked with *P. reticulatum*. Highest score for texture was 4.40 (*C. micranthum*) while the lowest was 3.60 (*A. indica*). Mean scored for acceptability ranged from 4.55 in fish smoked with charcoal to 4.05 in fish smoked with both *D. mespiliformis* and *C. micranthum.* Colour had the highest score of 4.40 in fish smoked with *D. mespiliformis* while the least was 3.85 in fish smoked with *P. reticulatum.* The overall scored ranged from 21.35 (charcoal) to 20.00 (*A. indica*). However, in the final sensory assessment, the highest score for taste was 3.75 in fish smoked with *D. mespiliformis* while the lowest was 2.37 in fish smoked with charcoal. The score for aroma ranged from 3.90 (*P.*

reticulatum) to 2.58 (charcoal). Fish smoked with *A. indica* had the highest score for texture while fish smoked with charcoal had the lowest score of 2.21. The score for acceptability also ranged from 3.95 (*P. reticulatum*) to 2.00 (charcoal). Fish smoked with *P. reticulatum* had the highest score of 3.90 in terms of colour while fish smoked with charcoal had the lowest score of 2.32. Final overall assessment ranged from 19.43 (*P. reticulatum*) to 11.48 (charcoal).

Table 3: Initial Sensory Evaluation of the Smoked Fish (*B. bajad*) from Dutin-Ma L.G.A

Parameters	**A**	**B**	**C**	**D**	**E**
Taste	4.10±0.85	4.15±0.88	4.00±0.86	4.10±0.85	4.20±0.89
Aroma	4.15±0.93	4.30±0.80	4.25±1.02	4.00±1.03	4.10±0.85
Texture	3.60±0.82	3.75±0.97	4.40±0.68	4.10±1.12	4.25±0.72
Acceptability	4.10±0.79	4.05±0.83	4.05±0.83	4.25±0.79	4.55±0.89
Colour	4.05±0.60	4.40±0.75	3.95±0.89	3.85±0.81	4.25±0.79
Overall	**20.00**	**20.65**	**20.65**	**20.30**	**21.35**

Values are represented as Mean ± standard deviation.

Keys: **A=** *Azadirachta indica***; B=** *Diospyros mespiliformis***; C=** *Combretum micranthum***; D=** *Piliostigma reticulatum***; E=** Commercial charcoal.

Table 4: Final Sensory Evaluation of the Smoked Fish (*B. bajad*) from Dutin-Ma L.G.A

Parameters	A	B	C	D	E
Taste	3.60±0.59	3.75±0.97	3.60±0.99	3.79±0.86	2.37±1.46
Aroma	3.35±0.75	3.65±0.75	3.70±0.92	3.90±0.66	2.58±1.39
Texture	4.00±0.92	3.60±0.75	3.45±0.89	3.89±0.99	2.21±1.69
Acceptability	3.60±0.60	3.90±0.79	3.85±0.75	3.95±0.71	2.00±1.45
Colour	3.70±0.80	3.70±0.86	3.60±0.82	3.90±0.80	2.32±1.49
Overall	**18.25**	**18.60**	**18.20**	**19.43**	**11.48**

Values are represented as Mean ± standard deviation.

Keys: **A=** *Azadirachta indica***; B=** *Diospyros mespiliformis***; C=** *Combretum micranthum***; D=** *Piliostigma reticulatum***; E=** Commercial charcoal.

3.2 Discussions

3.2.1 Proximate Composition

The heat and smoke associated with the smoke-drying process was reported to cause denaturation of protein content of the fish, which in other words alters the nutritional value. Accounting for different storage periods is important for the safety and quality of smoked fish offered for sale especially in open markets (Ikutegbe and Sikoki, 2014). All the five samples showed a significant increase in protein content after the eight weeks of storage period, and although all the fish were smoked to an average weight of 1 kg each, the total moisture content varied significantly, except for high moisture samples smoked with Purple orchid and charcoal. The dry matter content observed in the fish samples dictate the tune of microbial load especially bacteria. The study is in line with (Samuel, 2016) who reported that charcoal smoked fish had lower protein content than other woods due to the high heat intensity that causes denaturation. In addition, the protein content of smoked fish are favoured by protecting the fish from insect infestation during storage and the nutrient content of the fish is affected by several factors, including the processing method (Akintola and Lawal, 2011). The ash content indicated that fish is a good source of minerals such as calcium, potassium, zinc, iron and magnesium, although Silver catfish have lower mineral content (Sesugh *et al.,* 2012). In addition, the increase in ash content of the smoked fish sample is

due to loss of humidity as reported by (Nnaji and Ekwe, 2016). Silver catfish, as an oily fish (Sesugh *et al*., 2012) was found to have high lipid contents during storage. This is consistent with (Eyo, 2001) who reported that as the water content in a fish decreases, the lipid content also increases and vice versa. Fish smoked with Kinkeliba had highest protein content but also had the lowest total lipid content. Although the proximate composition of fish varied significantly depending on the environment, age, sex, species, migration, nutrients, and preservation method (Sesugh *et al.*, 2012), fish smoked with all the types of wood showed good percentage compositions of lipid, protein, ash, moisture and fiber content. The result showed that the different woods used in smoking the fish do not have a major impact on the immediate proximate compositions of the fish. The proximate analyses also showed discrepancies in percentage of Protein, lipid, Ash, Fibre, NFE and Fat in the results compared to other researchers such as Sesugh *et al*. (2012), Aremu *et al*. (2013) and Iheanacho *et al*. (2017) which might be due to smoking temperature, species age and sex, processing methods and storage condition.

3.2.2 Sensory Evaluation

The criteria for consumer's choice when purchasing smoked dried fish are physical attributes such as texture, colour, flavour and attractiveness. However, consumers have different preferences for light and dark brown colours, among others (Obodai *et al*., 2009). Furthermore, applying heat to dehydrate fish does not only remove water, but excessive heat can also degrade the nutritional content of smoked fish (Idah and Nwankwo, 2013). These characteristics however left out the microbiological quality that could stand as an important aspect to assess the quality and safety of fishery products. According to the wider concept of food quality, different attributes cover different dimensions, from health and production method to environmental and social orientation (Sheldon, 2017). Since such attributes cannot be verified, credibility attributes require standards or communication to be communicated and to ensure consumer safety (Sheldon, 2017). After eight (8) weeks of storage, the smoked fish with Neem tree, Jackal berry tree, Kinkeliba tree, Purple orchid tree and Charcoal still possess good organoleptic properties and accepted by the panelist. The preferences in flavour, taste, texture and acceptability might be attributed to the processing method (smoke) which might add nutrients to the fish (Eyo, 2001). The current study concurs with works of Sesugh *et al*. (2012) who stated that charcoal-smoked fish exhibits charred skin (skin damage) with slight muscle fragmentation, possibly due to the high-intensity of heat released by

charcoal during smoking. Dark brown and Golden brown were the two distinctive colours reflected in the smoked fish product. Result from sensory evaluation showed that fish smoked with *A. indica* and *D. mespiliformis* have the highest scores in terms of colours which were all dark brown followed by golden brown. Although the colours were all scored as good and very good by the panelist, which was in line with (Obodai *et al*., 2009 and Leksono *et al*., 2020) who concluded that dark brown and golden brown were the most acceptable colours among fish consumers and which were all scored good/acceptable. The study Therefore, demonstrated that the wood species being compared affects a desirable sensory attributes to the fish (*B. bajad*) that can last up to eight (8) weeks and still maintain its taste, texture, aroma, colour and acceptability.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Proximate analyses indicated slight variations before and after the storage period among the four smoke sources. The study concludes that fish smoked with Kinkeliba (*C. micranthum)* had the highest protein content but also had the lowest total lipid content which in line have the highest biochemical composition. All the fish smoked with the different wood species possessed good and desirable sensory attributes and are capable of maintaining these characters up to eight weeks of storage period.

4.2 Recommendations

Fish smoked with all the wood species in the current study can generally be termed as acceptable with good biochemical and keeping qualities , therefore all the wood types are recommended for smoking fish .

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