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Nutritional and Sensory Evaluation of Catfish (*Clarias gariepinus* Burchell, 1822*)* Smoked with *Eucalyptus camaldulensis* and *Azadirachta indica* Wood

Abubakar Mohammed Mohammed[1], Muhammad Yakubu Haruna[2,*], Muinat Monilola Bello[3], Maravi Inusa[4]

[1]Department of Fisheries and Aquaculture, Faculty of Agriculture and Life Sciences, Federal University Wukari, Taraba State, Nigeria.
[2]Department of Fisheries and Aquaculture, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi.
[3]Department of Fisheries, Faculty of Agriculture University of Maiduguri, Borno State, Nigeria.
[4]Department of Animal Science, Faculty of Agriculture, Borno state University, Nigeria.

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Corresponding Author
Tel.: +2348062900188
E-mail: harunamy001@gmail.com

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Abstract

The study was carried out to investigate the sensory and nutritive value of *Clarias gariepinus* smoked using two different sources of energy from neem and eucalyptus wood. The fuel was sourced from the tree *Azadirachta indica* and *Eucalyptus camaldulensis.* The fish were smoked using the local smoking kilns made from drums with a wire mesh placed on each of them. The neem/eucalyptus wood was introduced from the vent. Temperature of 70°C was maintained in the smoking oven for the first hour, then it was reduced to 40 – 50°C until the end of the drying period. There were also significant differences in proximate composition in terms of moisture, protein, lipid and crude ash content, between the fish smoked using neem and eucalyptus ($P<0.05$). The sensory evaluation was carried out by a 10- man evaluation panel using the 7-point hedonic scale and the nutritional composition was evaluated according to methods outlined by one-way analysis of variance. The sensory evaluation showed there was a significant difference ($P<0.05$) between the fish smoked using neem and eucalyptus wood in color, flavor and general acceptability. According to the results of the sensory evaluation, it could be said that eucalyptus was a better energy source for smoked *C. gariepinus* than neem wood.

Introduction

Fish is a good source of inexpensive premium protein, as it contains all of the essential amino acids. In the human's diet, fish is an essential source of animal protein (Bello *et al*., 2018). Fish has been widely accepted as a good source of protein and other elements necessary for the maintenance of a healthy body (Adebayo-Tayo *et al.*, 2012). Nigerians are the largest consumers of fish and it remains one of the main products consumed in terms of animal protein. It is cheap and highly acceptable, with little or no religious bias, which gives it an advantage over pork or beef (Eyo, 2001: Ligia, 2002). Currently only about 50% of fish demand is met by local supply. Fish is a highly perishable commodity that undergoes spoilage as soon as it is harvested. Once spoilage sets in, the odor/flavor, texture, color and chemical composition change (Omoruyi *et al*., 2016). One-third of fish produced worldwide was estimated to be wasted (Affognon *et al.*, 2015). To prevent economic losses, the processing and preservation of the fish is critical importance. *Eucalyptus camaldulensis*, commonly known as the river red gum (Hirsch *et al*, 2020) is a tree that is endemic to Australia. It has smooth white or cream-colored bark, lance-shaped or curved adult leaves, flower buds in groups of seven or nine, white flowers and hemispherical fruit with valves extending beyond the rim. A familiar and iconic tree, it is seen along many watercourses across inland Australia, providing shade in the extreme temperatures of central Australia. *Azadirachta indica*, commonly known as neem, nim tree or Indian lilac (Gibreel and Salih, 2019), is a tree in the mahogany family Meliaceae. It is one of two species in the genus *Azadirachta*, and is native to the Indian subcontinent and most of the countries in Africa. It is typically grown in tropical and semi-tropical regions.

Smoking involves use of wood fuel which in turn affects product quality (Kwaghvihi, 2020). However, changes in the quality of fish products produced depending on the type of wood fuel used for smoking have not been closely monitored. In addition to improving organoleptic quality, this could offer the chance to introduce newer wood fuel products until now unused for fish smoking. However, the utilization of *Eucalyptus camaldulensis* and *Azadirachta indica* (wood) as fuel sources will enhance good smoke-dried quality products that would draw consumers' attention as well as reduce environmental pollution. Smoking as a fish preservation method not only increases resistance to bacteria but also changes appearance, taste and aroma and reduces the risk of deterioration (Bello *et al.,* 2018). The preservation of fish is therefore considered a major hindrance to its production, utilization and consumption, especially in the tropical countries in Africa (Haruna *et al*., 2021). Therefore, in this study, it was aimed to evaluate some properties and nutritional composition of the African catfish *Clarias gariepinus* smoked with *Eucalyptus camaldulensis* and *Azadirachta indica* wood.

Materials and Methods

The study was conducted in the fish processing unit of the Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria. It is located at latitude11°15'N and longitude 13°15'E (Haruna *et al*., 2021). The area has an average mean annual rainfall of about 550mm3 (Shettima, 2018).

Fish Sample

A total of 3000 g of fresh *Clarias gariepinus* was procured from Monday market in Maiduguri, Borno State with lengths ranging from 11.0 - 36.2 cm. The fish were transported using an insulated cold flask to the processing unit.

Procurement of Fuel Source

A total of 10 kg each of *Azadirachta indica* and *Eucalyptus camaldulensis* wood was obtained from the University premises. The wood from this source were collected by cutting the branches of the trees and sun-dry, the leaves were separated from the wood and were allowed to dry for a period of 4-5 weeks.

Fish Preparation for Smoking

The fish were gutted-and washed thoroughly with water several times until they were clean. The fish were spread on wire mesh to drain under a shed. The fish were later arranged on the racks and placed for smoking using *Azadirachta indica* and *Eucalyptus camaldulensis* wood as a fuel source. Temperature of 70°C was maintained in the smoking kiln for the first hour, using ignited chaff. The temperature was then reduced to 40-50°C until the end of the drying period.

Packaging of Smoked Fish

The fish products were allowed to cool after the smoking process and packed in groups in a carton later transferred to room temperature for storage.

Proximate Composition Analysis

Proximate composition of fresh and smoked *C. gariepinus* which include moisture, fat, dry matter and ash content were assayed as describe by AOAC (2006).

Determination of Moisture

Moisture was determined by the reduction in weight when the sample was dried to a constant weight in an oven. About 2 g of fish sample was weighed into a silica dish which was previously dried and weighed; the sample was then dried again in an oven at 65°C for 36 h, cooled in a desiccator and weighed. This process was continued until a constant weight was achieved (Haruna *et al.,* 2021).

$$\%\ \text{Moisture} = \frac{\text{weight of sample + dish before drying - weight of sample + dish after drying}}{\text{weight of sample taken}} \times 100$$

Since the water content of fish varies, they usually compared for their nutrient content on moisture free or dry matter (DM) basis,

$$\%DM = 100 - \%Moisture$$

Determination of Crude Protein

In this method, the fish sample to be analyzed was digested with concentrated sulphuric acid in the presence of a small amount of copper sulphate, selenium and sufficient sodium or potassium sulphate with mercury (Hg) as a metal catalyst. Under these conditions, the organic matter was oxidized and the protein nitrogen was converted to ammonium sulphate (NH4)2 SO4. The digestion was followed by the addition of a strong base (NaOH) to liberate ammonia. The ammonia distilled, trapped in 0.5% boric acid indicator which was then titrated with 0.01 M HCl. Almost all organic forms of nitrogen were converted to ammonia by the conditions of the digestion. The result of Kjeldahl analysis is usually expressed as crude protein. The weight of nitrogen in a sample can be converted to protein using the appropriate factor based on the percentage of nitrogen in the protein sample. To convert gram of nitrogen to gram of protein, the common factors 6.25 was used. The nitrogen value was therefore multiplied by 6.25 to get the weight of protein (Oladipo and Jadesimi, 2013).

Determination of Crude Fat

The ether extract of a feed represents the fat and oil in the feed. Soxhlet apparatus is the equipment used for the determination of ether extract. It consists of 3 major components; an extractor: comprising the thimble which holds the sample, a condenser: for cooling and condensing the ether vapor and 250 ml flask. About 150 ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40-60°C was placed in the flask. 2–5 g of the sample was weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapor reached the condenser through the side arm of the extractor, it condensed to liquid form and dropped back into the sample in the thimble; the other soluble substances were dissolved and carried into solution through the siphon tube back into the flask. Extraction continued for at least 4 h. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65°C for 4 h, cooled in a desiccator and weighed.

$$\% \text{ of fat} = \frac{\text{weight of flask + extract - tare wt of flask}}{\text{weight of sample}} \times 100$$

Determination of Crude Ash

Ash is the inorganic residue obtained by burning off the organic matter of the samples at 400 – 600°C in a muffle furnace for 4 h. 2 g of the sample was weighed into a pre-heated crucible. The crucible was placed in muffle furnace at 400 – 600°C for 4 h or until a whitish-grey ash was obtained; and then was placed in the desiccators and weighed (Bello *et al.,* 2018).

$$\% \text{ ash} = \frac{\text{weight of crucible + ash - wt of crucible}}{\text{weight of sample}} \times 100$$

Determination Nitrogen Free Extract

The total carbohydrate content was determined by different methods. The sum of the percentage moisture, % ash, %crude lipid and % crude protein was subtracted from 100 (Abdullahi *et al.,* 2022)

$$\text{NFE}=100 - (\text{ash+crude lipid+crude protein+moisture})$$

Sensory Evaluation

The sensory evaluation was assessed consisting of staff and students using the 10-men panelist through a 7- point hedonic scale to analyze the degree in changes based on organoleptic characteristics such as flavor, color, appearance, texture and general acceptability (Bello *et al.,* 2018). The scale used was 7= excellence, 6= very good, 5= good 4= fair, 3= poor, 2= very poor and 1= extremely poor.

Statistical Analysis

Data were subjected to the analysis of variance and a significance test for difference among sample variance using the least significance difference (LSD) in the mean comparison of means at P<0.05 level of significance with the aid of statistical analysis (Statistix 10.0).

Discussion

The findings of this study showed that the fresh fish moisture content, which was 67.29±0.32%, decreased to 7.13±0. 41% for fish smoked with neem wood and to 8.22±0.33 for fish smoked with eucalyptus wood (Table 1). The fresh fish values were consistent with earlier research by Obande *et al*. (2012) and Umar *et al*. (2018), who found 67% moisture content in *Clarias gariepinus* and linked their findings to those of Pannevis (1993).

According to Rodrigues *et al*. (2023), one of the primary goals of smoking fish is to lower the moisture content of the fish to roughly 15-20 percent. This is applied to retard the microbial and chemical degradation process in fish. Yean *et al*. (2017) stated that, the quality of well-dried fish with 12-13% moisture content could be kept in sealed polyethylene bags for up to one year without significantly deteriorating their quality. The fish smoked using neem and eucalyptus wood, respectively, had moisture contents of about 7.13% and 8.22%, which indicated that the fish had been effectively smoked and had a reasonable amount of

Table 1. Proximate Composition of Fresh and Smoked *C. gariepinus* using Neem and Eucalyptus Wood

Groups	Moisture (%)	Protein (%)	Fat/lipid (%)	Ash (%)	NFE
Fresh fish	67.29±0.32[a]	16.24±2.94[c]	0.50±0.08[c]	6.61±1.02[c]	9.36±1.63[a]
X	7.13±0.14[b]	55.77±6.04[a]	13.74±0.59[b]	15.39±3.10[b]	7.97±1.63[a]
Y	8.22±0.33[b]	45.67±2.04[b]	25.14±0.95[a]	17.06±0.40[a]	3.91±0.82[b]

water removed. Although fish smoked with neem had lower moisture content than fish smoked with eucalyptus wood, no significant difference was found in the amount of moisture lost in either case (P>0.05).

While the protein content was found to be 16.24% in fresh fish before smoking, it was determined as 55.77% in those applied neem wood after smoking and 45.67% in smoked fish from eucalyptus wood. This concurred with related investigations by Eyo (2001), Obande *et al*. (2012) and Bello *et al.* (2018). It can be concluded that there is a proportional change due to the decrease in moisture content after smoking. According to Modibbo *et al*. (2014), a decrease in moisture content led to an increase in crude protein. On the other hand, lipid content was found as 25.14% for fish smoked with eucalyptus wood and 13.74% for fish smoked with neem (Table 1). The fish low fat level was a sign that fat content decreases as fish are exposed to dryness, which agrees with findings by (Bello *et al.,* 2018), who recorded fat contents of 24.14% for *Clarias gariepinus* smoked with bagasse. There was significant change in ash content after smoking process (P<0.05).

The sensory characteristics observed with the taste panel response revealed that people preferred fish smoked using eucalyptus over those smoked using neem wood (Figure 1). There was a significant difference in sensory attributes of fish smoked using neem or eucalyptus wood on the data recorded from general acceptability by the panelists (P<0.05) (Table 2). These results are in agreement with an earlier study (Mwambazi *et al.,* 1995) which found that eucalyptus wood-smoked fish had a golden-brown color and desirable texture and an attractive smoky flavor. There was no bitter taste when eaten and the product could potentially be sold. The sensory qualities of a processed fish sample are of great importance due to the fat that every consumer demands good qualities from their fish consumption (Paul *et al*., 2021).

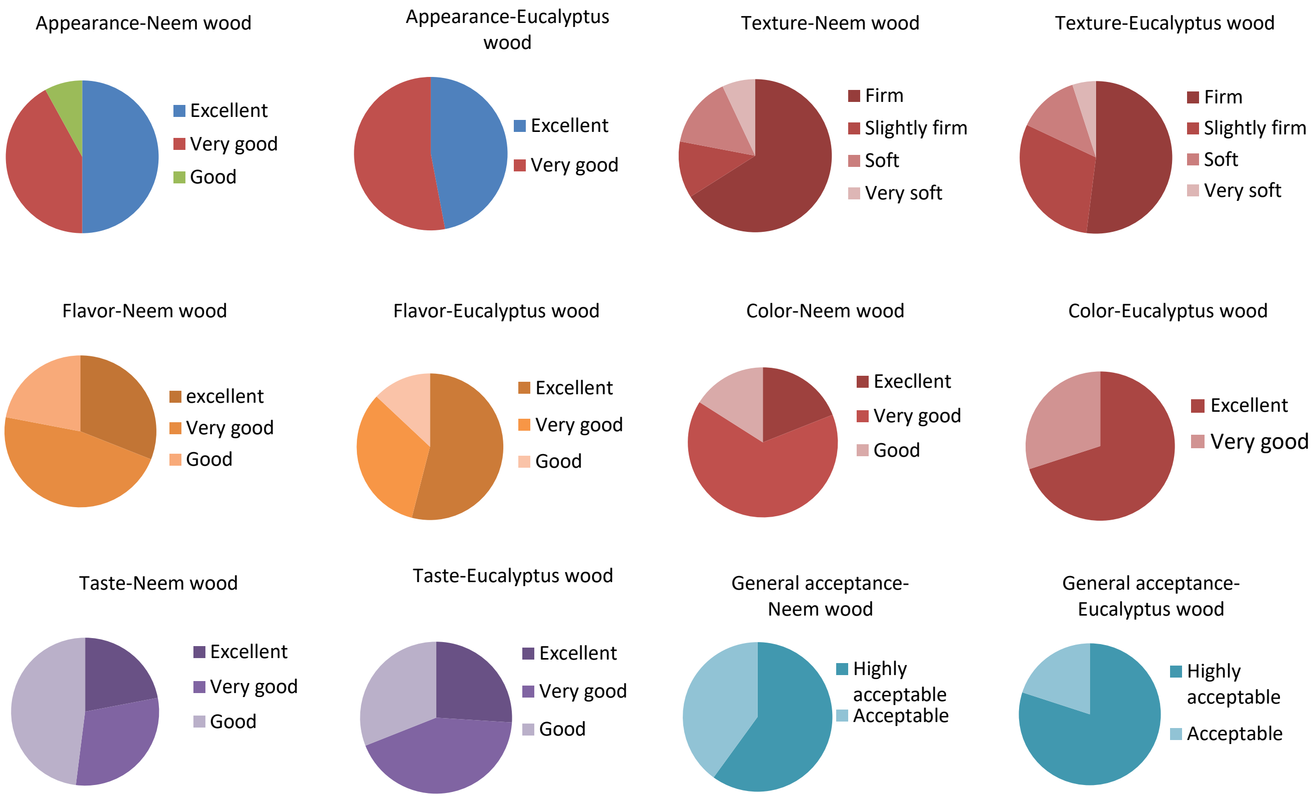

Figure 1. Percentage of sensory properties of *C. gariepinus* smoked using neem and eucalyptus wood

Table 2. Sensory attributes of Smoked *C. gariepinus* using neem and eucalyptus Wood

Groups	Appearance	Texture	Flavour	Colour	General acceptance	Taste
X	1.58±0.08^{a}	2.07±0.23^{a}	1.91±0.10^{a}	1.97±0.07^{a}	1.40±0.06^{a}	2.26±0.11^{a}
Y	1.53±0.16^{a}	2.07±0.46^{a}	1.59±0.20^{b}	1.30±0.14^{b}	1.20±0.12^{b}	2.05±0.21^{a}

Mean with the same superscripts in a column are not significantly different (p>0.05)
These values are the 7-point Hedonic scale of 10 men panel response to each attributes. The Hedonic scales are 1 = excellent: 2 = very good: 3 = good: 4 = fair: 5 = poor: 6 = very poor: 7 = extremely poor.

Conclusion

In conclusion, eucalyptus can be used to smoke fish, and fish smoked with eucalyptus had a more appetizing color than fish smoked with neem wood. It has also been noted that Eucalyptus has favorable combustion experience and reduces the amount of smoke loading with phenolic compounds that are thought to be carcinogenic, so it is recommended to smoke fish using Eucalyptus instead of neem.

Ethical Statement

No any ethical issues.

Funding Information

This study involved no external funding.

Author Contribution

All authors are responsible for the general design of the manuscript. AM collected the samples analysed the data and wrote the manuscript. MY contributed in samples collection, data analysis and revised the manuscript. MI contributed in reviewing the manuscript. MM supervised the whole project. All authors contributed on specific aspects.

Conflict of Interest

The authors declare no conflict of interest.

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