EFFECT OF SELECTED AROMATIC PLANT LEAVES ON THE SENSORY QUALITY OF THREE SMOKED-DRIED FRESHWATER FISH SPECIES (*CLARIAS GARIEPINUS, OREOCHROMIS NILOTICUS,* AND *HETEROTIS NILOTICUS*)

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ABSTRACT

The aim of this study was to evaluate the effect of selected aromatic plant leaves on the organoleptic properties of three smoked-dried freshwater fish species. Aromatic plant leaves, including neem (Azadirachta indica), eucalyptus (Eucalyptus camadulensis), mango (Mangifera indica), and guava (Psidium guajava), were collected within Maiduguri town, while the fish species (Clarias gariepinus, Heterotis niloticus, and Oreochromis niloticus) were sourced from the Lake Chad basin. The eviscerated fish were pre-treated in a brine solution prior to smoking with the respective plant leaves, followed by sensory evaluation of the final smoked-dried products. Results showed that P. guajava leaves had a highly significant positive effect on the sensory taste score (4.80±0.41) of smoked C. gariepinus (P<0.05). Similarly, the taste (4.53±0.74) and overall acceptability (3.93±0.46) scores of O. niloticus smoked with M. indica leaves were significantly higher than those of other treatments. However, there was no significant difference in the effect of all the tested plant leaves on the sensory quality of H. niloticus. Thus, P. guajava and M. indica leaves are recommended for processing C. gariepinus and O. niloticus, respectively, to enhance product flavor and overall consumer acceptability.

Keywords: Aromatic leaves, freshwater fish, Lake Chad basin, sensory evaluation, smoke-drying,

INTRODUCTION

Fish represents one of the healthiest food sources, packed with excellent sources of high-quality animal proteins. It complements land-based agricultural food supplies (Kareem and Olanrewaju, 2015) and occupies a prominent position in the dietary profile of Nigerians due to its affordability and nutritional value. In Nigeria, fish accounts for approximately 40 percent of the national animal protein intake, with an estimated annual per capita consumption of 13.3 kg/person/per year (Bradley *et al*., 2020). This supply is predominantly sourced from aquaculture and artisanal inland fisheries, which exploit over 300 inventoried freshwater fish species across the country (Olaosebikan and Raji, 2013), with the Lake Chad basin serving as a critical commercial hub.

Among the commercially valued freshwater species widely distributed in Nigerian inland waters are the African catfish (*Clarias gariepinus*), Nile tilapia (*Oreochromis niloticus*), and African bonytongue (*Heterotis niloticus*).) These indigenous species possess exceptional nutritional value, high market demand, and a favourable muscle-to-bone ratio that facilitates safe consumer handling (Olanrewaju, 2022; Olanrewaju *et al*., 2024). However, unlike catfish and tilapia, the African bonytongue frequently exhibits lower consumer

acceptability due to its distinct, less-preferred natural taste, which adversely affects its market value. Post-harvest value addition through smoke-drying offers an effective mechanism to improve the organoleptic properties (colour, odour, flavour, taste, and texture) of such fish products to enhance consumer appeal.

Smoked fish products enjoy widespread market penetration across local open markets and supermarkets in Nigeria, as well as export markets in Europe (Mshelia *et al*., 2024). This acceptance relies heavily on the unique sensory profiles imparted by specific smoke sources and processing adjuncts. Botanical leaves and spices are frequently incorporated into traditional smoking regimes as flavoring and preservative agents due to their volatile oils and aromatic compounds (Embuscado, 2015). Aromatic plants such as eucalyptus (*Eucalyptus camaldulensis*), mango (*Mangifera indica*), guava (*Psidium guajava*), and neem (*Azadirachta indica*) contain rich profiles of phenolic compounds (Samarth *et al*., 2017). These phenolics function as natural antioxidants and volatilize during combustion, subsequently embedding characteristic flavours, aromas, and colours into the fish flesh.

While the sensory effects of diverse herbs and spices on smoked fish have been documented by several researchers (Olusola, 2021; Adeyeye, 2019; Jega *et al*., 2018; Ariel *et al*., 2017; Ayeloja *et al*., 2015), empirical data regarding the application of these specific selected aromatic plant leaves remain scarce. Therefore, this study evaluates the effect of *E. camadulensis*, *M. indica*, *P. guajava*, and *A. indica* leaf smoke on the organoleptic qualities of brine-pretreated *C. gariepinus*, *O. niloticus*, and *H. niloticus*. Ultimately, this research aims to establish optimized botanical smoking frameworks to improve the sensory characteristics and marketability of processed freshwater fish products for the benefit of artisanal fisherfolk communities.

MATERIALS AND METHODS

Description of Experimental Location

The study was conducted at the Federal College of Freshwater Fisheries Technology (FCFFT), Baga, Borno State, Nigeria. The facility is a premier research institution situated within a region where fish processing and smoke-drying serve as critical post-harvest economic drivers and source of livelihoods. Geographically, the College is at Latitude $11^0$51'43" N and Longitude $13^0$13'36" E, at an altitude of 312 m above mean sea level.

Procurements and Handling of Experimental Fish Samples

Fresh samples of Clarias gariepinus, *Heterotis niloticus*, and *Oreochromis niloticus* were purchased from wild artisanal landings at the Doron-Baga landing site within the Lake Chad Basin, Nigeria. A total of ten specimens per species were randomly selected for the study. The fish samples were immediately transported in insulated ice boxes to the Fish Processing Laboratory Unit at the Federal College of Freshwater Fisheries Technology (FCFFT) Baga for morphometric measurement and processing. The mean initial body weights of the experimental fish were 800.80±83.35 g for *C. gariepinus*, 1250.80±430.35 g for *H. niloticus*, and 450.66±174.70 g for *O. niloticus*.

Collection, Identification, and Preparation of Aromatic Leaves

The botanical leaves evaluated as smoke-sources in this study comprised neem (*Azadirachta indica*), eucalyptus (*Eucalyptus camaldulensis*), mango (*Mangifera indica*), and guava (*Psidium guajava*). Fresh, mature samples of these leaves were collected

simultaneously from healthy parent trees within Maiduguri, Borno State, Nigeria. Taxonomic identification and authentication of the plant samples were performed at the Department of Forestry and Wildlife, University of Maiduguri. Following identification, the bulk leaf samples were transported to the Fish Processing Laboratory Unit, FCFFT Baga. The leaves were thoroughly cleaned to remove extraneous debris and subsequently air-dried at room temperature (28.0 ± 2^{o}C).

Description of the Smoke-drying Process

The sorting and preliminary preparation of the fish samples were executed in accordance with the established protocols described by Roth and Oines (2010). The pre-treated fish specimens were briefly air-dried under ambient laboratory conditions to remove surface moisture. Smoking operations were carried out using four separate Nigeria Institute of Oceanography and Marine Research (NIOMR) smoking kilns. Premium hardwood charcoal was utilized as a primary fuel and thermal source to achieve a controlled hot-smoking temperature regime of 70 – 80^{o}C. To introduce the respective experimental treatments, 200 g of the specific air-dried aromatic leaves (*A. indica*, *M. indica*, *E. camaldulensis*, and *P. guajava*) were introduced directly onto the glowing charcoal embers at 2-hour intervals throughout the smoke-drying cycle. The smoking process was maintained for a total duration of 12 hours until the fish samples attained a uniform golden-brown colouration and a stable, cured internal moisture level.

Sensory Quality Evaluation

Upon completion of the smoke-drying cycle, the fish samples were allowed to cool to ambient room temperature for 2 hours prior to sensory analysis. Sensory evaluation was conducted to assess six distinct attributes: appearance, taste, odour, texture, flavour, overall acceptability. Scoring was performed using 5-point hedonic-type scoring value adapted from Olanrewaju *et al*. (2024), where the numerical values corresponded to: 5 = excellent, 4 = very good, 3 = good, 2 = fair, and 1 = poor. A sensory panel consisting of fifteen (15) untrained consumer panelists was randomly drawn from the non-academic staff of the Federal College of Freshwater Fisheries Technology, Baga. All selected panelists were regular consumers of smoked fish and were free from food allergies or sensory impairments. To prevent taste carry-over and sensory fatigue between consecutive treatments, panelists were mandated to rinse their mouths thoroughly with room-temperature potable water during the evaluation intervals.

Statistical Analysis

The differences in sensory parameters between the tested aromatic leaves were statistically analysed using a one-way Analysis of Variance (ANOVA). Significant differences among the treatment means were separated using Duncan's Multiple Range Test (DMRT) at a significance level of $p \leq 0.05$. All experimental results are expressed as mean ± standard deviation. Statistical computations were performed using IBM SPSS Statistical software (version 20.0, IBM Corp., Armonk, NY, USA).

RESULTS

Sensory Evaluation of Smoked Clarias gariepinus

Table 1 summarizes the sensory and organoleptic attributes of *Clarias gariepinus* smoked with four different aromatic leaves. No significant differences ($p>0.05$) were observed among the treatments for appearance, odour, flavour, texture, and overall acceptability. Numerically, *C. gariepinus* smoked with *Magnifera indica* leaves obtained the highest scores for odour (4.40 ± 0.63), flavour (4.07 ± 1.10), texture

(4.07 ± 1.03), and overall acceptability (4.07 ± 0.80), while appearance scored highest in fish smoked with *Azadirachta indica* leaves. In contrast, taste scores varied significantly ($p < 0.05$), ranging from 4.01 ± 0.88 in fish smoked with *A. indica* leaves to a maximum of 4.80 ± 0.41 in those smoked with *Psidium guajava* leaves.

Sensory Evaluation of Smoked Heterotis niloticus

The organoleptic evaluation of *Heterotis niloticus* smoked with four selected aromatic leaves revealed a marginal difference ($p > 0.05$) between treatments (Table 2). The highest scores for appearance (3.87 ± 1.13) and taste (3.80 ± 1.08) were recorded in *Heterotis niloticus* smoked with *Mangifera indica* leaves. Furthermore, the highest scores for odour (3.67 ± 0.82), flavour (3.53 ± 1.25), and texture (3.93±0.88) were observed in fish smoked with *P. guajava*, *A. indica*, and *E. camaldulensis* leaves, respectively. Regarding overall acceptability, *H. niloticus* smoked with *P. guajava* and *M. indica* leaves shared the highest score (3.53 ± 0.83), whereas the lowest acceptability scores were observed in the *E. camaldulensis* and *A. indica* leaf treatments.

Table 1: **Organoleptic Attributes of Brine Pre-treated *Clarias gariepinus* Smoked with Four Selected Aromatic Leaves**

Sensory attributes	ECL	PGL	MIL	AIL
Appearance	3.67±1.05^{a}	3.60±0.99^{a}	3.47±0.92^{a}	3.93±0.96^{a}
Odour	3.80±0.86^{a}	3.80±0.86^{a}	4.40±0.63^{a}	4.13±1.06^{a}
Flavour	4.00±0.85^{a}	3.67±0.90^{a}	4.07±1.10^{a}	3.93±0.96^{a}
Taste	4.27±1.10^{ab}	4.80±0.41^{a}	4.33±0.82^{ab}	4.01±0.88^{b}
Texture	3.60±0.83^{a}	3.53±1.19^{a}	4.07±1.03^{a}	4.00±1.13^{a}
OA	3.87±0.52^{a}	3.87±0.83^{a}	4.07±0.80^{a}	3.87±0.64^{a}

CSH *Clarias gariepinus smoked with four selected plant leaves*, ECL *Eucalyptus camaldulensis leaf*, PGL *Psidium guajava leaf*, MIL *Mangifera indica leaf*, AIL *Azadirachta indica leaf*, OA *overall acceptability*. Different letters as superscripts across rows showed significant differences ($p \leq 0.05$).

Table 2: **Organoleptic Attributes of Brine Pre-treated *Heterotis niloticus* Smoked with Four Selected Aromatic Leaves**

Sensory attributes	ECL	PGL	MIL	AIL
Appearance	3.07±1.10^{a}	3.33±1.05^{a}	3.87±1.13^{a}	3.53±0.99^{a}
Odour	3.33±1.06^{a}	3.67±0.82^{a}	3.33±0.98^{a}	3.27±1.03^{a}
Flavour	3.13±1.06^{a}	3.33±0.82^{a}	3.47±1.25^{a}	3.53±1.25^{a}
Taste	3.53±1.25^{a}	3.73±0.96^{a}	3.80±1.08^{a}	3.33±1.05^{a}
Texture	3.93±0.88^{a}	3.60±0.83^{a}	3.80±0.86^{a}	3.67±1.18^{a}
OA	3.33±0.49^{a}	3.53±0.52^{a}	3.53±0.83^{a}	3.33±0.62^{a}

HSH *Heterotis niloticus* smoked with four selected plant leaves, ECL *Eucalyptus camaldulensis leaf*, PGL *Psidium guajava leaf*, MIL *Mangifera indica leaf*, AIL *Azadirachta indica leaf*, OA *overall acceptability*. Different letters as superscripts across rows showed significant differences ($p \leq 0.05$)

***Sensory Evaluation of Smoked* Oreochromis niloticus**

Table 3 presents the organoleptic quality of *Oreochromis niloticus* smoked with four selected aromatic leaves. Taste and overall acceptability scores differ significantly ($p < 0.05$) across the treatments. *Oreochromis niloticus* smoked with *Mangifera indica*

leaves obtained the highest taste (4.53 ± 0.74) and overall acceptability (3.93 ± 0.46) scores compared to fish smoked with the other leaves. Similarly, odour (4.00 ± 0.76) and texture (3.93 ± 0.46) scores were numerically highest in fish smoked with *M. indica* leaves, though these attributes did not differ significantly ($p > 0.05$) among treatments. Appearance scores ranged between 3.13 ± 1.19 (in fish smoked *Azadirachta indica* leaves) and 3.80±0.94 (in fish smoked *Psidium guajava* leaves) ($p>0.05$).

Table 3: **Organoleptic Attributes of Brine-Pretreated *Oreochromis niloticus* Smoked with Four Selected Aromatic Leaves**

Sensory attributes	ECL	PGL	MIL	AIL
Appearance	3.67±1.05^{a}	3.80±0.94^{a}	3.67±0.90^{a}	3.13±1.19^{a}
Odour	3.80±1.01^{a}	3.27±0.80^{a}	4.00±0.76^{a}	3.27±0.88^{a}
Flavour	3.13±1.06^{a}	3.33±0.90^{a}	3.27±0.88^{a}	3.60±1.24^{a}
Taste	3.67±1.23^{b}	3.87±1.19^{ab}	4.53±0.74^{a}	3.60±1.24^{b}
Texture	3.67±1.05^{a}	3.20±0.77^{a}	3.93±0.46^{a}	3.40±0.74^{a}
OA	3.47±0.52^{b}	3.47±0.64^{b}	3.93±0.46^{a}	3.40±0.74^{b}

OSH *Oreochromis niloticus smoked with four selected plant leaves*, ECL *Eucalyptus camaldulensis leaf*, PGL *Psidium guajava leaf*, MIL *Mangifera indica leaf*, AIL *Azadirachta indica leaf*, OA *overall acceptability*. Different letters as superscripts across rows showed significant differences.

DISCUSSION

The current study evaluated and compared the sensory qualities of *Clarias gariepinus*, *Heterotis niloticus*, and *Oreochromis niloticus* smoked with *Eucalyptus camaldulensis* (eucalyptus), *Mangifera indica* (mango), Psidium gaujava (guava), and Azadirachta indica (neem) leaves. There is a well-established trend towards enhancing fish organoleptic qualities through smoking with aromatic and flavouring plant materials (Olagbemide, 2015; Ekelemu *et al*., 2021). According to Belichovska *et al*. (2019), the sensory quality of smoked fish depends on numerous factors, including the species, sex, size, diet, physiological condition, pre-smoking treatments, and the specific smoking procedure.

In the present study, the sensory attributes of African catfish smoked with the four aromatic plant leaves received statistically similar scores across all parameters, except for taste. This similarity implies that all four plant species are rich in phenolic and carbonyl compounds such as phenolic acids, flavonoids, and terpenoids, which collectively impart desirable sensory characteristics during fish smoking. However, *C. gariepinus* smoked with guava leaves achieved a significantly higher taste score (4.80 ± 0.41) compared to the other treatments. The taste score from guava-leaf-smoked catfish in this study was higher than the 4.68 ± 0.63 recorded for charcoal-smoked catfish by Olanrewaju *et al*. (2024). Similarly, Ariel *et al*. (2017) reported an elevated taste quality in Surgeonfish smoked with guava leaves (4.60±0.97) over those treated with a brine solution (3.40±0.97), calamansi leaves (3.40±0.82), or lemongrass (3.70±1.20). This confirms a significant taste enhancement by guava leaves on smoked African catfish, which can be attributed to the rich profile of bioactive phytochemicals in *P. guajava* leaves, including quercetin, avicularin, apigenin, guaijaverin, kaempferol, hypericin, myricetin, gallic acid,

catechin, epicatechin, chlorogenic acid, epigallocatechin gallate, and caffeic acid (Kumar *et al*., 2021; Ariel *et al*., 2017).

For smoked *H. niloticus*, no significant differences ($p > 0.05$) were observed among the four aromatic treatments. However, the highest numerical scores for overall acceptability were shared by the guava and mango leaf treatments (both scoring 3.53 ± 0.83). This numerical superiority highlights the presence of rich bioactive compounds (phenolic acids, flavonoids, and tannins) in mango and guava leaves, which can be highly beneficial when utilized in smoked food systems (Kumar *et al*., 2021). The acceptability scores in this study are comparable to the findings of Amuneke *et al*. (2020), who reported that *H. niloticus* treated with salt, ginger, nutmeg, and their mixtures yielded overall acceptability scores ranging from 2.16 to 3.77. This demonstrates that aromatic plants can reliably match or enhance conventional curing mixtures. Conversely, Olanrewaju *et al*. (2024) observed that charcoal-smoked *H. niloticus* yielded higher overall acceptability scores (4.15 ± 0.56) than the leaf-smoked fish in this study.

Furthermore, *M. indica* leaves produced the highest significant sensory scores for taste (4.53 ± 0.74) and overall acceptability (3.93 ± 0.46) in *O. niloticus* ($p < 0.05$). This outcome indicates that using mango leaves for smoking tilapia significantly influences the fish's sensory profile, potentially enhancing consumer appeal by imparting a unique aroma and flavor. Nevertheless, the sensory scores across all plant treatments in this study were lower than the values reported by Olanrewaju *et al*. (2024) for charcoal-smoked tilapia. These variations may be attributed to the specific quality of the charcoal used in their study, for which the author did not specify the botanical source species.

CONCLUSION

The study demonstrated that *Psidium guajava* (guava) and *Mangifera indica* (mango) leaves significantly enhanced the taste and overall acceptability of smoked *Clarias gariepinus* and *Oreochromis niloticus*, respectively. Conversely, the four aromatic leaf treatments exerted no significant effect on the sensory qualities of smoked *Heterotis nioloticus*. Consequently, guava leaves are recommended for smoking *C. gariepinus*, while mango leaves are recommended for smoking *O. niloticus*, to optimize sensory profiles and maximize consumer acceptability.

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REFERENCES

Adeyeye, S.A.O. (2019). Smoking of fish: a critical review. *Journal of Culinary Science and Technology*, 17(6): 559-575, DOI: 10.1080/15428052.2018.1495590

Amuneke, K.E., Oguntade, O.R., Ikeogu, F.C., and Nomeh, U.A. (2020). Effect of natural preservatives on the organoleptic characteristics and storage stability of smoked *Heterotis niloticus*. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 19(2): 31 – 35.

Ariel, M.O., Francis, N.B., and Jonathan, M.B. (2017). Sensory, organoleptic, and

proximate composition of smoked surgeon fish Acanthurus sp. using selected herbs as a flavor enhancer. *International Journal of Food Science and Nutrition*, 2(1): 174-181.

Ayeloja, A.A., George, F.O.A., Akinyemi, A.A., Atanda, O.O. (2015). Proximate and mineral composition of spiced smoked catfish *Clarias gariepinus* (Burchell, 1822). *Journal of Agricultural Science and Environment*, 15(2): 68 – 74.

Belichovska, K., Belichovska, D., and Pejkovski, Z. (2019). Smoke and smoked fish production. *Meat Technology*, 1: 37-43. https://doi.org/10.18485/meattech.2019.60.1.6

Bradley, B., Byrd, K.A., Atkins, M., Isa, S. Akintola, S.L., Fakoya, K.A., Ene-Obong, H. and Thilsted, S.H. (2020). Fish in food systems in Nigeria: A review. WorldFish. https://hdl.handle.net/20.500.12348/4210.

Ekelemu, J.K., Nwabueze, A.A., Irabor, A.E., and Otuye, N.J. (2021). Spicing: A means of improving the organoleptic quality and shelf life of smoked catfish. *Scientific African*, 13 e00930.

Embuscado, M.E. (2015). Spices and herbs: Natural sources of antioxidants, a mini review. *Journal of Functional Foods*, 18: 811–819.

Jega, I.S., Michael, P. and Ribah, I.M. (2018). Effect of Onion top leaves extract on the quality of smoked *Heterotis niloticus* (Cuvier, 1829). *Research in Agriculture, Livestock and Fisheries*, 5(2): 241 – 248.

Kareem, O.K. and Olanrewaju, A.N. (2015): Effect of different stocking density on nutrient utilization, growth performance and survival of African Catfish (*Clarias gariepinus*, Burchell 1822) fry in recirculatory system. *Journal of Fisheries and Aquatic Science*, 10 (5): 400-404. DOI: https://scialert.net/fulltext/?doi=jfas.2015.400.404

Kumar, M., Tomar, M., Amarowicz, R., Saurabh, V., Nair, M.S., Maheshwari, C., Sasi, M., Prajapati, U., Hasan, M., Singh, S., Changan, S., Prajapat, R.K., Berwal, M.K., and Satankar, V. (2021). Guava (*Psidium guajava* L.) Leaves: Nutritional Composition, Phytochemical Profile, and Health-Promoting Bioactivities. *Foods*, 10(4):752 - 765. doi: 10.3390/foods10040752

Mshelia, J.P., Micheal, K.G., Olanrewaju, A.N., and Grema, F.A. (2024). Proximate composition and storage quality of Smoke-gutted and degutted Catfish (*Clarias gariepinus*, Burchell, 1822) from two different smoking kilns. In: E.K. Ajani *et al*. (*eds*.); *Unlocking the Investment Potential of Nigeria's Blue Economy: Advancing the Fisheries and Aquaculture Sector for Sustainable Development*. Proceedings of the 39th Annual Conference of the Fisheries Society of Nigeria (FISON) held at Raw Material Research and Development Centre (RMRDC), Abuja, Nigeria, between 28th October and 1st November 2024. Pp. 646 – 650.

Olagbemide, P.T. (2015). Nutritional values of smoked *Clarias gariepinus* from major markets in southwest Nigeria. *Global Journal of Science Frontier in Research Development, Agriculture and Veterinary*, 15(6): 32-43.

Olanrewaju, A.N. (2022). Fatty acids and amino acids content of *Heterotis niloticus* (Cuvier, 1829) and *Protopterus annectens* (Owen, 1883) from Lake Alau, Northeast Nigeria. *Biotechnology*, 21(2): 59–64. *Biotechnology*, 21(1): 59–64. DOI: https://doi.org/10.3923/biotech.2022.59.64.

Olanrewaju, A.N., Gombe, K., Kareem, O.K., Awoyale, M.O., Sodeeq, A.T., and Abdulganiyu, A. (2024). Comparative studies on nutritional composition and sensory attributes of smoked-dried *Heterotis niloticus*, *Clarias gariepinus*, and *Oreochromis niloticus* from Lake Chad Basin. *Nigerian Journal of Fisheries*, 21(2): 3016–3023.

Olaosebikan, B.D., and Raji, A. (2013). *Field guide to Nigerian freshwater fishes*. Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria. Revised edition. 144pp.

Olusola, S.E. 2021. Influence of smoking and natural preservatives on shelf-life and microbial quality of *Clarias gariepinus* during storage. *Ife Journal of Science*, 23(1): 145 – 151. https://dx.doi.org/10.4314/ijs.v23i1.14

Roth, B., and Oines, S. (2010). Stunning and killing of Edible Crabs (*Cancer pagurus*). *Journal of Animal Welf*are, 19(3): 287–294.

Samarth, R.M., Meenakshi Samarth, M. and Matsumoto, Y. (2017). Medicinally important aromatic plants with radioprotective activity. *Future Science*, 3(4): FSO247. Doi: 10.4155/fsoa-2017-0061