Effects of Neem, Gmelina, and African Velvet Tamarind Wood Fuel on the Organoleptic and Shelf Life of *Clarias gariepinus*

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ABSTRACT

This work aimed to evaluate the effects of smoking African catfish (Clarias gariepinus) using wood fuel obtained from Neem (Azadirachta indica), Gmelina (Gmelina arborea) and African velvet tamarind (Dialium guineense) on the organoleptic properties (appearance, aroma, taste, and texture) and shelf life. The research was conducted at the fish processing unit of the Department of Fisheries and Aquaculture Management, Nnamdi Azikiwe University, Awka. A total of 12 matured catfish, 6 males and 6 females which weighed 1kg each were used for the study. After fish preparation, a total of four fish (2 males and 2 females) were smoked in three different smoking kilns using the three wood types. The organoleptic properties of the smoked catfish were analyzed by ten member panel while shelf life was determined by the period of mold and insect infestation. The results indicated that there was no significant difference (P>0.05) in the effects of these wood types on the organoleptic properties assessed. However, catfish smoked with the African velvet tamarind wood had the most preferable organoleptic qualities with a mean score of appearance (4.20±0.92^a), aroma (4.30± 0.82^a), taste (4.70± 0.67^a), and texture (4.10± 0.86^a). This was followed by catfish smoked with Gmelina wood with a mean score of appearance (2.90 ±0.88a), aroma (3.00± 0.94^a) taste (3.00± 0.67^a), and texture (2.90± 1.19^a), while catfish smoked with Neem wood had the lowest mean score of appearance (2.00± 0.67^a) and texture (2.50± 0.85^a). It was also observed that there was no insect attack in all the smoked fish samples during the period of storage. However, catfish smoked with Neem wood showed the highest severity to mold attack (3.00) while fish smoked with Gmelina wood showed no mold attack (0.00). Therefore, these results indicated that fish processing with the use of these woods is effective in extending the shelf-life of smoked African catfish. As a result, the study suggests that the use of African velvet tamarind wood in smoking fish should be adopted to improve the organoleptic properties of smoked catfish which would also increase its profitability.

INTRODUCTION

Fish has traditionally been an important food source for humans and contains high-quality protein, vitamins, and omega-3 fatty acids. Fish is the most perishable of all food commodities, as it deteriorates after death (Kwaghvihi *et al.*, 2020). Inadequate post-harvest preservation and processing of fish can cause massive spoilage (Kumolu-Johnson *et al*., 2010). Smoking has been used as a preservation technique for centuries to preserve fish (Rahman, 2007, Huong, 2014) and extend their shelf life.

Smoking is the process of flavoring, cooking, or preserving food by exposing it to smoke from burning or smoldering materials, most commonly wood. In recent times, smoking is used as a method of preservation with the incorporation of smoke flavor and the development of color (Varlet *et al*., 2007). Smoking introduces aroma, taste, and color to processed fish (Visciano *et al*., 2008). Smoking also retards the development of toxins in fish products (Huong, 2014) and extends their shelf life due to the dehydrating, antimicrobial and antioxidant effects of smoke components (Visciano *et al*., 2008). It reduces the growth of bacteria, through the removal of moisture in fish induced by heat application and drying which creates a physical surface barrier (Rorvik, 2000). The spoilage and pathogenic microflora of smoked products are affected by the density of smoke, the concentration of active components of the smoke in combination with the salt content, and, the time and temperature of smoking (Kwaghvihi *et al.*, 2020).

The chemical composition of smoke is complex and more than 300 components have been identified (Guillen and Manzanos, 1999). Smoke is generated through the incomplete combustion of wood (Muyela *et al*., 2012) and contains phenolic compounds, acids, and carbonyls which contribute significantly to the overall flavor of smoked fish. The relative concentration of phenolic compounds

depends on the nature of the wood used in the smoking process (Serot *et al*., 2004). These active compounds are effective in improving the shelf life as well as the organoleptic properties of the fish.

Fuel wood is the main source of energy for smoking fish, though many wood types can be used as fuel for smoking fish. Fuel wood used as a smoked source in fish smoking can be hardwood such as beech, neem, gmelina, oak, or fruitwood such as apple, tamarind velvet, etc (Huong, 2014). Plant-based natural constituents can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc, and may contain active components (Ajiboye *et al.,* 2015). Medicinal plants have been used for centuries as remedies for human diseases and offer a new source of biologically active chemical compounds as antimicrobial agents. Among all the factors influencing the choice of wood, the type of wood used is dependent on local availability (Nerquaye-Tetteh *et al*., 2002). The fuel wood preferences of most fish smokers are related to the physical characteristics of the wood and how they affect the smoked fish. Different fuel woods may affect the quality of the smoked fish differently (Nerquaye-Tetteh *et al*., 2002).

The organoleptic properties and shelf life of smoked fish depend on the type of wood used in smoking. The chemical composition of wood differs from one another, which can influence greatly these properties. These organoleptic properties affect consumer acceptability, commercial value, and income of the fish farmer. Therefore, this research work is aimed at ascertaining the effect of different wood sources (Neem, Gmelina, and African velvet tamarind) on the organoleptic properties and shelf life of smoked *Clarias gariepinus*.

MATERIALS AND METHODS

Study area

The study was carried out in the Fish Processing Unit of the Department of Fisheries and Aquaculture Management, Nnamdi Azikiwe University, Awka, Anambra State, South Eastern Nigeria.

Collection of firewood

The dry woods of the three plants were purchased from a local wood seller in Umuahia, Abia State. The choices of these woods were attributed to their availability, smoke concentration, pH, bacteriological stability, and high content of some phenolic compounds. The three different kinds of wood were dried for 1 month before being transported to the study area.

Fish sample collection and preparation

A total number of twelve mature *Clarias gariepin*us (6 males and 6 females) of an average weight of 1kg were purchased from Izundu fish farm Awka for the study. The fish were sacrificed, degutted, washed and prepared thoroughly, and arranged on a rack for smoking.

Smoking process

Three smoking kilns were used for fish smoking concerning the three different kinds of firewood used. The twelve fish were grouped into three groups with four fish in each group – Group A smoked on Neem wood fuel, Group B on Gmelina, and Group C on Tamarind wood. The woods were set up 30 minutes before smoking and allowed to smolder to charcoal. To control the excessive temperature in the kiln, the intensity of the heat was reduced by the intermittent withdrawal of some wood. At intervals, the fish under smoking were turned to different sides to enable even distribution of heat. After the smoking process, each of the samples was packed separately in a transparent plastic container and stored at ambient temperature (38˚F) with no preservative applied.

Storage trials

Insect and mold attacks were monitored during the storage periods on daily basis. Attacks by insects or moulds were determined according to the method of Khan and Khan (2001). Insect and mould attacks were evaluated by giving scores on a hedonic scale of 0 - 3. A numerical score of 0 meant there was no sign of infestation or damage, 1 for occasional infestation, 2 for noticeable consistent infestations, and 3 for heavy insect/mould infestations covering the whole fish. For insect infestation, a score of 3 and above meant rejection of the fish, and a score above 0 was the limit of acceptability for mould. Signs of mould attack were the limit of acceptability, while a score of 3 for insects was the limit of acceptability beyond which the fish would be rejected.

Organoleptic analysis

The appearance, aroma/odour, taste, and texture of the fish from different smoking sources were analyzed. A 10-man panel consisting of 5 staff and 5 students of the Department of Fisheries and Aquaculture, Nnamdi Azikiwe University, Awka was used. The sample products were scored using hedonics of:

1 = Excellent, 2 = Very Good, 3 = Good, 4 = Fair, 5 = Poor

Statistical analysis

The data collated was subjected to analysis of variance (ANOVA). Duncan's multiple range tests were employed to reveal significant differences among the treatment means at a level of $p < 0.05$.

RESULTS

Table 1 shows that there was no significant difference ($p<0.05$) in the means. The result of the organoleptic properties of *Clarias gariepinus* smoked with three different kinds of wood is shown in table 1. This study showed that the catfish smoked with the African velvet tamarind wood had the highest means score of appearance (4.20 ± 0.92^a), followed by that of Gmelina 2.90 ± 0.88^a) while the lowest means score was observed in the catfish smoked with Neem wood (2.00 ± 0.67^a). A similar result was obtained in fish smoked with velvet tamarind wood which recorded the highest mean score in both (4.30 ± 0.82^a), and taste (4.70 ± 0.67^a), while the lowest means score was observed in both aroma (3.00 ± 0.94^a) and taste (3.00 ± 0.67^a) of catfish smoked with Gmelina wood. It was also observed that catfish smoked with African velvet tamarind wood had the highest mean score of texture (4.10 ± 0.86^a) while those smoked with Gmelina and Neem wood recorded (2.90 ± 1.19^a) and texture (2.50 ± 0.85^a) respectively. The results indicated that there was no significant difference ($P>0.05$) in the effects of these wood types on the organoleptic properties assessed.

Table 1: Organoleptic properties of catfish smoked with different wood source

Parameters	Gmelina wood	Neem wood	African velvet wood
Appearance	2.90 ± 0.88^a	2.00 ± 0.67^a	4.20 ± 0.92^a
Aroma	3.00 ± 0.94^a	3.40 ± 0.84^a	4.30 ± 0.82^a
Taste	3.00 ± 0.67^a	3.00 ± 0.94^a	4.70 ± 0.67^a
Texture	2.90 ± 1.19^a	2.50 ± 0.85^a	4.10 ± 0.86^a

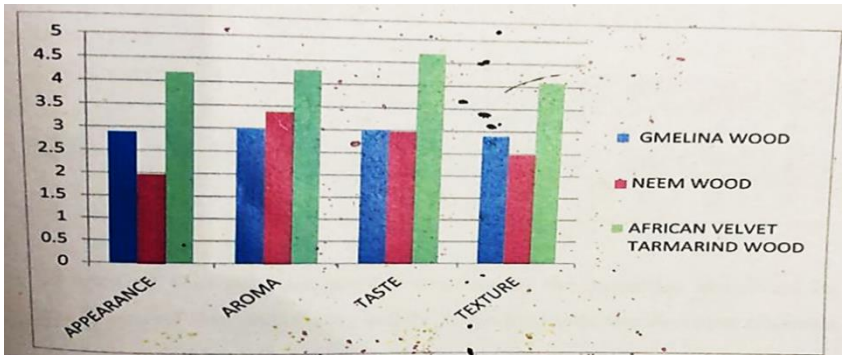

Fig. 1: Bar graph illustrating the organoleptic properties of fish smoked by the distinct medicinal woods.

Table 2 showed the results of insect attacks on catfish smoked with the three different kinds of wood after 48 days of storage. All the smoked fish samples had a score of 0.00, implying that there was no insect attack on the fish till the end of the study.

Table 2: Insect Score of catfish smoked with Gmelina, African velvet tamarind, and Neem woods

Parameter	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Gmelina wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
African velvet tamarind wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neem wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3 showed the results of mold attack on catfish smoked with the three different wood sources. Catfish smoked with Neem wood showed the highest severity to mold attack (3.00), followed by that of African tamarind velvet (1.00) while that of Gmelina wood showed no mold attack (0.00) after 48 days of storage.

Table 3: Mould score of catfish smoked with Gmelina, African velvet tamarind, and Neem woods

Parameter	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Gmelina wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
African velvet tamarind wood	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Neem wood	0.00	0.00	0.00	2.00	3.00	3.00	3.00

DISCUSSION

The study assessed the organoleptic properties of medicinal woods (Gmelina, Neem, and African Velvet Tamarind) used in the smoking of catfish, as well as their effect on the shelf life of the fish. The organoleptic qualities (appearance, aroma, taste, and texture) of smoked fish, determines the acceptability to consumers and the market price of the fish. Table 1 expressed the choices made by the 10 panelists for this study. For all parameters assessed, fish smoked by African velvet tamarind *(Dalium guineense*) was adjudged to be the best.

The appearance, taste, aroma, and texture of fish smoked with tamarind velvet were better than other wood sources. The result of the African velvet tamarind wood source for the texture and aroma/flavor of fish in this work was similar to the work done by Agbabiaka *et al*., (2012). Catfish *(Clarias gariepinus*) smoked with Neem wood (*Azadirachta indica*), had the lowest mean score in terms of appearance and texture. This was in contrast to the work of Oduor-Odote *et al*. (2010), where fish smoked with neem wood maintained an above-average score for appearance. This can be attributed to the low burning intensity of the wood caused by the high moisture retention by the neem plant (Oduor-Odote *et al*., 2009). However, all the mean scores for taste and aroma/flavor in this study were above average for all wood sources.

Till the end of the research (48 days), there was no observable insect infestation on the fish smoked by the medicinal wood source in this study. The result was similar to the study of Oduor-Odote *et al*., (2010), where freshwater fish smoked by Neem wood experienced no insect infestation until after the 48th day. The result from this study can be attributed to the fact that these medicinal woods possess bioactive compounds which can be transferred to the fish through smoking, hence deterring insect infestation during storage.

Mould was first detected in fish smoked with African velvet tamarind wood and Neem wood on the 23rd day and 28th day (fourth week) respectively. This was in contrast to the work done by Oduor-Odote *et al*. (2010), where they first witnessed mold attacks on the 48th day. The catfish smoked with African velvet tamarind wood had a mild infestation with a score of 1.00, and there was no increase in mold infestation till the end of the experiment, while the fish smoked with Neem wood had a score of 2.00, which later progressed to 3.00 in the 5th week. There was no evidence of mold attack in the fish smoked by Gmelina wood for the first five weeks of storage but a little infestation of mold was observed in the fish with a score of 1.00 in the sixth week. There was however no literature on the use of Gmelina wood in smoking fish for the assessment of mold attack. Mold attack on the fish might be attributed to the temperature and humidity of the storage environment. Agbabiaka *et al.* (2012) reported that the wood used for smoking fish might contain natural chemical compounds (phenols, carbonyl, and syringol) which are responsible for the pleasurable taste, color, and flavor in the smoked product.

CONCLUSION

According to the findings of this study, processing fish using medicinal woods obtained from Neem, Gmelina, and African velvet tamarind is effective in improving the organoleptic properties of the smoked catfish as well as extending their shelf-life. The result also showed that fish smoked with African velvet tamarind wood was the most preferred in terms of all the parameters assessed suggesting that African velvet tamarind wood should be adopted for fish smoking.

RECOMMENDATION

All fish smoked with the medicinal wood exhibited an insect-deterring effect on the fish; this suggested that these woods can be adopted in aquaculture as a means of smoking to improve the shelf-life of fish, hence increasing profitability. In addition, there should be more research on other woods of medicinal plants for smoking fish.

REFERENCES

Agbabiaka, L. A., Amadi, A. S., Eke, L. O., Madubuko, C. U. And Ojukannaiye, A. S. (2012)
Nutritional and storage qualities of Catfish (*Clarias gariepinus*) smoked with the fruit pulp of *Dialiumguineense* (velvet tamarind) on some microbial isolates. *Journal of Microbiology and Antimicrobials*, 7(4): 31-44

Guillen, M. D., and Manzanos, M. J. (1999). Study of the components of a solid smoke flavouring preparation. *Food Chemistry*, 55 (3), 251-257

Houng, D.T.T. (2014). The effect of the smoking method on the quality of smoked Mackerel. United Nations University Fisheries Training Programs, Iceland Final Project. http://www.unuftp.is/static) fellows/document Tent/Houng13prg.

Khan, A. A., and Khan, A. S. (2001). Insects' infestations and preventive measures in dry fish storage Chittagong, Bangladesh. *Journal of Biological Sciences* 1 (10): 963-965

Kwaghvihi, O. B., Akombo, P. M. and Omeji, S. (2020). Effect of wood smoke on the quality of smoked -fish. *Mediterranean Journal of Basic and Applied Science*. 4(2): 72-82.

Kumolu-Johnson, C. A., Aladetohun, N. F. and Ndimele, P. E. (2010). The effect of smoking on the nutritional qualities and shelf-life of *Clarias gariepinus.*, *African Journal of Biotechnology*, 9(1): 73-76.

Muyela, B., Shitandi, A. and Ngure, R. (2012). Determination of benzo[a]pyrene levels in smoked and oil fried *Lates niloticus. International Food Research Journal*, 19(4): 1595-1600.

Nerquaye-Tetteh, G. A., Dassah, A. L. and Quashe- Sam, S. J. (2002). Effect of fuel wood type on the quality of smoked fish- *Chrysichthys auratus*. *Ghana Journal of Agricultural Science*, 35(1): 95-101.

Oduor- Odote, P. M., Obiero, M., and Odoli, C. (2010). Organoleptic effect of using different plant materials on smoking of marine and freshwater catfish, *African Journal of Food Agriculture Nutrition and Development*, 10(6): 2658-2677.

Rahman, M. S. (2007). Handbook of food Preservation, 2nd edition, CRC Press, 479-480.

Rorvik, L. M. (2000). Listeria monocytogenes in the smoked salmon industry, *International Journal of Food Microbiology*, 62, 183-190.

Sérot, T., Baron, R., Knockaert, C. and Vallet, J. L., (2004). Effect of smoking processes on the contents of 10 major phenolic compounds in smoked fillets of herring (*Cupleaharengus*). *Food Chemistry*, 85(01): 111-120.

Varlet, V., Serot, T., Knockaert, C., Cornet J., Cardinal, M., Monteau F., Bizec, B. L. and Prost, C. (2007). Organoleptic characterization and PAH content of salmon (*Salmon salar*) fillets smoked according to four industrial smoking techniques: *Journal of the Science of Food and Agriculture*, 87(5): 847-854.

Visciano, P., Perugini, M., Conte, F., and Amorena, M. (2008). Polycyclic aromatic hydrocarbons in farmed rainbow trout (*Oncorhynchus mykiss*) processed by traditional flue gas smoking and by liquid smoke flavourings, *Food, and Chemical Toxicology*, 46: 1409-1413.