EFFECT OF DIFFERENT FUEL ENERGY SOURCES FOR SMOKING ON THE QUALITY OF SMOKED *Clarias gariepinus*

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ABSTRACT
The research was carried out to evaluate the effect of different fuel energy sources for smoking on the quality of smoked Clarias gariepinus. Thirty-six (36) live Clarias gariepinus with average weight of 508 g were purchased from Mobil Fish Market, Minna, Niger State, the samples were divided into three (3) batches of twelve (12) pieces each and were smoked using Vitellaria paradoxa (shea butter) firewood, Prosopis africana (African mesquite) charcoal and rice husk briquettes, and polycyclic aromatic hydrocarbons (PAHs) analysis was carried out to determine the levels of PAHs in the smoked samples. Four (4) carcinogens of health risk were identified: benzo(a)fluoranthene, benzo(a)anthracene, chrysene and benzo(a)pyrene in all the samples. There was significant difference (p<0.05) in all the PAHs levels of all the smoked samples. Samples smoked with charcoal were low in benzo(a)anthracene, chrysene and benzo(a)pyrene while samples smoked with briquettes have the highest levels of the PAH4 except benzo(a)anthracene which was found to be low.
Keywords: Fuel energy sources, *Clarias gariepinus,* Health risk, Smoking, Polycyclic aromatic hydrocarbons

INTRODUCTION

Fish are well-known excellent sources of essential nutrients (Mahmud *et al*., 2018). However, they are extremely perishable. The deterioration that sets in when a fish dies is both physiological and microbial; these invariably degrade the quality of fish. Fish are generally dehydrated as a method of preservation, as fish is well-known for its spoilage issues (Fitri *et al*., 2022). Hence, a significant effort has been directed to lengthen the shelf-life. In Nigeria, fish smoking is the most practiced preservation method. Practically all species of fish available in the country can be smoked (Pemberton-Pigott *et al*., 2016). Polycyclic aromatic hydrocarbons (PAHs) are a group of very stable organic pollutants that are produced when complex organic matters are exposed to heat and most commonly by the incomplete combustion of wood and fossil fuel (Mojiri *et al*., 2019). The smoking equipment and the type of fuel used for smoking were previously reported to favour the production of PAHs in smoked shrimp (Kpoclou *et al*., 2014). Pissinatti *et al*. (2015) studied the presence of polycyclic aromatic hydrocarbons in food and concluded that they are potential risk to human health.

MATERIALS AND METHODS

Experimental Site

The fish smoking experiment was carried out in the Fisheries Teaching and Research Farm of the School of Food Science and Agricultural Technology, Federal University of Technology, Bosso campus, while the briquetting experiment was carried out at the Mechanical Central Workshop of the School of Engineering and Engineering Technology, Federal University of Technology, Gidan Kwanu campus, Minna-Niger state. The polycyclic aromatic hydrocarbons analysis was carried out in the Department of Chemical and Petroleum Engineering laboratory, Afe Babalola University Ado-Ekiti, Ekiti state.

Fish Sample

Thirty-six (36) fish samples (*Clarias gariepinus*) with average weight of 508 g were purchased from Mobil Fish Market Minna, Niger State. The fish samples were gutted and washed thoroughly with clean tap water to remove blood and slime. Thereafter, the fish samples were grouped into three (3) batches of 12 pieces each and were bent into horseshoe shapes, for smoking with firewood, charcoal and rice husk briquettes.

Fuel Energy Sources

Vitellaria paradoxa firewood, *Prosopis africana* charcoal, and rice husk briquettes were used as the fuel energy sources for this experiment. The firewood and charcoal were purchased from local firewood and charcoal sellers at Bosso, Minna; the rice husk was purchased from a rice mill at Gidan Kwanu settlement, Minna-Niger State. Waste papers were sourced from printing and binding shops which were used as binder.

Smoking Procedure

The fish samples were smoked using a modified drum smoking kiln. Firewood, charcoal and briquettes were placed in the combustion chamber, ignited and monitored to generate smoke for the smoking process. Each batch of fish was smoked separately but concurrently using firewood, charcoal and briquettes. At one (1) hour intervals, the fish samples were turned to avoid charring. Subsequently, the smoked fish samples were packaged in low-density polyethylene zip lock bags and taken to the laboratory for polycyclic aromatic hydrocarbon analysis.

Polycyclic Aromatic Hydrocarbons Analysis

The polycyclic aromatic hydrocarbons level was determined using Gas Chromatography-Mass Spectrometry (GC-MS) analysis based on the method described by Tidiane (2022).

Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using IBM Statistical Package for Social Sciences (SPSS) version 20.0 software, and Duncan Multiple Range Test (DMRT) was used for mean separation at 5% level of significance ($P < 0.05$).

RESULTS AND DISCUSSION

Effect of different fuel energy sources on the PAHs levels of smoked *C. gariepinus*

Table 1 showed the polycyclic aromatic hydrocarbon (PAH4) levels of *C. gariepinus* smoked using different fuel energy sources. The PAHs analysis carried out in this study followed the suggestions of Bansal and Kim (2015) and Domingo and Nadal (2015) who maintained that to determine the amount of the most important polycyclic aromatic hydrocarbons in food, the European Commission recommended an analysis for benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene, summarised as PAH4. There was significant difference ($p<0.05$) in all the PAHs levels of all the smoked samples. The table 1 revealed that charcoal smoker sample has the lowest levels of benzo(a)pyrene followed by briquettes then firewood. The levels of benzo(b)fluoranthene, chrysene, and benzo(a)pyrene were higher in briquettes smoked samples. Benzo(a)pyrene had the least value among the other PAH4.

The PAH4 values obtained in this study were lower than those report by Hasselberg *et al*. (2020) who observed high mean values of 478±164 µg/kg, 553±155 µg/kg, 418±103 µg/kg and 443±91 µg/kg in smoked European anchovy, bigeye grunt, *Sardinella* and African moonfish respectively, and Afé *et al*. (2021) who reported the minimum and maximum levels of occurrence of PAH4 in smoke-dried fish for benzo(b)fluoranthene to be 7.6 µg/kg and 166.7 µg/kg, benzene(a)anthracene to be 31.9 µg/kg to 403.7 µg/kg, chrysene to be 32.1 µg/kg and 603.3 µg/kg, and benzo(a)pyrene to be 10.1 µg/kg and 183.4 µg/kg.

In 2005, the European Commission (EC) introduced for benzo(a)pyrene (chosen as a marker of the occurrence and carcinogenic potency of the entire class of carcinogenic and genotoxic PAHs) a maximum level of 5µg kg^{-1} in smoked fish and meat (Coutrelis, 2005). In a study conducted in Ghana, it reported elevated levels of polycyclic aromatic hydrocarbons in smoked fish sample ranging from 250.59 µg/kg to 1,143.5 µg/kg for two hours of smoke-curing, 595.33 µg/kg to 1,315.66 µg/kg for 4 hours and 574.97 µg/kg to 1,376.90 µg/kg for eight hours of smoke-curing (Essumang *et al*. (2013) which were higher than the values recorded in this study, this could be due to the energy source(s) used in the smoke generation process. Though the PAHs levels found in this study were lower compared to those mentioned however, they were still beyond the maximum recommended limit of 10 µg/kg as reported by European Commission (2011).

The PAH4 of this study were also lower than those report by Akpambang *et al.* (2009) who reported the presence of low molecular weight polycyclic aromatic hydrocarbons ranging from 113.5 µg/kg to 209.3 µg/kg in fish smoked using hardwood charcoal in a laboratory in comparison to fish smoked by commercial vendors purchased from a local market, the firewood smoked samples had low molecular weight polycyclic aromatic hydrocarbons ranging from 152.1 to 936.4 µg/kg.

Table 1: Polycyclic aromatic hydrocarbons level in smoked *C. gariepinus*

Energy source	B(b)F (µg/kg)	B(a)A (µg/kg)	Chrysene (µg/kg)	B(a)P (µg/kg)
Firewood	113.2^{a}	49.8^{a}	66.3^{b}	14.4^{b}
Charcoal	128.6^{b}	63.4^{c}	46.5^{a}	8.3^{a}
Briquettes	236.5^{c}	57.2^{b}	78.1^{c}	16.9^{c}

Mean values with different superscript within the same column are significantly different ($p<0.05$).
B(a)F = Benzo(b)Fluoranthene
B(a)A = Benzo(a)Anthracene
B(a)P = Benzo(a)Pyrene

CONCLUSION

The moisture content of fish is of great importance as most of the biochemical reactions and physiological changes in fish depends on the moisture content, the three energy sources however, showed good drying qualities. These energy sources especially *Prosopis africana* charcoal could be harnessed by fish processors and local fish communities in their smoking processes. Four polycyclic aromatic hydrocarbons of great health concern were detected over maximum permissible limits. The research demonstrated that the choice of energy source plays a crucial role in the formation of PAH4 during the smoking process.

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