THE SIGNIFICANCE OF PROCESSING TECHNIQUES ON THE QUALITY OF SMOKED AFRICAN CATFISH (*Clarias gariepinus*) USING DIFFERENT ENERGY SOURCES

ABSTRACT

There is unavoidable need for fish smoking as a preservative technique to reduce rampant post harvest losses in the tropical Africa. Howeverthe imperative of healthier and quality smoked products through improved processing method were however investigated. Organoleptic and chemical assessment of African catfish collected from a reputable fish farm in Ogbomoso, Oyo state Nigeria was carried out. Eviscerated and non-eviserated fish samples were smoked using four different smoke sources:Gmelina (*Gmnelinaarborea)*, Parkia(*Parkiabiglobosa)*, Neem(*Azadirachitaindica)* and charcoal. Overall acceptability was based on 5-point Hedonic scale (excellent (5) - poor (1). Chemical test was on Polycyclic Aromatic Hydrocarbon contents (benzo(a)pyrene, Fluoranthene, Napthalene, Acenapthalene, Chrysene and Benzo(ghi) perylene). Data were subjected to one way Analysis of Variance (ANOVA) using general linear mode (GLM) of Factorial Experimental Design and means were separated by Duncan's multiple range tests ($P<0.05$).Non- eviscerated smoked African catfish samples had lower scores for colour than eviscerated smoked samples for energy sources used. Eviscerated samples had mean scores of 4.64, 3.91, 3.36 and 2.82 for charcoal, Gmelina, Neem and Parkia smoked samples respectively, much better than scores of 4.36, 2.46, 2.36 and 2.27 obtained for non-eviscerated samples. Total concentrations of polycyclic aromatic hydrocarbons (PAH) were highest in samples produced using Gmelinaas smoke source and Neem for eviscerated (15.25 µg/kg) and non-eviscerated (29.43 µg/kg) samples respectively.Evisceration of fish prior to smoking enhances its sensory characteristics however; concentrations of PAHs for both eviscerated and non-eviscerated fish samples were within the recommended international standard limit.

Keywords: Catfish, smoked fish, smoke sources, organoleptic properties

1. INTRODUCTION

Fish is a very important source of animal protein, whose importance has been recognized by man from the distant past [1]. The nutritional benefits of fish are linked to high quality protein and the presence of certain vitamins and minerals [2]. In addition, the fish contain polyunsaturated fatty acids that play an important role in human health [3]. Fish consumption is not forbidden within religious groups, unlike eating beef, dog, and pork, which is forbidden in some religions [4]. The drying effects during smoking, together with the antioxidant and bacteriostatic effects of the smoke, allow smoked products to have extended shelf life [5].In Nigeria, processing of fish either through smoking or drying is widely used in fish preservation. In the process, moisture content present in the fish is extracted through heating, thus inhibiting the action of micro-organisms and prolongs shell life [6, 7, 8].Storage life extension of smoked fish can result from a combination of lowered water activity and the uptake by the product of bactericidal and antioxidant components of wood smoke [9, 10]Smoking is one of the fish preservation methods that combine drying and decomposition of wood during combustion that lead to component such as phenol, formaldehyde, organic acids, and polycyclic aromatic hydrocarbons[11]. Smoking is mainly applied because it improves the organoleptic profile such as, colour, texture, and flavour of the fish [12]. On the other hand, it provides undesirable effects of amount which, the most important is the contamination of food by toxic and carcinogenic compounds such as PAHs, N-nitrosamines, aromatic amines, and β-carbolines [13].Smoke is the product of incomplete combustion of wood and consists of numerous individual components, namely, aldehydes, ketones, alcohols, acids, hydrocarbons, esters, phenols, ethers, etc. These components are transferred to the smoked goods by deposition on their surface and subsequent penetration into their flesh [14]. For this reason, the exportation of smoked fish is becoming increasingly stringent due to the emergence of food safety and agricultural health standard, along with the fact that buyers keep changing their requirements, offer new parameters for food safety [15].

This experiment was undertaken to determine the variation in the level of Polycyclic Aromatic Hydrocarbons present in eviscerated and non-eviscerated smoked African catfish (*Clarias gariepinus*) samples and also to examine the organoleptic charateristics using different smoke sources (Gmelina, Parkia, Neem and charcoal) with the aim of predicting their suitability for human consumption.

2. MATERIALS AND METHODS

A total of hundred (100) smoking size African catfish (*C. gariepinus*) were obtained from a reputable fish farm in Ogbomoso. The modern smoking process (using charcoal oven) experiment was carried out at the fishery unit, Ladoke Akintola University of Technology (LAUTECH) Teaching and Research Farm, Ogbomoso. African catfish samples were eviscerated ,washed with clean water and smoked using four different fuel sources Beachwood *(Gmelina arborea*), African locust bean *(Parkia biglobosa*), Neem (*Azadirachita indica*) and charcoal.The fishes were eviscerated while some were not eviscerated. The fish were then scrubbed with potassium aluminum sulfate and later rinsed with clean water. They were all placed inside the charcoal oven for drying. The fish samples were turned every 2 hours to prevent the fish from burning. The drying lasted for 36hours after which they were removed. The samples were kept at room temperature after complete dryness and about 5g samples for each treatment were transported to the laboratory for analysis.

2.1Organoleptic Assessment

The smoked fish samples assessment was based on scoring system which involved measurement of certain parameters on a 5-point hedonic scale (excellent (5), very good (4), good (3), fair (2) and poor (1) for colour, texture, taste, flavour and overall acceptability. [16]

2.2 Chemical Analysis

Smoked fish were analyzed for the following Polycyclic Aromatic Hydrocarbon contents: (Benzo(a)pyrene, Fluoranthene, Napthalene, Acanapthalene, Benzo(ghi)perylene), Chrysene, Pyrene and Phenanthrene at the Animal science laboratory, University of Ibadan, Oyo state.

2.3. Statistical Analysis

Data collected were subjected to one way Analysis of Variance (ANOVA) using general linear Model (GLM) of Factorial Experimental Design and means were separated by Duncan's multiple range test (*P* = .05).

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation

The mean sensory score for colour in eviscerated African catfish as shown in table 1are 4.64, 3.91, 3.36 and 2.82 respectively for charcoal, Gmelina, Neem and Parkia, much better than scores of 4.36, 2.46, 2.36 and 2.27 obtained for non-eviscerated fish samples (table 2) smoked with charcoal, Parkia, Neem and Gmelina respectively. Eviscerated samples also produced better scores of texture, taste and acceptability for all treatments. Non eviscerated fish samples only had better score for flavour than eviscerated in all treatments except Parkia smoked sample. The samples were all generally acceptable to the taste panel.

3.2 Polycyclic Aromatic Hydrocarbons Concentration

Generally, smoke sources employed had a significant effect (*P* = .05) on concentrations of all PAHs. As shown in table 4, smoked eviscerated African catfish produced using Gmelina had highest concentration ofAcenaphthalene (0.74µg/kg), Pyrene(1.92µg/kg) andNapthalene (2.89µg/kg) while charcoal smoked samples had lowest concentration in all PAHs except Benzo(ghi)perylene (0.67µg/kg). In non-eviscerated African catfish samples, charcoal smoked samples record highest concentration (table 5) in chrysene (2.75µg/kg), Benzo(a)pyrene (2.95µg/kg) and Naphthalene (3.76µg/kg).However, total concentration of PAHs in eviscerated fish sample was highest in Gmelina smoked samples (15.25µg/kg) and the lowest was in charcoal (2.19µg/kg) while the highest total PAHs in non-eviscerated was in Neem smoked fish (29.43µg/kg) and the least was recorded in Gmelina (15.25µg/kg).

Table 1: Sensory scores for Eviscerated African Catfish (*C. gariepinus*) smoked under different energy sources

Parameter	GSE	Judgement	PSE	Judgement	NSE	Judgement	CSE	Judgement
Colour	3.91	Light	3.36	Intermediate	2.82	Intermediate	4.64	Very light
Flavour	2.61	Medium	2.55	Medium	2.52	Medium	2.67	Slightly mild
Texture	2.55	Medium firm	3.55	Firm	3.27	Medium firm	2.27	Delicate
Taste	3.27	Fair	3.55	Good	4.09	Good	3.01	Fair
Acceptability	2.88	Acceptable	3.25	Acceptable	3.25	Acceptable	3.07	Acceptable

GSE: Gmelina smoked eviscerated PSE: Parkia smoked eviscerated NSE: Neem smoked eviscerated CSE: Charcoal smoked eviscerated

Table 2: Mean sensory scores for Non-eviscerated African catfish (*C. gariepinus*) smoked under different energy sources

	GSNe	Judgement	PSNe	Judgement	NSNe	Judgement	CSNe	Judgement
Colour	2.57	Dark	2.46	Dark	2.36	Dark	4.36	Light
Flavour	2.82	Medium	2.72	Medium	2.64	Medium	2.64	Medium
Texture	2.18	Delicate	2.82	Medium firm	3.09	Medium firm	2.27	Delicate
Taste	2.46	Bad	3.18	Fair	3.18	Fair	3.82	Good
Acceptability	2.43	Moderately acceptable	2.80	Acceptable	2.82	Acceptable	3.27	Acceptable

GSNe: Gmelina smoked non-eviscerated PSNe: Parkia smoked non-eviscerated NSNe: Neem smoked non-eviscerated CSNe: Charcoal smoked non-eviscerated

Table 3: Mean Sensory score for Eviscerated and Non-eviscerated African Catfish (*C. gariepinus*).

Parameters	Treatments							
	GSE	**GSNe**	**PSE**	**PSNe**	**NSE**	**NSNe**	**CSE**	**CSNe**
Colour	3.91	2.27	3.36	2.46	2.82	2.36	4.64	4.36
Flavour	2.61	2.82	2.55	2.72	2.82	2.64	2.27	2.64
Texture	2.55	2.18	3.55	2.82	3.27	3.09	2.27	2.27
Taste	3.27	2.46	3.55	3.18	4.09	3.18	3.01	3.82
Acceptability	2.88	2.43	3.25	2.80	3.25	2.82	3.07	3.27

GSE: Gmelina smoked eviscerated, GSNe: Gmelina smoked non-eviscerated, PSE: Parkia smoked eviscerated, PSNe: Parkia smoked non-eviscerated, NSE: Neem smoked eviscerated, NSNe: Neem smoked non-eviscerated, CSE: Charcoal smoked eviscerated, CSNe: Charcoal smoked non-eviscerated.

Table 4: Concentration of Polycyclic Aromatic Hydrocarbons present in Smoked Eviscerated African catfish (*C. gariepinus*) using different energy sources

Parameters	**Treatments**				
	GSE	**PSE**	**NSE**	**CSE**	**SEM**
Benzo (ghi)perylene (µg/kg)	0.76^a	0.69^a	0.12^b	0.67^b	0.16
Acenaphthrene (µg/kg)	0.74^a	0.68^a	0.73^a	0.31^a	0.11
Phenanthrene (µg/kg)	1.24^a	1.72^a	0.17^b	0.05^b	0.19
Chrysene (µg/kg)	2.70^b	2.71^b	0.72^a	0.31^a	0.24
Pyrene (µg/kg)	1.92^b	1.86^b	0.23^a	0.18^a	0.40
Benzo (a)pyrene(µg/kg)	2.74^a	2.75^a	0.73^a	0.32^b	0.26
Fluoranthene (µg/kg)	2.04^a	2.19^b	0.25^b	0.19^b	0.24
Naphthalene (µg/kg)	2.89^a	3.83^a	0.83^b	0.79^b	0.37
ΣPAHs (µg/kg)	15.25^c	11.91^b	2.27^a	2.19^a	3.17

GSE: Gmelina smoked eviscerated PSE: Parkia smoked eviscerated NSE: Neem smoked eviscerated CSE: Charcoal smoked eviscerated

Table 5: Concentration of Polycyclic Aromatic Hydrocarbons present in Smoked Non-Eviscerated African catfish (*C. gariepinus*) using different energy sources

Parameters	Treatments				
	GSNe	**PSNe**	**NSNe**	**CSNe**	**SEM**
Benzo (ghi)perylene (µg/kg)	0.80^{b}	1.08^{a}	1.23^{a}	0.29^{b}	0.11
Acenaphthrene (µg/kg)	0.77^{a}	1.16^{a}	0.77a	0.29^{b}	0.08
Phenanthrene (µg/kg)	0.03^{c}	1.03^{b}	1.77^{a}	1.16^{b}	0.18
Chrysene (µg/kg)	0.77^{b}	2.29^{a}	2.39^{a}	2.75^{a}	0.34
Pyrene (µg/kg)	0.31^{d}	3.09^{b}	3.66^{a}	1.76^{c}	0.26
Benzo (a)pyrene(µg/kg)	0.79^{c}	2.24^{b}	2.65^{ab}	2.95^{a}	0.34
Fluoranthene (µg/kg)	0.68^{c}	0.21^{b}	2.79^{a}	2.23^{b}	0.33
Naphthalene (µg/kg)	0.90^{b}	3.64^{a}	3.70^{a}	3.76^{a}	0.46
ΣPAHs (µg/kg)	4.00^{d}	11.91^{b}	29.43^{a}	13.85^{c}	1.75

GSE: Gmelina smoked eviscerated, GSNe: Gmelina smoked non-eviscerated, PSE: Parkia smoked eviscerated, PSNe: Parkia smoked non-eviscerated, NSE: Neem smoked eviscerated, NSNe: Neem smoked non-eviscerated, CSE: Charcoal smoked eviscerated, CSNe: Charcoal smoked non-eviscerated.

Table 6: Concentration of Polycyclic Aromatic Hydrocarbons present in Smoked African Catfish using different energy sources

Parameters	Treatments								
	GSE	**GSNe**	**PSE**	**PSNe**	**NSE**	**NSNe**	**CSE**	**CSNe**	**SME**
Benzo (ghi)perylene (µg/kg)	0.76^{bc}	0.80^{b}	0.69^{c}	1.08^{ab}	0.12^{a}	1.23^{a}	0.67^{d}	0.29^{d}	0.10
Acenaphthrene (µg/kg)	0.74^{abc}	0.77^{ab}	0.68^{bcd}	1.16^{a}	0.73^{abc}	0.77^{ab}	0.31^{cd}	0.29^{b}	0.07
Phenanthrene (µg/kg)	1.24^{b}	0.03^{c}	1.27^{b}	1.03^{b}	0.17^{c}	1.77^{a}	0.05^{c}	1.16^{b}	0.13
Chrysene (µg/kg)	2.70^{a}	0.77^{b}	2.71^{a}	2.29^{a}	0.72^{b}	2.39^{a}	0.31^{b}	2.75^{a}	0.21
Pyrene (µg/kg)	1.92^{c}	0.31^{d}	1.86^{c}	3.09^{b}	0.23^{b}	3.66^{a}	0.18^{b}	1.76^{c}	0.26
Benzo (a)pyrene(µg/kg)	2.74^{a}	0.79^{c}	2.75^{a}	2.24^{b}	0.73^{cd}	2.65^{ab}	0.31^{d}	2.95^{a}	0.22
Fluoranthene (µg/kg)	2.04^{a}	0.68^{b}	2.19^{a}	0.21^{a}	0.25^{b}	2.79^{a}	0.19^{b}	2.23^{a}	0.22
Naphthalene (µg/kg)	2.89^{a}	0.90^{b}	3.83^{a}	3.64a	0.83^{b}	3.70^{a}	0.79^{b}	3.76^{a}	0.30
ΣPAHs (µg/kg)	15.25^{c}	4.00^{f}	11.91^{e}	27.98^{b}	2.27^{g}	29.43^{a}	2.18^{g}	13.85^{d}	2.10

GSE: Gmelina smoked eviscerated, GSNe: Gmelina smoked non-eviscerated, PSE: Parkia smoked eviscerated, PSNe: Parkia smoked non-eviscerated, NSE: Neem smoked eviscerated, NSNe: Neem smoked non-eviscerated, CSE: Charcoal smoked eviscerated, CSNe: Charcoal smoked non-eviscerated.

3.3 Discussion

African catfish produced using charcoal for both eviscerated and non-eviscerated had a lucid brownish colour and had the highest score for colour. The sensory score shows that colour of the products is important and thus has influence on the general preference of the consumer. This is consistent with other findingswhich states that consumer preference for smoked fish was primarily based on the colour and the best appearance of smoked fish is characterized by its surface colour [17].
Non-eviscerated fish samples produced dark and dull appearance compared to eviscerated samples. This due to the prompt degradation of hemoglobin present in the visceral organs thereby changing from red to dark coloration.

Organoleptic properties of the smoked fish samples vary with the smoke sources used and this also conforms to the findings which explained that sensory qualities of smoked products are decisively influenced by composition of the smoke and nature of wood involved [17]. This is also in agreement with Eyo who posited that better flavoured smoked fish are obtained by smoking with hardwoods than softwoods due to higher content of some phenolic compounds particularly guaiacol and syringol in the hardwood [5].

The PAHs concentration recorded in the smoked African catfish produced using Neem and Parkia for eviscerated and non-eviscerated was relatively high compared to other treatments. This may be attributed to the longer drying times as a result of the less heat and high smoke produced by Neem and Parkia resulting to prolonged fish contact with the smoke, being the major source of the PAHs contamination.This is consistent with the findings of [18] who observed in their study that at high temperatures, less smoke was produced and at lower temperatures, more smoke was produced during the smoking process.

The variation in concentration of PAHs in all treatments was also in agreement with [19] who states that the actual levels of PAHs in smoked foods depend on several variables in the smoking process, including type of smoke generator, combustion temperature, and degree of smoking.The duration of smoking non-eviscerated fish samples was longer than eviscerated samples due to differences in mass as a result of the visceral organs.

4. Conclusion

This study revealed that smoked non-eviscerated African catfish and eviscerated African catfish produced using Charcoal and Gmelina as smoke sources had higher overall acceptability.However, in all the smoked fish samples examined, the 5 µg/kg acceptable limits of Benzo(α)pyrene which is the marker of the carcinogenic PAHs as recommended by the European Commission was not exceeded [20].Also, evisceration of African catfish samples prior to smoking enhances its sensory characteristics.

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