

# EVALUATION OF POLYCYCLIC AROMATIC HYDROCARBONS CONCENTRATIONS IN LOCALLY SMOKED AND FRESH CLARIAS GARIEPINUS FROM GOVERNMENT ASSISTED CLUSTERED FISH FARM, IKORODU, LAGOS STATE.

## ABSTRACT

**Aims:** ~~was to Evaluate~~ ~~ion of the~~ polycyclic aromatic hydrocarbons (PAHs) concentrations ~~was in~~ ~~conducted on~~ fresh and smoked *Clarias geriepinus*

**Study Design:** Fifty numbers of fresh ~~and smoked~~ *Clarias geriepinus* ~~which ranges in weight between 200.5g and 655.2g was~~ collected from selected clustered farmers and ~~separated categorized based on their intoweight into~~ five groups. ~~based on their weight range of 200.5g and 655.2g for the analysis.~~ ~~The tissues were collected from each fresh fish for analysis of PAHs before smoking.~~

**Place and Duration of Study:** The sampled fish were collected from government assisted clustered fish farm estate. The analyses for PAHs were carried out at the central laboratory of Nigeria Institute for Oceanography and Marine Research, Lagos.

**Methodology:** The laboratory procedures and analyses for the detection of sixteen PAHs in the muscles of fresh and smoked on each five grouped of *C. geriepinus* were carried out using Gas Chromatography (Model HP 6890A).

**Results:** ~~The significant levels of PHAs concentration were determined using a two-way analysis of variance (SPSS version 25).~~ There is no significant difference in the means concentrations of PAHs in both fresh and smoked fish muscles but significant difference occurs ( $p=.05$ ) in the grouped smoked fish. However, Indeno (1, 2, 3-c, d) Pyrene mean concentrations was higher in both fresh and smoked fish.

**Conclusion:** PAHs concentrations from both fresh and smoked *C. geriepinus* muscles are below the FAO/WHO threshold limit. It is therefore safe for human consumption, but a gas or electric powered smoking kiln is hereby recommended to prevent further accumulation of PAHs in smoked fish, which could be carcinogenic to human consumers.

Keywords: Polycyclic Aromatic Hydrocarbons, *Clarias geriepinus* Evaluation

## 1. INTRODUCTION

Food toxicity from ~~the~~ harmful substances and the determination of lethal level concentrations ~~forte~~ consumers ~~are~~ the mainstream of food safety and standards regulatory agencies all over the world. In most cases, The toxic substances in food ~~in most cases~~ are usually chemical compounds ~~which that~~ are either elemental or complex harmful materials, or rather organics toxicants such as polycyclic aromatic hydrocarbons (PAHs).

According to [1] PAHs are a group of organic compounds consisting of two or more fused aromatic rings and a group of lipids-soluble compounds that are carcinogenic in nature, and their presence have been found in all our bionetworks [2]. The formation of PAHs ~~are-is~~ known by researchers to be through the natural processes of carbonization and subsequent separations into small amounts of persistent organic pollutants that usually occur in ~~our-the~~ entire biospheres [3], [4], [5] formed from distance and settled elsewhere, or formed as a native of a particular place (allochthonous and autochthonous) [6], and it could

**Comment [J1]:** The word evaluate should be included to the topic, as well as the traditionally method of smoking

**Comment [J2]:** There should be only one aim

**Comment [J3]:** State the duration of the study, the months and year of the study

**Comment [J4]:** The finding of this study has not been reported here, only the statistical statement was presented

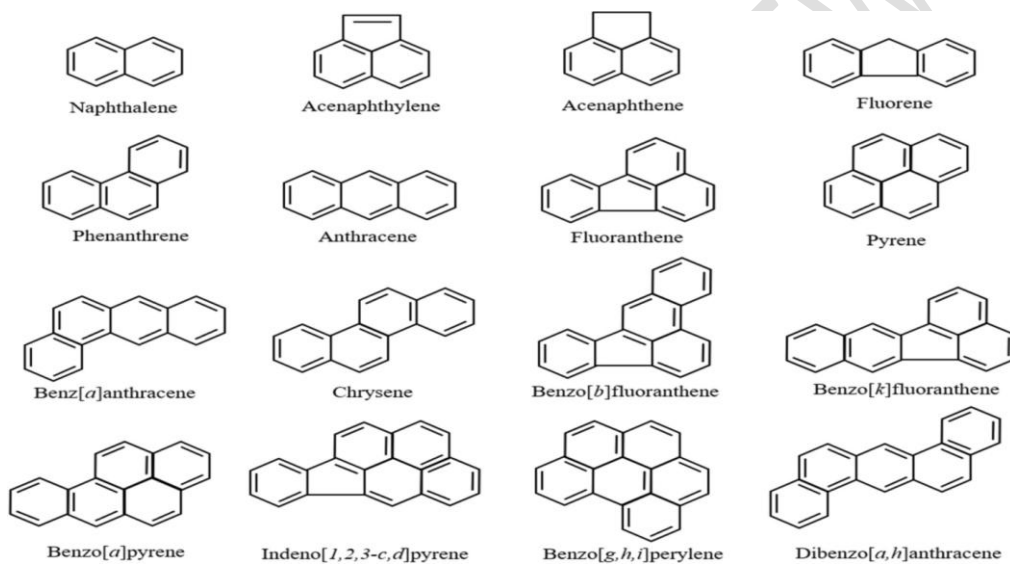
**Comment [J5]:** The source of these information should be acknowledged

**Comment [J6]:** The information should not be personalized

**Comment [J7]:** Link to the proceeding statement

45 | also be a by-products from ~~the~~ incomplete combustion or burning ~~and~~ organic matter such as tobacco  
46 | smoke, engine exhausts, petroleum distillates, and coal-derived products, with combustion sources  
47 | predominating during industrial processing or from natural processes ~~of such as~~ volcanic eruptions and,  
48 | various anthropogenic activities [7].

49 | PAHs are dispersed extensively into the atmosphere, and this could form another complex compounds  
50 | with sulfur dioxide, nitrogen oxides, and ozone pollutants under processes known as Photo-Degradation  
51 | [8]. There are sixteen (16) known PAHs and their sources are but not limited to; coal tar, petroleum  
52 | fraction, diesel exhaust fumes, spruce needle, tree leaves, grass and plants, vehicle exhaust, processing  
53 | of organic material, emissions from petroleum refining, incomplete combustion of organic matter,  
54 | agricultural burning and hazardous waste sites, tobacco smoke, coal tar, soot and certain food products,  
55 | especially smoked and barbecued foods [9] and [8].



56 |  
57 | **Fig 1: Chemical structure of 16 PAHs (Source: [10])**

58 |

59 | [11] Classified PAHs as ninth among other chemical compounds causing health issues in humans. The  
60 | health risk factor associated with PAHs could serve as precursor for incurable diseases such as cancer  
61 | attacks on consumers of such contaminated food items.

62 | In Nigeria, smoked or barbecued fish is one of the consumer's preferences ~~of-for~~ eating fish, and data  
63 | shows that out of 30,000 Tons of various freshwater and brackish water fish species produced in Nigeria,  
64 | about 61% ~~of it~~ are smoked [12]. Fish smoking is one of the prehistoric technologies of fish processing  
65 | and preservation that has been assisting fishermen, fish farmers and fish mongers for ages. Smoked fish  
66 | commands a high market price due to its aesthetic taste and ~~the~~ availability for consumption during ~~period~~  
67 | ~~of periods of~~ fresh fish scarcity, and most times, some species of fish are considered ~~as a~~ "status foods"  
68 | when smoked. The traditional fish smoking techniques involve subjecting the entire or gutted fish ~~into~~  
69 | smoldering wood or charcoal that comes into direct contact with the fish, and this process gives  
70 | opportunity for the accumulation of PAHs on fish with its attendant carcinogenic effect on consumers [13].

71 The rate of accumulation of PAHs on smoked fish depends on the techniques, combustion temperature  
72 and intensity of smoking ~~used during smoking~~ [14].

**Comment [J8]:** No need to repeat this

73 *Clarias gariepinus*, is a cultivable fish species ~~and~~ of great economic importance in Nigeria. The species  
74 ~~of fish~~ is widely accepted, and most times, it is at the center of meal in some households in Nigeria. It is a  
75 preferred source of animal protein due to its distinctive taste, flavor and tenderization [15]. Smoking ~~of~~ *C.*  
76 *gariepinus* is one of the most popular methods of processing and preserving the fish, as well as improving  
77 the taste qualities of the fish [16].

78 Government-assisted clustered fish farm estate in Ikorodu occupies about 34 hectares of land with 250  
79 ~~numbers of~~ prospective fish farmers that form clustered groups with a production capacity of over 12 tons  
80 of both fresh and smoked fish per annum, ~~majorly mainly~~ *Clarias gariepinus*. This annual tonnage of fish  
81 production can support ~~in~~ meeting the protein needs of about one-third of Lagos population annually.  
82 Hence, the need to conduct a toxicological study on the fish produced, considering the number of people  
83 that may be predisposed to these harmful substances, ~~their health will be at risk if the fish is not~~  
84 ~~evaluated to determine the level toxicants in them and make recommendations to appropriate authority~~.

**Comment [J9]:** This should be deleted or rephrased

## 85 86 2. MATERIALS AND METHODS

87 *Clarias garipenus* with a weight range between 200.5g and 655.2g were randomly taken from a  
88 government assisted clustered fish farm estate, Ikorodu, Lagos State, for the analyses of sixteen PAHs.  
89 Fifty (50) numbers of *C. garipenus* were collected from selected clustered farmers and are separated into  
90 5 groups based on their weight range (table. 1)

91  
92 Table 1: Grouped wet weight of *C. garipenus* for PAHs determination

GROUP	NUMBER OF FISH	WEIGHT RANGE (g)
1	10	200.5 – 220.1
2	10	315.2 - 325.5
3	10	410.3 – 455.5
4	10	515.4 – 550.3
5	10	620.2 – 655.2

**Comment [J10]:** What informed the categorization into this groups and is their scientific basis for it. The author should explain this. The sample size is not too large why categorize them into groups?

**Comment [J11]:** The author was bias in his categorization of the fish, and this will affect the general outcome of the result. Each group should have had the same mean weight rather than using smaller fish and categorizing then together and bigger fish categorizing the together. The author ought to have use random sampling technique and give use the mean weight for each group.

93  
94 Fish muscles were taken from each ~~of~~ the 50 fresh *C. garipenus* and tagged before smoking  
95 accordingly to avoid mix-ups. Likewise, fifty (50) samples of *C. garipenus* muscles from the tagged fish  
96 were taken after smoking ~~from~~ the same set of fish.

**Comment [J12]:** The author should state part of the fish tissue that was taken prior to smoking. This is important as different tissues may have affinity to absorb different substances.

97 The smoked *C. garipenus* ~~were was~~ subjected to the same smoking temperature between 66<sup>o</sup>c and 77<sup>o</sup>c  
98 for 6 hours in a 1000kg ~~capacity~~ charcoal-powered smoking kiln. From each smoked and fresh *C.*  
99 *garipenus*, 10g of fish muscle was taken respectively at the ventral axis of the fish girth and the samples  
100 collected were conveyed to the laboratory using standard chains of custody involved in PAHs sampling  
101 and assessment. The analysis of PAHs concentrations in the muscles of fresh and smoked *C. geriepinus*  
102 was carried out at the central laboratory of the Nigeria Institute for Oceanography and Marine Research,  
103 Lagos.

**Comment [J13]:** The study design has not been adequately described by the author. The author should explain properly how the study was designed.

### 104 105 2.1 Investigated organics toxicant

106 Nephthalene, Acenaphthalene , Fluorene, Phenanthrene, Anthracene, Fluoranthene - pyrolytic,  
107 Pyrene, Benz(a) anthracene, Chrysene, Benzo(b) fluoranthene, Acenaphthene, Benzo [k] Fluoranthene,  
108 Benzo [a] pyrene, Benzo [g,h,f] Perylene, Indeno [1,2,3-c,d] and Dibanzo[a,h]Anthracene.

**Comment [J14]:** In Line 85 the author mention they are going to investigate 16 organic toxicant, but here there are more 16 toxicants. The author should harmonized.

### 110 2.1.1 Reagents, Stock Solution Preparation, and Extraction Methods for Fish Muscle Samples

111 The reagents used in stock solution preparation are; Silica gel, 60-120 mesh, baked at 130<sup>o</sup> C for 8  
112 hours, Dichloromethane (hplc-grade), n- Hexane (hplc-grade), Acetone (hplc-grade) and Sodium sulfate,  
113 Anhydrous (ACS-grade). Fish samples were shade-dried, and separately homogenized with a blender. A  
114 5g portion of each sample homogenate was separately saponified with 200 ml of methanol/KOH (12%  
115 KOH in 95% methanol) solution in an ultrasonic bath at 60 °C, for 30 min. The extract was cooled and  
116 filtered, through glass wool, into a separatory funnel. The filtrate was extracted twice with 25 ml of  
117 hexane. The extract was washed with methanol/water (4:1) mixture, and then concentrated to 1ml with a  
118 rotary evaporator. The concentrate was fractionated through a silica gel column, first eluted with 10 ml  
119 hexane to collect the aliphatic hydrocarbon fraction, and then with 15 ml methylene chloride to collect the  
120 aromatic hydrocarbon fraction. The aromatic hydrocarbon fraction was dried over anhydrous sodium  
121 sulfate, and then concentrated to 1 ml with a rotary evaporator, and saved in GC vials for subsequent  
122 determination of PAHs.

**Comment [J15]:** There is no need listing the materials used, the procedure has the materials.

#### 123 2.1.1.1 Analysis protocol, GC Set-up conditions for PAHs and quantitation and detection limits

124 The extracts in the GC vials were transferred to a GC auto-sampler and analyzed by GC/FID following the  
125 procedures specified in the appropriate PAHs method. Gas Chromatography model HP 6890A with  
126 Column DB 5 MS (30m x 0.25mm x 0.5um) was used in the determination of PAHs. The oven was set to  
127 40°C and hold-held for 2 min, then ramp 250°C at 25°C/min to 265°C, and at 5°C/min to 300°C. Then  
128 hold 4 min, at 25°C. Flame Ionization Detector (FID) was set at 350°C. The Carrier Gas, Hydrogen at 4  
129 ml/min (constant flow Injector: 350°C). The Injection volume: 1 uL, splitless, (hold 2 min). 1µL of the  
130 aromatic hydrocarbon fraction was injected into the GC, set-up for the quantitation of PAHs, using the  
131 Agilent Chemstation Software. The lowest concentration of Polycyclic Aromatic Hydrocarbons was taken  
132 as detection limits that are extractable with good recoveries. The procedures in PAHs determination in  
133 smoked and fresh *C. garipenus* is followed with slight modifications by [17]

#### 134 2.1.1.1.1. Applications and Statistical Analysis

135 Evaluation of polycyclic aromatic hydrocarbon concentrations in smoked and fresh *C. garipenus* from  
136 government assisted clustered fish farm estate and its dietary effect on human health. Statistical  
137 significance was assessed using a two-way analysis of variance (ANOVA) and the software used is SPSS  
138 version 20. The correlation coefficient and differences between groups were considered significant when  
139  $p = .05$  (two tailed)

## 140 3. RESULTS AND DISCUSSION

141 The results of levels of concentrations (µg/kg) of PAHs from GC analyses on fresh and smoked fish  
142 muscles are shown in Table 2. It indicated that Dibenz (a,h)anthracene had the highest concentration in  
143 fresh fish from Group 3 (0.085µg/kg) while smoked fish had the highest concentration of Benzo (g, h, i)  
144 Perylene (0.085µg/kg) in group 1. Benzo (a) Pyrene had the lowest concentrations of 0.001µg/kg in both  
145 fresh and smoked fish form groups 5 and 1 respectively. Though, Napthalene, Anthracene, Chrysene,  
146 Benzo (b) Fluoranthene, Benzo (k)Fluoranthene, and Benzo (a) Pyrene concentrations from fresh and  
147 smoked fish in both Group 3 are below the detection level (BDL) while Acenaphthylene concentration  
148 was below the detection level in Group 1 of fresh fish muscle but detected in all grouped smoked fish  
149 muscle. Furthermore, other listed PAHs in Table 2 and their detected concentrations are predominant in  
150 all the grouped wet and dried weights of fish. The mean concentrations of PAHs ( $\Sigma$ PAHs) present in  
151 smoked fish are higher than that in fresh fish, smoked fish muscles had mean total of 0.0014176µg/kg  
152 while fresh fish had mean total of 0.0009496µg/kg but Indeno (1, 2, 3-c, d) Pyrene had the highest mean  
153 PAHs concentrations in smoked fish while Dibenz (a, h) Anthracene had the highest mean PAHs  
154 concentrations in fresh fish as indicated in table 2. Nevertheless, the mean PAHs concentrations did not

160 increase with increase in the weight of fresh and smoked fish but statistical analysis shows no significant  
161 differences within the grouped fresh and smoked fish respectively.

**Comment [J16]:** Include the statistical output here

UNDER PEER REVIEW

Table 2: showing the concentrations of Polycyclic Aromatic Hydrocarbons in fresh and smoked muscle of *Clarias gariepinus*

S/N	PAHs	PAHs Concentrations in Fresh Fish Muscle						PAHs Concentrations in Smoked Fish Muscle					
		Grp. 1 (µg/kg)	Grp. 2 (µg/kg)	Grp. 3 (µg/kg)	Grp. 4 (µg/kg)	Grp. 5 (µg/kg)	Mean (STD±)	Grp. 1 (µg/kg)	Grp. 2 (µg/kg)	Grp. 3 (µg/kg)	Grp. 4 (µg/kg)	Grp. 5 (µg/kg)	Mean (STD±)
1	Napthalene	0.004	0.004	BDL	0.004	0.004	0.003±0.000 <sup>b</sup>	BDL	0.006	BDL	BDL	0.004	0.002±0.001 <sup>d</sup>
2	Acenaphthylene	BDL	0.003	BDL	0.003	0.005	0.002±0.001 <sup>b</sup>	0.004	0.006	BDL	0.008	0.004	0.004±0.002 <sup>d</sup>
3	Acenaphthene	0.011	0.006	0.011	0.011	0.023	0.013±0.006 <sup>b</sup>	0.044	0.028	0.028	0.024	0.017	0.028±0.010 <sup>a,b,c</sup>
4	Fluorene	0.008	0.007	0.008	0.007	0.008	0.008±0.001 <sup>b</sup>	0.011	0.010	0.011	0.011	0.012	0.011±0.001 <sup>b,c,d</sup>
5	Anthracene	0.013	0.012	BDL	0.011	0.004	0.008±0.004 <sup>b</sup>	0.006	0.015	0.008	0.016	0.013	0.012±0.004 <sup>b,c,d</sup>
6	Phenanthrene	0.004	0.004	0.012	0.004	0.004	0.006±0.004 <sup>b</sup>	0.011	0.006	0.013	0.006	0.003	0.008±0.004 <sup>c,d</sup>
7	Fluoranthene	0.009	0.006	0.008	0.006	0.004	0.007±0.002 <sup>b</sup>	0.014	0.008	0.011	0.010	0.007	0.01±0.003 <sup>b,c,d</sup>
8	Pyrene	0.004	0.004	BDL	0.004	0.004	0.003±0.000 <sup>b</sup>	0.004	0.006	0.011	0.009	0.005	0.007±0.003 <sup>b,c,d</sup>
9	Benz (a) Anthracene	0.010	0.005	0.011	0.007	0.006	0.008±0.003 <sup>b</sup>	0.011	0.013	0.012	0.007	0.006	0.010±0.003 <sup>b,c,d</sup>
10	Chrysene	0.005	0.005	BDL	0.005	0.004	0.004±0.001 <sup>b</sup>	0.004	BDL	BDL	BDL	0.004	0.002±.000 <sup>d</sup>
11	Benzo (b)Fluoranthene	0.007	0.006	BDL	0.008	0.008	0.006±0.001 <sup>b</sup>	0.008	0.008	BDL	0.008	0.007	0.006±0.001 <sup>c,d</sup>
12	Benzo (k)Fluoranthene	0.007	0.005	BDL	0.006	0.006	0.005±0.001 <sup>b</sup>	0.007	BDL	BDL	BDL	0.005	0.002±0.001 <sup>d</sup>
13	Benzo (a) Pyrene	0.002	0.012	BDL	0.007	0.001	0.004±0.005 <sup>b</sup>	0.001	0.026	BDL	BDL	0.021	0.010±0.013 <sup>b,c,d</sup>
14	Dibenz (a, h) Anthracene	0.071	0.026	0.085	0.005	0.042	0.046±0.033 <sup>a</sup>	0.051	0.043	0.071	0.012	0.024	0.040±0.023 <sup>a</sup>
15	Indeno (1,2,3 – c,d)Pyrene	0.015	0.007	0.031	0.005	0.015	0.015±0.010 <sup>b</sup>	0.095	0.006	0.073	0.033	0.015	0.044±0.038 <sup>a</sup>
16	Benzo (g, h, i) Perylene	0.004	0.004	0.027	0.004	0.036	0.015±0.015 <sup>b</sup>	0.085	BDL	0.068	BDL	BDL	0.031±0.012 <sup>a,b</sup>
	Total PAHs (µg/kg)	0.174	0.116	0.193	0.097	0.174		0.356	0.181	0.306	0.144	0.147	
	Mean of PAHs (ΣPAHs)	0.011 <sup>a</sup>	0.008 <sup>a</sup>	0.012 <sup>a</sup>	0.007 <sup>a</sup>	0.011 <sup>a</sup>		0.024 <sup>a</sup>	0.014 <sup>ab</sup>	0.031 <sup>ab</sup>	0.013 <sup>b</sup>	0.010 <sup>b</sup>	
	STD ±	0.018	0.006	0.026	0.002	0.012		0.031	0.012	0.028	0.008	0.007	

\* Grp = Group

\*\*[18] Threshold limit =10µg/kg)

\*\*\* BDL = below detection level

**Comment [J17]:** In the methodology the author mention that each *Clarias* fish was analyze separately. Buy here on the table the author is providing results for a group. The author should explain if this if this is the mean concentration of the Polycyclic Aromatic Hydrocarbons. Also, if this is the mean values, the author must explain clearly in the methodology and should capture the heading as mean conc.

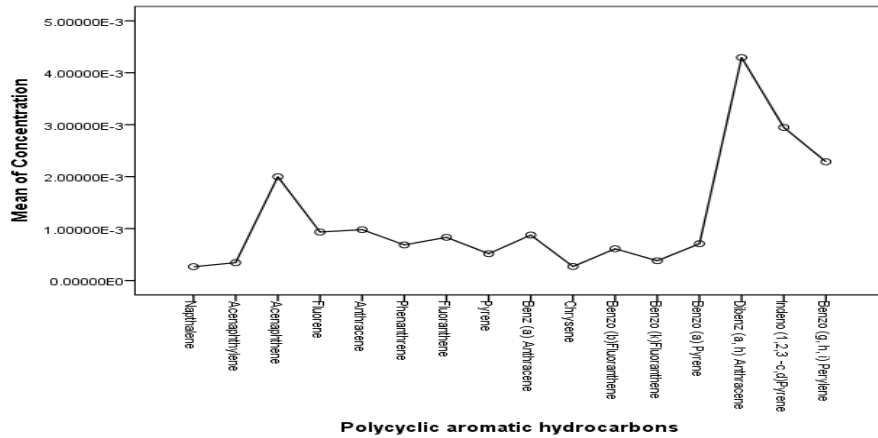


Fig. 2 shows the combined PAHs concentrations in both fresh and smoked fish.

The overall concentrations of PAHs shows that PAHs in smoked fish is higher than that of fresh fish in Groups 1 to 4, but in group 5, the overall concentrations of PAHs in fresh fish is higher than that of smoked fish as indicated in the multiple bar chart above in Figure 3. The sixteen types of PAHs concentration between and within the grouped fresh fish in the experiment shows that there is no significant difference among the means concentrations while PAHs concentration between and within the grouped smoked fish also shows that there is no significant difference among the mean concentrations of sixteen types of PAHs but the concentration of each of PAHs type in grouped smoked fish showed that there is significant difference among the mean concentration ( $p = .05$ ). Moreover, positive correlation in PAHs concentrations exists between fresh fish and smoked fish. The dependent variable for all the analyses in the experiment is the concentrations of Polycyclic Aromatic Hydrocarbons in both fresh and smoked fish muscles.

- Comment [J18]:** For this figure to be relevant in this study, the author must present separate lines for smoked and unsmoked fish on the same graph for comparison, since the study is trying to analyze the impact of fish smoking on the availability and concentration of organic toxicant. As it is there no information as to whether the smoking of the fish have tendencies to increase the level of organic contaminants or not.
- Comment [J19]:** There is no multiple bar chart above but below.
- Comment [J20]:** Present the statistical value. The P value, Df, and sig level
- Comment [J21]:** See comment above

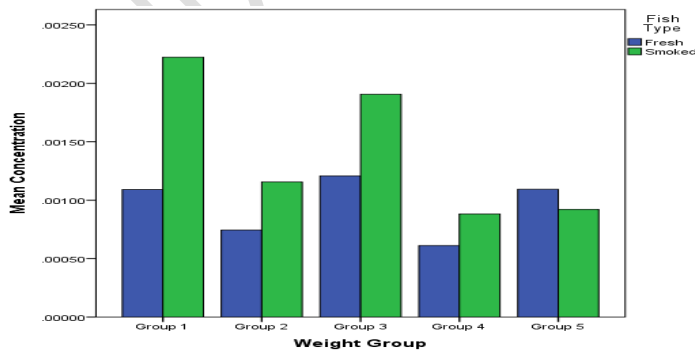


Fig. 3 Overall concentrations of PAHs in smoked and fresh fish

The Dietary effect of food on human growth, performance, and health has been the major concern of the stakeholders saddled with the responsibility of public health, food security and safety. The focus of food growers and food processing industries should be on food items that are consumed to be holistic and devoid of toxicants and food poisoning substances that can cause ill-health in human but with high nutritive values. However, the presence of toxicant in some food items has been identified to cause adverse health effects in human consumers with various clinical manifestations and symptoms [19].

Fresh *C. geriepinus* that was taken from rearing pond from fish farm estate had some levels of PAHs concentrations in their muscle which may probably be gotten from ingestion of fish feed because they were not exposed to direct carbonization during rearing. The contamination of food items could be from the raw ingredients before harvesting or during storage or processing for fish food [20]. Other route by which PAHs can bioaccumulated in the muscle of fresh fish is through PAHs contaminated water that enters into fish pond and permeate through their skin. This process is referred to as "atmospheric deposition" where water is polluted through atmospheric pollutants and such pollutants are detected in fish [21]. Most fish farmers from fish farm estate depends on deep bore-hole water for their source of water and overhead tanks for water storage and the atmospheric carbon can find their way into the storage tank. The levels PAHs concentrations from fresh fish muscle is significantly lower than that of USEPA threshold limit for fish possibly, because the fish are raised under the manageable production system of aquaculture.

The assessment of PAHs concentrations in smoked farmed *C. geriepinus* muscles are also below the USEPA threshold limit but, comparatively it has elevated-higher concentrations than that of fresh fish. The elevated concentrations in smoked fish muscle might be due to the charcoal used in smoking the fish. This observation agreed with the scientific publication of [13] on the effect of traditional smoking techniques on quality of smoked fish using charcoal or wood. Moreover, some PAHs elements that are in fresh fish but not detected in the same fish when smoked may perhaps be due to volatility properties of some PAHs types that are initially bioaccumulated in fresh fish but when subjected to heat during smoking, it becomes volatile [22] as cited by [19] on the volatility properties of PAHs under certain heat conditions.

All the sixteen (16) PAHs tested were found in both fresh and smoked fish muscles of *C. geriepinus*, although some that were found in fresh fish may not occur in smoked fish and vice versa because farmed *C. geriepinus* are known to be rich in saturated fatty acids, monounsaturated fatty acids, and omega-6 polyunsaturated fatty acids [23] PAHs are described to be as lipophilic in nature, which gives result in a strong bonding-bonding between the fatty acids deposits and PAHs concentrations in fish [2] and [24]. It is the fatty acids content, properties of the PAHs and methods of rearing and processing the fish and processing it that that determines the level of PAHs concentrations in their muscles. However, the weight of the fish plays no significant roles in the concentration of PAHs in their muscles.

In addition, it is sufficient to mention the adverse effects of consuming smoked and fresh fish that have accumulated PAHs in their muscles to on human health. The health risks involved in ingesting fish laden with PAHs that is above the agency's regulatory permissive limit ranges from carcinogenic to complex physiological health issues [14]. The presence of Pyrene and benzo (a) pyrene in fresh and smoked *C. geriepinus* muscles could be fatal to human health when consumed. These two types of PAHs have the ability to undergo numbers of phase transformation and DNA methylation in humans when ingested in the food and the concentrations are above threshold limit, and when this occurs, it could lead to dangerous and unsolicited gene editing, and or genetic mutagenization in humans as reiterated by [24] on the effect of using different wood in smoking fish and PAHs concentrations.

#### 4. CONCLUSION

PAHs concentrations from both fresh and smoked *C. geriepinus* muscles from the government assisted clustered fish farm are below [the](#) USEPA threshold limit and therefore safe for human consumption but the long-term effect of bioaccumulation, and subsequent bio-magnification of it in consumers over time should not be overlooked. The need to reduce the accumulation of PAHs on fish items during processing, preservation and storage is very important. It is therefore, recommended that periodic sensitization programs from The National Agency for Food and Drug Administration and Control in conjunction with, Standard Organization of Nigeria be embarked on to those in the fish production line from this teaming fish farmers from government assisted fish farm estate on the essentiality of quality assurance and quality control using standard operating procedures in fish production, processing, preservation, and storage.

[The](#) Government should also endeavour to introduce to the clustered fish farmers the use of gas or electric powered smoking kilns instead of ~~using wood or charcoal that which~~ will promote PAHs accumulations on the smoked fish. The food and safety regulatory agencies and extension workers from [the](#) Ministry of Agriculture should also visit the clustered fish farmers on a regular basis to educate them and promote new technology in fish processing, preservation, and storage that will improve the quality of fish produced. Above all, bush burning should be discouraged, and the use of environmentally-friendly materials should be encouraged.

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**Comment [J22]:** None of the references in the reference list was properly written. The author must ensure the references are written properly before the work is published.

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