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Health Risk Implications of Polycyclic Aromatic Hydrocarbons in Smoked and Dried Fish Consumed in Nigeria

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About Article

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants of global concern due to their mutagenic, carcinogenic, and bioaccumulative properties. This study quantified sixteen priority PAHs in Nile tilapia (Oreochromis niloticus), processed using four different drying methods: fresh air-dried (FAD), fresh oven-dried (FOD), fresh wood-dried (FWD), and fresh wood-smoked (FWP). Gas chromatography–mass spectrometry (GC–MS) analysis revealed that naphthalene was the most abundant PAH across all samples, with the highest concentration detected in FWP (112.85 mg kg^{-1}), followed by FOD (62.01 mg kg^{-1}). Carcinogenic PAHs such as chrysene, benzo[b]fluoranthene, and dibenzopyrenes were also identified, particularly in wood-smoked fish. Benzo[a]pyrene equivalent (BaPeq) concentrations ranged from 0.510 to 1.046 mg kg^{-1}, and estimated daily intake (EDI) values were 3.57×10^{-4}–7.32×10^{-4} mg kg^{-1} day^{-1} for adults and 6.81×10^{-4}–1.40×10^{-3} mg kg^{-1} day^{-1} for children. Corresponding lifetime excess cancer risk (LCR) estimates (2.61×10^{-3}–5.35×10^{-3} for adults and 4.97×10^{-3}–1.02×10^{-2} for children) exceeded the United States Environmental Protection Agency's acceptable range (10^{-6}–10^{-4}), indicating a potentially significant carcinogenic hazard from chronic consumption of smoked fish. The findings highlight that traditional wood-smoking significantly increases PAH accumulation and health risks, underscoring the need for safer fish processing technologies and stricter food-safety regulations in Nigeria.

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1. INTRODUCTION

Fish is a crucial part of the human diet worldwide, offering high-quality protein, essential amino acids, vitamins, and bioavailable minerals at relatively low cost compared to other animal protein sources (Nnaji *et al.*, 2010; FAO, 2020). In Nigeria, especially in the Niger Delta region, fish consumption holds cultural significance and is economically vital, with smoked and dried fish making up a large part of daily meals (Isioma *et al.*, 2016).

However, beyond its nutritional benefits, processed fish can also be a route for exposure to environmental contaminants such as polycyclic aromatic hydrocarbons (PAHs) (Okpoji *et al.*, 2025a). PAHs are hydrophobic organic compounds produced during the incomplete combustion of organic materials, including wood, coal, petroleum, and plastics (Ravindra *et al.*, 2008; Mojiri *et al.*, 2019). Several congeners, especially the high molecular weight (HMW) PAHs, are known for their mutagenic and carcinogenic properties, with benzo[a]pyrene (BaP) serving as a key marker for dietary exposure (IARC, 2010). Food is a primary route of exposure, and smoked or wood-dried fish has repeatedly been identified as a high-risk product (Perugini *et al.*, 2006; Akpambang *et al.*, 2009).

In Nigeria and other low- and middle-income countries, traditional fish processing methods like wood-smoking and open-fire drying remain prevalent (Ekwere *et al.*, 2025). These techniques often involve uncontrolled combustion of biomass or, in some cases, the addition of synthetic materials such as polythene to speed up burning (Nunoo *et al.*, 2018). Such practices increase smoke density and temperature, which enhances the deposition of PAHs—including carcinogenic species such as chrysene, benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, and dibenzopyrenes—onto fish tissues (Cheung *et al.*, 2007; Ding *et al.*, 2012).

While several Nigerian studies have reported PAH contamination in smoked or dried fish (Akpan *et al.*, 1994; Duke, 2007; Isioma *et al.*, 2016), few have provided a comparative, quantitative assessment of the carcinogenic risk associated with different processing methods using standardised risk models. Most prior research relied on concentration comparisons against regulatory limits such as the European Union's PAH_4 benchmark (BaP, chrysene, benzo[a]anthracene, and benzo[b]fluoranthene) (EU Commission Regulation No. 1327/2014). However, such concentration-based evaluations fail to translate contaminant levels into meaningful human health outcomes. Quantitative risk approaches—incorporating toxic equivalency factors (TEFs), estimated daily intake (EDI), and lifetime excess cancer risk (LCR)—provide a more robust framework for assessing dietary carcinogenic hazards (Nisbet & LaGoy, 1992; USEPA, 2012). This study, therefore, fills a critical knowledge gap by conducting a quantitative, comparative risk assessment of PAHs in Nile tilapia (Oreochromis niloticus) processed through four common Nigerian preservation methods: air-drying, oven-drying, wood-drying, and traditional wood-smoking.

2. LITERATURE REVIEW

2.1. Sources and environmental occurrence of PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 hydrophobic organic compounds generated mainly during incomplete combustion of organic matter, including biomass, coal, petroleum, and plastics (Ravindra *et al.*, 2008; Mojiri *et al.*, 2019). These compounds are environmentally persistent and can accumulate in air, soil, sediments, and aquatic systems, where they are bioavailable to organisms across the food chain (Wilms, 2000; Essumang *et al.*, 2012). In coastal and riverine regions of Nigeria, frequent oil spills, artisanal refining, and indiscriminate burning of waste have been reported to release significant PAH loads into aquatic environments (Nwaichi & Wegwu, 2010; Anarado *et al.*, 2023). Consequently, fish harvested from these ecosystems may contain elevated levels of PAHs.

2.2. Toxicological significance of PAHs

PAHs are of major toxicological concern because several congeners are classified as probable or known human carcinogens. The International Agency for Research on Cancer (IARC) designates benzo[a]pyrene (BaP) as a Group 1 human carcinogen, while others, such as chrysene, benzo[b] fluoranthene, and dibenzopyrenes, are Group 2A/2B (IARC, 2010). Toxicity depends largely on molecular size: low molecular weight (LMW, 2–3 ring) PAHs such as naphthalene are acutely toxic, while high molecular weight (HMW, 4–7 ring) PAHs are more strongly associated with mutagenesis, carcinogenesis, and endocrine disruption (Andrzej & Zdzislaw, 2005). PAHs undergo bioactivation to reactive metabolites that bind DNA and proteins, initiating genotoxic and carcinogenic effects (Boström *et al.*, 2002).

2.3. PAHs in Foods and human exposure

Food is considered one of the main routes of human exposure to PAHs, along with inhalation and dermal contact (European Food Safety Authority [EFSA], 2008). Grilling, smoking, and drying of foods significantly increase PAH contamination due to direct contact with combustion by-products (Perugini *et al.*, 2006). Fish, in particular, is vulnerable because of its lipid-rich tissue, which favours the accumulation of lipophilic PAHs (Storelli *et al.*, 2003). In Nigeria and other developing countries, smoked fish is widely consumed, but market surveys have revealed concentrations of BaP and PAH4 (BaP, chrysene, benzo[a]anthracene, benzo[b]fluoranthene) that often exceed European Union safety limits (Akpambang *et al.*, 2009; Isioma *et al.*, 2016). Similar contamination trends have been documented in Ghana, Cameroon, and Asia, suggesting a global food safety concern (Cheung *et al.*, 2007; Nunoo *et al.*, 2018).

2.4. Health risk assessment of PAHs

Traditional monitoring of PAHs in food often compares measured concentrations against regulatory limits, such as the EU maximum permissible levels for BaP and PAH4 (EU Commission Regulation No. 1327/2014). However, single-congener limits may underestimate risk because multiple carcinogenic PAHs are usually present together (Ekpe *et al.*, 2025). To overcome this limitation, the toxic equivalency factor (TEF) approach was developed to express total carcinogenic potency as benzo[a]pyrene equivalents (BaPeq) (Nisbet & LaGoy, 1992). Combined with dietary exposure models, BaPeq allows estimation of estimated daily intake (EDI) and lifetime

excess cancer risk (LCR), following frameworks developed by the United States Environmental Protection Agency (USEPA, 2012). LCR values greater than 10^{-4} are typically considered unacceptable for human health, while risks between 10^{-6} and 10^{-4} fall within the tolerable range for regulatory purposes (Okpoji *et al.* 2025).

3. METHODOLOGY

3.1. Study design and sample collection

This study employed an experimental design to evaluate the concentration of polycyclic aromatic hydrocarbons (PAHs) in fish subjected to different processing methods. Fresh fish samples of uniform size and weight were obtained from a local market in southeastern Nigeria. The fish were randomly divided into four groups, each subjected to a different preservation technique: air-drying (FAD), oven-drying (FOD), wood-drying (FWD), and traditional wood-smoking (FWP). To minimise cross-contamination, separate equipment and clean surfaces were used for each processing method. Processed samples were homogenised using stainless steel equipment and stored in solvent-rinsed glass containers at 4 °C until analysis.

3.2. Chemicals and reagents

All solvents, including n-hexane, dichloromethane, and acetone, were of high-performance liquid chromatography (HPLC) grade (≥ 99% purity). Certified PAH standards (16 EPA priority PAHs) were obtained from a recognised supplier to ensure accurate calibration. Anhydrous sodium sulfate was baked at 450 °C for 4 h prior to use to remove organic contaminants.

3.3. Sample preparation and extraction

Approximately 10 g of each homogenised fish sample was weighed and subjected to Soxhlet extraction using a solvent mixture of dichloromethane and n-hexane (1:1 v/v) for 16 h, following APHA (1995) and ASTM International (2016) protocols. The extracts were concentrated using a rotary evaporator under reduced pressure and purified through silica gel column chromatography to remove lipids and co-extracted materials. Elution was carried out with n-hexane/dichloromethane (3:1 v/v), and the purified eluates were concentrated to 1 mL under a gentle stream of nitrogen gas.

3.4. Instrumental analysis

Quantitative and qualitative analysis of PAHs was performed using gas chromatography coupled with mass spectrometry (GC–MS). The GC–MS system was equipped with an HP-5MS capillary column (30 m × 0.25 mm × 0.25 µm film thickness). The oven temperature was programmed as follows: initial 60 °C (held for 2 min), ramped to 200 °C at 10 °C/min, then to 280 °C at 5 °C/min (held for 15 min). Helium was used as the carrier gas at a constant flow rate of 1 mL/min. The injector temperature was set at 250 °C in splitless mode, and the MS detector operated in electron ionisation mode (70 eV). Quantification was based on calibration curves generated from PAH standards with correlation coefficients (R^2) > 0.995.

3.5. Quality assurance and quality control (QA/QC)

Strict QA/QC measures were implemented to ensure analytical accuracy and reliability. Procedural blanks, matrix spikes, and duplicate samples were analysed with each batch of samples. Method detection limits (MDLs) and instrument detection limits (IDLs) were determined following ASTM guidelines. Recovery experiments were conducted by spiking blank fish matrices with PAH standards, yielding recovery rates between 85–105%, which are within acceptable ranges for environmental and food chemistry studies (APHA, 1995; ASTM, 2016). Data below detection limits were reported as not detected (ND).

3.6. Health risk assessment

The carcinogenic potency of PAHs was estimated using toxic equivalency factors (TEFs) proposed by Nisbet and LaGoy (1992). The benzo[a]pyrene equivalent concentration (BaPeq) was calculated using the equation: BaPeqΣ(Ci×TEFi), where C_i is the concentration of individual PAHs (mg/kg) and TEF_i is the corresponding toxic equivalency factor.

Human health risk was characterised by estimating the daily intake (EDI) and lifetime excess cancer risk (LCR) following USEPA (2012) guidelines. The EDI was calculated as:

EDI = (C × IR) / BW

Where,

C is the BaPeq concentration (mg/kg), IR is the ingestion rate of fish (kg/day), and BW is the body weight (kg).

Lifetime cancer risk was then estimated using: LCR = EDI × CSF, where CSF is the oral cancer slope factor for benzo[a] pyrene, taken as 7.3 $(mg/kg\text{-}day)^{-1}$.

Adults: Fish ingestion rate (IR): 0.042 kg day^{-1} (42 g day^{-1}). This reflects the higher mean fish intake in southern Nigeria (≈ 16.9 kg $capita^{-1}$ yr^{-1} ≈ 46 g day^{-1}), widely used in dietary-exposure studies. Body weight (BW): 60 kg. A representative average for Nigerian adults and consistent with previous local food-safety risk assessments.

Children (1–6 years): Fish ingestion rate (IR): 0.020 kg day^{-1} (20 g day^{-1}). Derived from the U.S. EPA default (16 g day^{-1}) and adjusted upward (~25 %) for the higher fish reliance documented in southern Nigeria. Body weight (BW): 15 kg. Adopted from USEPA/ATSDR standard defaults. Toxicity value: Benzo[a] pyrene oral cancer slope factor (CSF) = 7.3 $(mg\ kg^{-1}\ day^{-1})^{-1}$ (USEPA IRIS).

3.7. Data analysis

Descriptive statistics were used to summarise PAH concentrations across the four processing methods. Results were expressed in mg/kg dry weight. Comparative analysis between processing methods was conducted using one-way analysis of variance (ANOVA) followed by post-hoc tests to identify significant differences ($p < 0.05$). Statistical analyses were performed using IBM SPSS version 25. Concentration profiles were categorised into low molecular weight (2–3 rings) and high molecular weight (4–6 rings) PAHs for the interpretation of environmental behaviour and toxicological implications.

4. RESULTS AND DISCUSSION

4.1. Concentrations of PAHs in processed fish

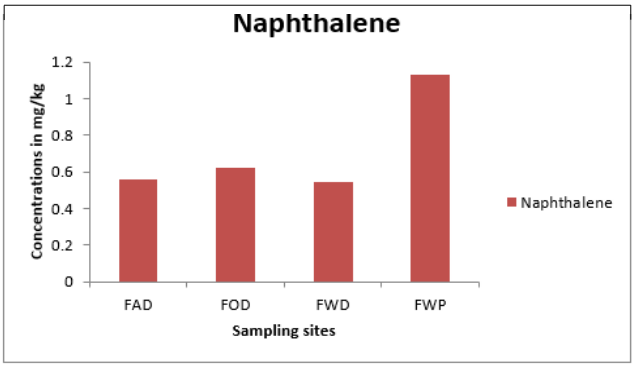
Naphthalene was the most abundant PAH detected across all

samples, with the highest concentration observed in wood-smoked fish (FWP: 112.85 mg/kg). This value was nearly double the concentrations found in oven-dried (62.01 mg/kg) and air-dried samples (55.99 mg/kg). Other low molecular weight PAHs (acenaphthylene, phenanthrene) were present at relatively low levels (< 1.5 mg/kg). In contrast, high molecular weight PAHs (chrysene, fluoranthene, dibenzopyrenes) were detected at trace levels (0.04–0.21 mg/kg), indicating lower accumulation compared to lighter compounds. The comparative assessment revealed that traditional wood-smoking (FWP) consistently produced the highest PAH concentrations across detected compounds. In particular, concentrations of naphthalene, benzo[b,j,k]fluoranthene, 3-methylcholanthrene, and dibenzopyrenes were significantly elevated in smoked samples relative to dried samples ($p < 0.05$). In contrast, oven-dried (FOD) and air-dried (FAD) fish exhibited similar PAH concentrations, both substantially lower than smoked fish. Wood-dried fish (FWD) showed intermediate concentrations but generally higher than air-dried fish, reflecting partial combustion exposure.

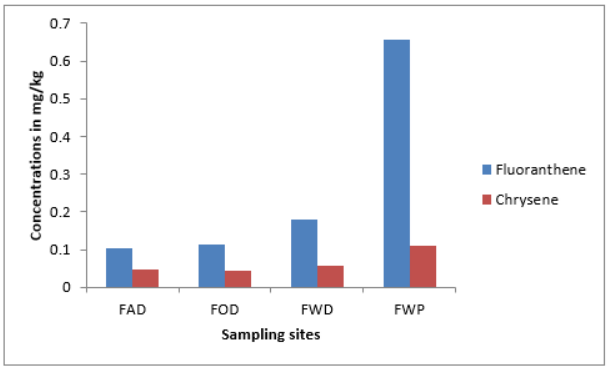
Table 1. Concentrations of selected PAHs (mg/kg) in fish subjected to different drying methods

Compound	FAD	FOD	FWD	FWP
Naphthalene	55.9940	62.0084	54.2236	112.8528
Acenaphthylene	0.6936	0.6987	0.6958	1.2904
Phenanthrene	Nd	0.6149	0.5675	0.2424
Fluoranthene	0.1048	0.1148	0.1801	0.6554
Chrysene	0.0473	0.0435	0.0558	0.1107
Benzo[b]fluoranthene	0.5846	0.5861	0.5669	1.1153
3-Methylcholanthrene	0.9707	0.9659	0.9557	1.9255
Indeno(1,2,3-cd)pyrene	0.1018	0.0980	0.0997	0.2046
Dibenz(a,l)pyrene	0.0980	0.0984	0.0974	0.2070
Dibenz(a,i)pyrene	0.0973	0.1020	0.0974	0.2039
Dibenz(a,h)pyrene	0.1000	0.0994	0.0972	0.1948

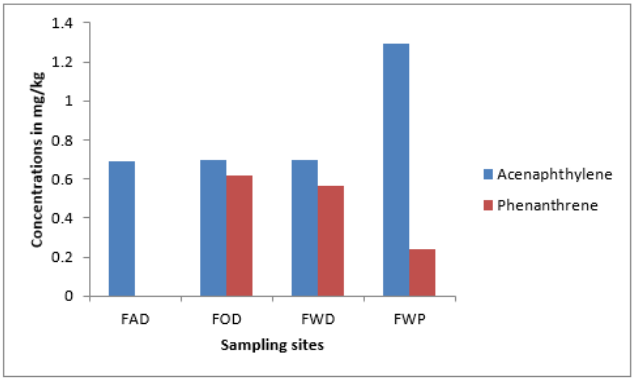
Note: Nd = not detected



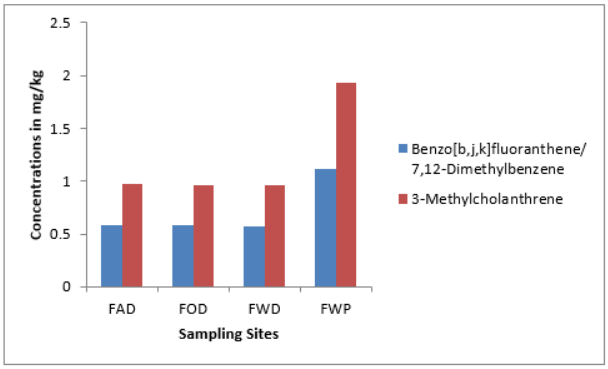
Concentrations of detected 2-Ring PAHs in the different sampling sites



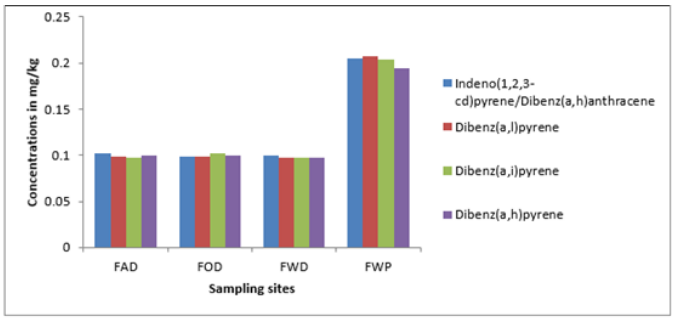
Concentrations of detected 4-Ring PAHs in the different sampling sites



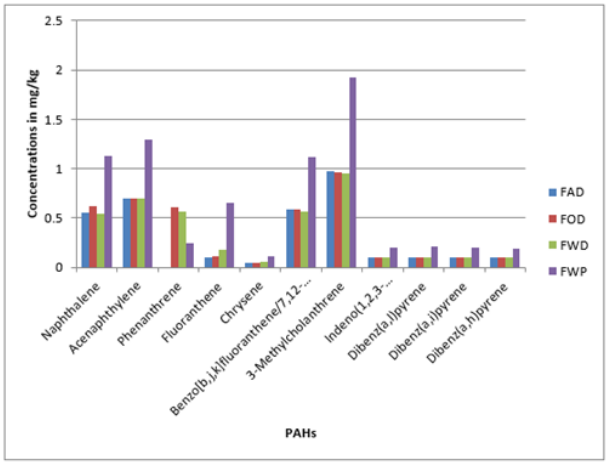
Concentrations of detected 3-Ring PAHs in the different sampling sites



Concentrations of detected 5-Ring PAHs in the different sampling sites



Concentrations of detected 6-Ring PAHs in the different sampling sites



Comparison of the detected PAHs with respect to their preparation methods

Figure 1. Concentrations of selected PAHs (mg/kg) in fish subjected to different drying methods

4.2. Benzo[a]pyrene Equivalent Concentrations (BaPeq)

The toxic equivalency factor (TEF) approach was applied to derive benzo[a]pyrene equivalents (BaPeq) for each sample. The highest BaPeq was observed in FWP (1.046 mg/kg), which was approximately twice the levels detected in the other three methods. FAD, FOD, and FWD yielded similar BaPeq values, ranging between 0.510 and 0.529 mg/kg.

Table 2. Benzo[a]pyrene equivalent concentrations (BaPeq) in fish processed by different methods

Drying Method	BaPeq (mg/kg)
FAD	0.5183
FOD	0.5287
FWD	0.5105
FWP	1.0464

4.3. Estimated daily intake (EDI)

Using BaPeq values in combination with dietary exposure equations, the estimated daily intake (EDI) was determined for both adults and children. EDI values for adults ranged between 3.57×10^{-4} and 7.32×10^{-4} mg/kg-day, while values for children ranged between 6.81×10^{-4} and 1.40×10^{-3} mg/kg-day. The highest exposures were consistently associated with the FWP treatment.

Table 3. Estimated daily intake (EDI) of PAHs from fish consumption

Drying Method	EDI (Adult, mg/kg-day)	EDI (Child, mg/kg-day)
FAD	3.63×10^{-4}	6.91×10^{-4}
FOD	3.70×10^{-4}	7.05×10^{-4}
FWD	3.57×10^{-4}	6.81×10^{-4}
FWP	7.32×10^{-4}	1.40×10^{-3}

4.4. Lifetime excess cancer risk (LCR)

Cancer risk characterisation showed that all processing methods produced LCR values exceeding the upper bound of the acceptable risk range (10^{-6}–10^{-4}). Adult risk estimates ranged between 2.61×10^{-3} and 5.35×10^{-3}, while child risk estimates ranged from 4.97×10^{-3} to 1.02×10^{-2}. The FWP method posed the highest risk, with a child LCR approaching 1% probability of excess lifetime cancer.

Table 4. Lifetime excess cancer risk (LCR) from consumption of processed fish

Drying Method	LCR (Adult)	LCR (Child)
FAD	2.65×10^{-3}	5.04×10^{-3}
FOD	2.70×10^{-3}	5.15×10^{-3}
FWD	2.61×10^{-3}	4.97×10^{-3}
FWP	5.35×10^{-3}	1.02×10^{-2}

4.5. Discussion

The findings of this study confirm that processing methods significantly influence the contamination of fish by polycyclic aromatic hydrocarbons (PAHs). Naphthalene dominated the PAH profile across all methods, with concentrations in smoked samples almost twice those of oven- and air-dried fish (Okpoji *et al.* 2025). This predominance of low molecular weight PAHs has been widely reported in food items exposed to biomass combustion, reflecting their volatility and high transfer efficiency from smoke to food matrices (Abrantes *et al.*, 2009; Wilms, 2000). Similar to observations in Nigerian smoked meat and fish, the accumulation of PAHs during wood-smoking appears to result from incomplete combustion processes and direct deposition of particulates onto fish tissues (Akpambang *et al.*, 2009; Akpan *et al.*, 1994). Although benzo[a]pyrene, a sentinel carcinogen commonly used in food safety regulation, was not detected in the present study, other carcinogenic markers such as chrysene, benzo[b,j,k]fluoranthene, and dibenzopyrenes were consistently present, albeit at low levels. This mirrors reports by Andrzej and Zdzislaw (2005), who emphasised that the absence of benzo[a]pyrene does not equate to safety, since other PAHs in smoked fish may present cumulative toxicological risks. The toxic equivalency factor (TEF) approach developed by Nisbet and LaGoy (1992) underscores the significance of these compounds, as even low concentrations of high molecular weight PAHs contribute meaningfully to overall carcinogenic potential (Ekwere *et*

al. 2025). Chronic exposure through regular consumption of smoked fish thus remains a concern, as highlighted by studies in Southern Nigeria where risk assessments confirmed elevated lifetime cancer risk associated with PAH-contaminated fish (Isioma *et al.*, 2016).

The comparative differences among processing methods observed in this study further emphasise the health risks of traditional smoking practices. Oven- and air-drying produced comparatively lower PAH concentrations, while wood-drying yielded intermediate levels, reflecting limited but measurable smoke exposure. In contrast, smoked fish accumulated the highest levels of both low- and high-molecular-weight PAHs, corroborating the findings of Nunoo *et al.* (2018) and Okenyi *et al.* (2016), who reported that smoking chambers without adequate ventilation or temperature control result in substantial PAH deposition. Such trends extend beyond Nigeria, as Perugini *et al.* (2006) also observed elevated PAH concentrations in cold-smoked Atlantic salmon compared with fresh fillets.

When benchmarked against global regulatory standards, the concentrations measured here raise serious food-safety concerns. European Union Regulation (EU No. 1327/2014) limits benzo[a]pyrene to 2 μg kg^{-1} and ΣPAH_4 to 12 μg kg^{-1} in smoked fish—values several orders lower than those obtained in this study. The extraordinarily high naphthalene levels and measurable HMW PAHs highlight the inadequacy of relying solely on benzo[a]pyrene as a safety indicator, supporting calls for multi-analyte monitoring (Andrzej & Zdzislaw, 2005). The quantified lifetime-cancer-risk (LCR) values further emphasise the public health significance. Adult LCR (5.35×10^{-3}) and child LCR (1.02×10^{-2}) exceed the USEPA's acceptable range (10^{-6}–10^{-4}) by several orders of magnitude. An LCR of 10^{-2} for children implies roughly a 1 in 100 probability of developing cancer from smoked fish consumption alone—an alarming figure that demands urgent attention. Comparable studies elsewhere report substantially lower risks: Tongo *et al.* (2017) found ILCRs of 10^{-6}–10^{-4} for Nigerian smoked fish; Asadi *et al.* (2025) reported 3.7×10^{-7} –5.4×10^{-7} in Iranian smoked fish; and Okpoji *et al.* (2025) observed 10^{-6}–10^{-4} in bC. Sapidus from Iko, Akwa Ibom State. Thus, the present LCR values are two to five orders of magnitude higher than most literature estimates, reflecting unusually intense smoke contamination—probably worsened by the use of plastics or petroleum residues as combustion aids in artisanal kilns (Ewuola *et al.* 2025). In public health terms, such exposure could substantially increase community-level cancer incidence in the Niger Delta, where smoked fish is consumed daily as an affordable protein source. Children face disproportionately greater risk owing to lower body weight and higher food intake relative to body mass. Without intervention, chronic exposure to PAH-laden fish could worsen Nigeria's growing non-communicable disease burden. The absence of effective local regulation—contrasting sharply with the enforcement frameworks of the EU and North America—further compounds consumer vulnerability (Ravindra *et al.*, 2008).

The public health implications of these findings are particularly pressing in Nigeria, where smoked fish is widely consumed as a cheap protein source. Chronic ingestion of fish with elevated PAH levels could contribute to long-term risks of cancer, endocrine disruption, and genotoxicity. Studies by Alonge (1988) and Duke (2007) on smoked meat products, as well as Akpan *et al.* (1994) on smoked fish, consistently reported PAH concentrations that exceeded safe thresholds, underscoring those traditional smoking practices are a persistent source of dietary carcinogens (Okpoji *et al.* 2025). The lack of effective regulation in Nigeria, unlike the robust systems in the European Union or North America, exacerbates this risk and places consumers in a vulnerable position (Ravindra *et al.*, 2008). The results also have broader environmental significance (Onoja *et al.* 2025). The Niger Delta is already subject to hydrocarbon pollution from oil spills, gas flaring, and artisanal refining, which contribute to background contamination of aquatic ecosystems (Anyakora & Herbert, 2005; Okpoji *et al.*, 2025b). This environmental burden is compounded when fish exposed to hydrocarbons during their life cycle undergo smoking, thereby accumulating additional PAHs through post-harvest processing. Similar concerns have been raised globally, with Cheung *et al.* (2007) reporting bioaccumulation of PAHs in fish from Hong Kong markets and Easton *et al.* (2002) documenting contaminant loadings in farmed salmon. These findings illustrate that PAH contamination in fish is not only a Nigerian problem but a global food safety issue that demands consistent monitoring and regulatory action.

5. CONCLUSION

The findings of this study demonstrate that commercially important fish species from markets in Akwa Ibom State, Nigeria, contain significant levels of polycyclic aromatic hydrocarbons, with both low- and high-molecular-weight congeners contributing to contamination. The calculated benzo[a]pyrene equivalents, estimated daily intake values, and lifetime excess cancer risk estimates confirm that long-term consumption of these fish poses unacceptable health risks, especially in a region where fish is a primary dietary protein source. While earlier research in Nigeria and elsewhere has documented the presence of PAHs in smoked or grilled foods, this work offers a more comprehensive perspective by applying risk assessment models that convert chemical concentrations into quantitative measures of consumer exposure and cancer risk. In doing so, it reveals that PAH burdens in some fish sold in Akwa Ibom markets surpass internationally recognised safety thresholds, including the European Union's PAH4 limits. These results have critical implications for public health and food security in the Niger Delta. They underscore the urgent need to discourage unsafe fish processing practices, particularly the use of polythene and petroleum residues in smoking kilns, which elevate the levels of carcinogenic PAHs. Improved preservation technologies, such as gas ovens and modern smoking kilns, offer safer alternatives and should be promoted through targeted policies, regulatory enforcement, and community sensitisation. Strengthening food safety monitoring systems and aligning local standards with international benchmarks will be essential steps toward protecting consumers.

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