



PREVALENCE OF POLYCYCLIC AROMATIC HYDROCARBONS IN FRESH MEAT TYPES AT GUSAU CENTRAL ABBATOIR, ZAMFARA STATE, NIGERIA

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ABSTRACT

Ingestion of Polycyclic Aromatic Hydrocarbons (PAH) in food can cause cancer not only through the mutagenic properties of their metabolites, but also through their parent compounds which potentially enhance tumor initiation and progression. World Health agencies mentioned PAHs in priority pollutant list owing to their carcinogenic and mutagenic properties. This research was conducted between the months of April to August 2023 in Gusau Central Abattoir Zamfara State, to determine the type and prevalence of PAH in fresh beef, chevon and mutton. The samples were collected in two visits with a total of 36 samples collected and analyzed using Gas Chromatography Mass Spectroscopy (GC-MS) technique. Results indicated a total of 45 PAHs belonging to 16 types of PAH compounds were detected in both rainy and dry season among the three meat types. Seventeen PAH compounds were detected in fresh beef samples, 13 PAH occurred in chevon 15 were detected in mutton samples. The PAH 1,2,3,4-tetrahydro Naphthalene was found to be more prevalent (37.77%), followed by Decahydro-1-Naphthalene with (8.88%) and Decahydro-2-met-Naphthalene, Naphthalene, 2-methyl-Naphthalene, were identified with prevalent of about 6.66% each. Similarly, Decahydro-Naphthalene, 2,3,6-trimethyl-Naphthalene, 1,6-dimethyl-4-(1)-Naphthalene and 1,5-dimethyl-Naphthalene were found with 4.44% each. However, the less occurring PHA were Anthracene, Phenanthrene, 1,2-dimethyl-Naphthalene, 2,6-dimethyl-Naphthalene, 1-methyl-Naphthalene, 1,8-dimethyl Naphthalene and Azulene at 2.23% each. It was therefore concluded the presence of some PAH in fresh meat pose safety risks to consumers owing to their toxicity and their possible bioaccumulation.

KEYWORDS: Polycyclic Aromatic Hydrocarbons, Prevalence, Beef, Chevon, Mutton-----

1. INTRODUCTION

Meat refers to the flesh or muscle of an animal, usually of mammals, fish or birds, which is used as food by humans worldwide. Meat provides a rich source of animal protein and other essential micronutrients needed for nourishment, growth and good physiological functions of the body. Despite the significance of meat, it is sometimes limited by its intrinsic content of some biological or chemical contaminants which has direct effect of the consumers. Intrinsic chemical contaminants in meat may include heavy metals and polycyclic aromatic hydrocarbons (PAH). These contaminants, usually from the environment in animal feeds and water gradually accumulate in the muscles of animals and cause adverse effects to consumers in form of food poisoning.

Environmental contaminants include compounds such as polycyclic aromatic hydrocarbons (PAHs) which come from the incomplete combustion of organic materials. These compounds over the years have been subjected to research because of their ability to cause cancer (Bulanda, and Janoszka, 2023; Woko *et al.*, 2021 and Akpambang *et al.*, 2009). In a report by the International Agency for Research on Cancer (IARC) in 2025, carcinogenic substances were classified into four groups based on their potential carcinogenicity to humans. Group 1 was categorized as carcinogenic, Group 2A was probably carcinogenic, Group 2B is possibly carcinogenic while Group 3 has been categorized as not classifiable as to its carcinogenicity to humans (IARC, 2025). Furthermore, Benzo[a]pyrene (BaP) were classified to Group 1 as a result of investigations for several decades owing to its toxic effects specifically



regarding their genotoxicity and carcinogenicity. Other compounds such as benz[a]anthracene (BaA), chrysene (Chr), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), and indeno[1,2,3-c,d]pyrene (IcdP) belong to Group 2B, and dibenz[a,h]anthracene (DahA) belongs to Group 2A (da Silva et al., 2024; Mallah et al. 2022 and IARC 2010). When ingested, unmetabolized Polycyclic Aromatic Hydrocarbons (PAHs) can have toxic effects, but the ability of its reactive metabolites such as epoxies and dihydrodiols to bind to cellular proteins and DNA with its resultant biochemical disruptions and cell damage leading to mutations, developmental malformations, tumors and cancer is of major concern (Nisha *et al.*, 2015).

In livestock like cattle sheep and goat, the type, production system and age, dietary habits, slaughtering environment, transportation conditions and exposure time of animals are some important factors that determines contamination of meat (Sabir *et al.*, 2003). Sampaio *et al.* (2021) reported that environmental contamination can occur when gas-phase light PAHs that are present in the atmosphere are adsorbed and accumulated in the soil and water which enters the food chain through their direct or indirect uptake via grazing on plant materials. Hence, when contaminated vegetation is used to feed livestock, it could result in gradual bioaccumulation of PAHs in the muscles, milk and other products of animal origin and their derivatives (Garcia *et al.*, 2014). Similarly, system of livestock production can affect the quality of the meat and other products. Extensive production systems where livestock are reared on contaminated pasture or feed are good sources of exposure to PAHs and other environmental contaminants (Abdulai *et al.*, 2025). Zamfara State, Nigeria is home to a good number of livestock. Meat and milk are part of the population's daily food. Similarly, the state is home to illegal mining, logging, charcoal and fuel wood activities thereby producing dust, smoke and other gasses which could potentially contaminate the environment including grazing lands and water bodies. To this end, this research was designed to investigate the prevalence of PAHs among beef, chevon and mutton in Gusau local Government Area, Zamfara State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted between the months of April 2023 and August 2023 in Gusau Central Abattoir Zamfara State. The city of Gusau, located in northwestern Nigeria, Gusau is the capital city of Zamfara State, Nigeria.

2.2 Sampling and Sample Size

The samples being used for the study were obtained from Gusau central abattoir. The samples were collected in two (2) visits; rainy and dry season. In each visit, six (6) fresh meat samples were collected each from beef, mutton and chevon making Eighteen (18) samples in every visit. A total of 36 samples were collected. For every collection, the fresh meat samples were taken to the chemical Laboratory for the determination of polycyclic aromatic hydrocarbons.

2.3 Determination of Polycyclic Aromatic Hydrocarbons

The polycyclic aromatic hydrocarbon content of the samples was determined using gas chromatography mass spectroscopy (GC-MS model 6800) according to the method described by Texas Natural Resource Conservation Commission (TNRCC) (2015).

2.4 Data Analysis

The PAHs data collected on prevalence in the three (3) meat type samples were subjected to descriptive statistics and expressed in percentages.

3. RESULTS AND DISCUSSION

Prevalence of PAHs Detected in Beef, Chevon and Mutton Samples in Dry and Rainy Seasons at Gusau Central Abattoir

Results on prevalence of PAHs detected in beef, chevon and mutton in dry and rainy season in Gusau Central Abattoir Zamfara State are presented in Table 4.1. Results indicated a total of (45) PAHs belonging to 16 types of PAHs were detected in both rainy and dry seasons in all the types of meat. Therefore (17) of the compounds were found in raw beef meat samples. While (13) compounds were detected in chevon raw meat samples and (15) compound were detected in mutton raw meat samples. Among the PAHs detected, 1,2,3,4-tetrahydro Naphthalene was found to be more prevalent (37.77%) identified for both rainy and dry season samples and was more prevalent in Mutton (detected 11 out of 12 samples). Decahydro-1-Naphthalene had 8.88% and was only detected in beef samples (3). Also, Decahydro-2-met Naphthalene, Naphthalene, 2-methyl-Naphthalene, were identified with prevalence of about 6.66%



each, then it was followed by Decahydro-Naphthalene, 2,3,6-trimethyl-Naphthalene, 1,6-dimethyl-4-(1) Naphthalene and 1,5-dimethyl-Naphthalene with 2.44% each. However, the less occurring PAHs includes Anthracene, Phenanthrene, 1,2-dimethyl-Naphthalene, 2,6-dimethyl-Naphthalene, 1-methyl-Naphthalene, 1,8-dimethyl Naphthalene and Azulene were found with prevalence of 2.23% each from the samples collected in the study area. Among the types of PAHs detected in both beef chevon and mutton raw meat samples in dry and rainy season, only Phenanthrene and Anthracene were classified among the carcinogenic compounds by NIOSH (2019).

Table 1
Prevalence of PAHs Detected in Beef, Chevon and Mutton samples in Dry and Rainy Seasons in Gusau Central Abattoir

Type of PAHs detected	Type of meat			Frequency (%)
	Beef	Chevon	Mutton	
Decahydro-2-met Naphthalene	3	0	0	3(6.66)
Decahydro- Naphthalene	2	0	0	2(4.44)
1,2,3,4-tetrahydro Naphthalene	4	2	11	17(37.77)
2,3,6-trimethyl- Naphthalene	2	0	0	2(4.44)
1,6-dimethyl-4-(1) Naphthalene	2	0	0	2(4.44)
Anthracene	1	0	0	1(2.23)
1,5-dimethyl- Naphthalene	1	1	0	2(4.44)
Phenanthrene	1	0	0	1(2.23)
1,2-dimethyl- Naphthalene	1	0	0	1(2.23)
Decahydro-1 Naphthalene	0	4	0	4(8.88)
2,6-dimethylNaphthalene	0	1	0	1(2.23)
1-methyl- Naphthalene	0	1	0	1(2.23)
1,8-dimethyl Naphthalene	0	1	0	1(2.23)
Naphthalene	0	1	2	3(6.66)
2-methyl- Naphthalene,	0	1	2	3(6.66)
Azulene	0	1	0	1(2.23)
Total 16	17	13	15	45(100)

The effect of naphthalene exposure can be harmful to human health. Inhalation or ingestion of naphthalene can cause symptoms such as headache, nausea, vomiting, diarrhea, confusion, and in severe cases, liver and kidney damage. (CDCP, 2020). Chronic exposure to naphthalene has been linked to an increased risk of developing cancer, 1,5-dimethyl-naphthalene is a chemical compound with two methyl groups attached to specific positions on a naphthalene ring. Chemical Safety Data Sheet for Naphthalene. (NIOSH, 2019). The presence of methyl groups at the 1 and 5 positions of the naphthalene ring affects its chemical stability and reactivity compared to unsubstituted naphthalene. The rate and extent of naphthalene absorption in humans exposed by inhalation have not been determined, but there is evidence for uptake via inhalation from case reports and occupational health studies. Clinical reports suggest that prolonged exposure to naphthalene vapors can cause adverse health effects in humans Harden *et al*, (2018). In addition, naphthalene has been detected in the expired air of workers exposed to naphthalene-containing jet fuels, and naphthalene metabolites have also been detected in the urine of such workers (Egeghy *et al*, (2016).

The compound 2-methyl naphthalene is toxic and potentially carcinogenic. It can also contribute to environmental pollution, particularly in areas where there is incomplete combustion of fossil fuels (EPA, 2021). Its specific effects can vary depending on the context of its application, such as in chemical reactions, pharmaceutical research, or material science. (National Library of Medicine (NLM, 2016).

4. CONCLUSION

In conclusion, Phenanthrene, anthracene, azulene and different forms of naphthalene were the prevalent PAHs detected from the fresh meat samples. The presence of some of the identified PAH in fresh meat types could pose safety risks to consumers owing to their toxicity and their possible gradual bioaccumulation overtime.



5. REFERENCES

1. Abdulai-et-al-2025-polycyclic-aromatic-hydrocarbons-burden-of-meats-singed-with-different-fuel-sources-from-abattoirs (1)
2. Akpambang, V. O. E., Purcaro, G., Lajide, L., Amoo, I. A., Conte, L. S., and Moret, S. (2009). Determination of polycyclic aromatic hydrocarbons (PAHs) in commonly consumed Nigerian smoked/grilled fish and meat. *Food Additives and Contaminants* 26(07): 1096-1103.
3. Bulanda, S.; Janoszka, B. (2023). Polycyclic Aromatic Hydrocarbons (PAHs) in Roasted Pork Meat and the Effect of Dried Fruits on PAH Content. *Int. J. Environ. Res. Public Health* 2023, 20, 4922. <https://doi.org/10.3390/ijerph20064922>
4. Egegly (2016). (M.Sc Biochemistry, Scientific Officer), wokoezechidozie@gmail.com Polycyclic Aromatic Hydrocarbon, Heavy Metal, and Derivable Metabolic Water and Energy of Cattle Hides Processed by Singeing <https://doi.org/10.110/2020.03.18.994962>.
5. EPA (United States, Environmental Protection Agency), (2017). (Regional Screening Levels (RSLs) – Users Guide. U.S. Environmental Protection Agency with scrap tyres in akropong-akuapem abattoir, Ghana. *Applied Research*.
6. Garcia L.P., Gonçalves B.L., Panho G., Scussel V.M. Hidrocarbonetos policíclicos aromáticos em alimentos: Uma revisão. *Pubvet*. 2014;8 doi: 10.22256/pubvet.v8n19.1788.
7. Harden, A. A., Habeeb, A. S. & Chima, E. O. (2018). Assessment of microbiological load of street-vended “suya” in Bida, Niger State. *Ife Journal of Science and Technology*, 1, 1–8.
8. Nisha, A. R., Dinesh, K. V., Arivudainambi. S., Umer, M., and Khan, M. S. (2015). Polycyclic aromatic hydrocarbons in processed meats: A toxicological perspective. *Research Journal of Chemistry & Environment* 19(6): 72-76.
9. NLM (National Library Of Medicine) (2021). Determination of Polycyclic Aromatic Hydrocarbons (PAHs) In Smoked Fish and Meat Samples In Organic Chemistry Unit, Dept. of Chemistry, Federal Univ. of Agriculture, Abeokuta. *J. Chem Soc. Nigeria*, Vol. 44, No. 1, pp 096 -106.
10. Sabir, S. M., Khan, Sardar, W. and Hayat, I. (2003). Effect of Environmental Pollution on Quality of Meat in District Bagh, Pakistan. *Journal of Nutrition* 2(2): 98-101.
11. Sampaio, G.R.; Guizzellini, G.M.; da Silva, S.A.; de Almeida, A.P.; Pinaffi-Langley, A.C.C.; Rogero, M.M.; de Camargo, A.C.; Torres, E.A.F.S. Polycyclic Aromatic Hydrocarbons in Foods: Biological Effects, Legislation, Occurrence, Analytical Methods, and Strategies to Reduce Their Formation. *Int. J. Mol. Sci.* 2021, 22, 6010. <https://doi.org/10.3390/ijms22116010>
12. TNRCC, (Texas Natural Resource Conservation Commission).(1997). *Total Petroleum Hydrocarbons*. TNRCC Method 1005, December.
13. da Silva, S.A., de Rossi, G.Z., de Almeida, A.P., Guizzellini, G.M., da Silva Torres, E.P.F., Rogero, M.M and Sampaio, R.M. (2024). Occurrence and exposure to polycyclic aromatic hydrocarbons (PAHs) in traditional dry-cured or smoked meat products from Brazil. *Food Production, Processing and Nutrition*, 224, 82: 1-21.
14. WOKO, E.C., IBEGBULEM, C.O. and ALISI, C.S. (2021). Polycyclic Aromatic Hydrocarbon, Heavy Metal, Derivable Metabolic Water and Energy Content of Cattle Hides Processed by Singeing. *OSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 15 (7):07-13.
15. Abdulai, P.M., Chika C., Ezejiolor, A.N., Frazzoli, C., Rovira, J., Ekhatior, O.C., Firempong, C.K. and Orisakwe, O.E. (2025). Polycyclic Aromatic Hydrocarbons Burden of Meats Singed with Different Fuel Sources from Abattoirs in Ghana and Associated Cancer Risk Assessment. *Environmental Health Insights*, 19: 1–21.