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Research Article

Determination of polycyclic aromatic hydrocarbons in grilled and roasted meat sold in some meat shops, Maiduguri metropolitan council, Nigeria

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds generated during the incomplete combustion of organic materials, and pose significant health risks due to their carcinogenic properties. This study assessed the presence of 17 PAHs in grilled and roasted meat samples, including naphthalene, 2-methyl naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benz(a)pyrene (bap), dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene. Meat samples from various types prepared using both cooking methods were collected systematically and analyzed for PAH concentrations using gas chromatography-mass spectrometry (GC-FID). The results revealed that grilled beef had a higher PAH level, specifically benz(a)pyrene at 0.56 µg/kg, compared to roasted beef meat, which contained benz(a)anthracene at 0.40 µg/kg, and roasted lamb meat at 0.42 µg/kg. This discrepancy is likely due to the direct exposure to flames and smoke during grilling. Additionally, elevated PAH levels were recorded at specific sampling sites: benz(a)pyrene was highest at APgx, benz(a)anthracene at APLrx, benzo(k)fluoranthene at ALry, and benzo(b)fluoranthene at APLry. In conclusion, this study highlights the significant impact of cooking methods on PAH formation and recommends strategies to reduce the formation of these harmful compounds, such as using indirect cooking techniques and selecting leaner cuts of meat. These findings offer crucial insights into the health implications of PAHs in cooked meats and emphasize the necessity for consumer awareness and stringent food safety regulations.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are potent carcinogenic compounds comprise of two or more fused aromatic rings. These compounds are generated during the incomplete combustion and high-temperature pyrolysis of coal, oil, and other organic materials. Major sources of PAHs include coke ovens used in aluminum, iron, and steel production, heating in power plants and residences, cooking, motor vehicle emissions, environmental tobacco smoke, and waste incineration [1].

PAHs pose significant health and environmental risks. The health effects associated with PAHs include carcinogenesis, skin disorders, respiratory issues, reproductive and developmental toxicity, neurotoxicity, and damage to various organ systems [2]. Notably, human liver toxicity has been linked to PAH exposure. PAHs are prevalent in various ecosystems, making them a major concern due to their potential toxicity, mutagenicity, and carcinogenicity [3, 5-6].

To assess the health risks linked to PAH exposure through contaminated food, the European Food Safety Authority categorizes PAHs into three groups based on their carcinogenic, mutagenic, and toxic properties. These categories are PAH2 (including benzo[a]pyrene and chrysene), PAH4 (including benzo[a]pyrene, benzo[b]fluoranthene, and others), and PAH8 (encompassing eight specific compounds including benz[a]anthracene and dibenz[a, h]anthracene). The PAH8 group is considered representative of PAH contamination levels in food products [4, 7-8].

Meat, defined as the edible part of an animal's skeletal muscle that is healthy at slaughter, is a widely consumed protein source in many developing countries, particularly Nigeria [9]. It is often cooked or processed to prevent spoilage [13]. However, due to its biological and chemical properties, meat deteriorates progressively from slaughter to consumption [10]. While unmetabolized PAHs are toxic, the more significant concern lies with reactive metabolites, such as epoxies and dihydrodiols, which can bind to cellular proteins and DNA [15, 22]. This binding disrupts biochemical processes, leading to mutations, developmental malformations, tumors, and cancer [14-15].

PAHs are commonly formed in smoked, grilled, or barbecued meat, contributing to DNA damage and increasing the risk of cancer [12]. Although no direct evidence links meat consumption to this mechanism, cooking methods like barbecuing, grilling, and roasting have been associated with higher levels of carcinogenic PAHs in red meat [17]. Therefore, it is essential to evaluate the PAH levels in commercially consumed processed meats, such as grilled and roasted varieties, to mitigate the health risks associated with PAH exposure.

2. Materials and methods

2.1. Sample site

The Post Office area, Polo area, Lagos street, and Pompomari bypass are located in Maiduguri, a city in Borno State in North-East Nigeria. Maiduguri also called Yerwa by its locals is the capital and the largest city of Borno State in north-eastern Nigeria. The city sits along the seasonal Ngadda River, which disappears into the Firki swamps in the areas around Lake Chad. Maiduguri was founded in 1907 as a military outpost by the British and has since grown rapidly, with a population exceeding a million by 2007. Maiduguri lies on latitude 11⁰49′59.99″ N and longitude 13⁰08′60.00″ E and the highest recorded temperature was 47 °C (117 °F) on 28 May 1983, while the lowest recorded temperature was 5°C (41 °F) on 26 December 1979 [12].

2.2. Samples collection

Processed meat samples (grilled and roasted) were collected in July, 2024 from meat vendors at four different commercial locations (Post office area, Polo area, Lagos street and Pompomari bypass) within Maiduguri metropolis using foil paper and plastic containers labelled with unique identification numbers and transported to Jawura Environmental Services Laboratory based in Lagos, Nigeria.

2.3. Sample preparation

Five grams (5.0 g) of meat sample was weighed using a weighing balance and twenty-five milliliters (25 mL) of DCM (dichloromethane) was added to extract the sample. Then the extract was dried using anhydrous sodium sulphate (Na_2SO_4). DCM (dichloromethane) fraction was evaporated to ten milliliters (10 mL) under reduced pressure at 40^{o}c using a rotary evaporator. Ten millimeter (10 mm) column was filled with a silica gel made into slurry by adding DCM (dichloromethane). Then two grams (2g) of sodium sulphate (Na_2SO_4) was added to the gel. Therefore, fifty milliliters (50 mL) of DCM (dichloromethane) mixture was introduced into the column to obtain the fraction which was concentrated to one milliliter (1 mL) using a rotary evaporator for the determination of PAHs using GC-FID [18].

2.4. Analysis of PAHs

Analyses of the PAHs in meat samples were carried

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Table 1. Concentration of some polycyclic aromatic hydrocarbons in grilled meat sample.

PAHs	RT	Concentration (µg/kg)				(MAC>)
		Code FDS 824	Code FDS 825	Code FDS 826	Code FDS 827	
Naphthalene	5.116	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2
2-methyl Naphthalene	7.049	1.23E-02	1.70E-02	3.00E-02	2.00E-02	2
Acenaphthylene	9.337	1.20E-02	2.03E-02	1.50E-02	1.03E-02	2
Acenaphthene	9.796	2.06E-02	2.06E-02	2.06E-02	2.06E-02	2
Fluorene	11.012	1.55E-02	1.60E-02	1.30E-02	1.30E-02	2
Anthracene	13.176	4.10E-01	3.00E-01	2.00E-01	2.00E-01	2
Phenanthrene	13.271	1.70E-02	2.30E-02	1.65E-02	1.30E-02	2
Fluoranthene	15.847	2.06E-01	3.06E-01	3.06E-01	3.06E-01	2
Pyrene	16.308	1.00E-02	1.10E-02	1.05E-02	1.00E-02	2
Benz(a)anthracene	19.059	3.00E-02	2.00E-02	3.60E-02	3.00E-02	2
Chrysene	19.146	2.20E-02	2.20E-02	2.20E-02	2.20E-02	2
Benzo(b)fluoranthene	21.335	2.60E-02	2.60E-02	2.60E-02	2.60E-02	2
Benzo(k)fluoranthene	21.383	1.20E-02	1.20E-02	1.20E-02	1.20E-02	2
Benz(a)pyrene	21.929	5.60E-01	4.40E-01	4.23E-01	3.90E-01	2
Dibenz(a,h)anthracene	23.915	1.30E-02	1.30E-02	1.30E-02	2.30E-02	2
Indino(1,2,3-cd)pyrene	24.004	2.30E-02	2.30E-02	2.30E-02	2.30E-02	2
Benzo(g,h,i)perylene	24.314	1.10E-02	1.11E-02	1.10E-02	1.10E-02	2

APgx- (824) Post office grilled beef meat, APLgx- (825) Polo grilled beef meat, ALgx- (826) Lagos Str. grilled beef meat, APbgx- (827) Pompomari by-pass grilled beef meat, MAC>2- Maximum Acceptable Concentration [7].

out at Jawura Environmental Services Laboratory based in Lagos. Using gas chromatographic method with Flame Ionization detector (GC/MS) to determine the following (17) PAHs: naphthalene, 2-methyl naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benz(a)pyrene, dibenz(a,h)anthracene, indino(1,2,3-cd)pyrene, benzo(g,h,i)perylene [16].

3. Results and discussion

In this study, 12 different meat samples consisting of grilled and roasted meat, which were processed for consumption by heat treatment at different temperatures were obtained from Four (4) different commercial locations within Maiduguri metropolis and analyzed using GC-MS to determine the levels of PAHs compounds. In this study, a developed and approved (validated) method was used for the quantitative analysis of 17 PAH compounds in heat treated meat samples. The results obtained are presented in the following discussion.

3.1. Concentration of some polycyclic aromatic hydrocarbons in grilled and roasted meat sample

Table 1 show the results obtained from grilled beef meat from sites AP (Post office), APL (Polo), AL (Lagos Street) and APB (Pompomari Bye-pass). Benz (a) pyrene recorded the highest PAH (5.6E-01) from APgx,–whereas pyrene recorded the lowest PAH (1.00E-02) from APgx.

The results shown above shed light on the levels of polycyclic aromatic hydrocarbons (PAHs) in grilled beef from four different spots: AP (Post Office), APL (Polo), AL (Lagos Street), and APB (Pompomari Bye-pass). Of particular concern is that benzo(a)pyrene (BaP) had the highest concentration of 5.6E-01 µg/kg from the APgx site. As a known carcinogen, BaP is often considered a red flag for PAH pollution. This elevated level suggests that consuming grilled beef from this location might carry a heightened health risk, possibly related to factors such as the grilling method, type of fuel used, or surrounding environmental conditions.

On a more positive note, pyrene was found at the lowest concentration of 1.00E-02 µg/kg, also from the

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Table 2. Concentration of some polycyclic aromatic hydrocarbons in roasted meat samples.

PAHs	RT	Concentration (µg/kg)				(MAC >)
		Code FDS 828	Code FDS 829	Code FDS 830	Code FDS 831	
Naphthalene	5.116	2.00E-02	2.00E-02	1.70E-02	2.00E-02	2
2-methyl Naphthalene	7.049	2.30E-02	2.40E-02	1.50E-02	1.20E-02	2
Acenaphthylene	9.337	1.33E-02	2.03E-02	1.30E-02	2.03E-02	2
Acenaphthene	9.796	2.06E-02	2.06E-02	2.06E-02	2.06E-02	2
Fluorene	11.012	1.50E-02	2.05E-02	1.60E-02	1.05E-02	2
Anthracene	13.176	1.70E-01	1.80E-01	2.00E-01	1.30E-01	2
Phenanthrene	13.271	1.00E-02	1.00E-02	1.10E-02	1.00E-02	2
Fluoranthene	15.847	1.30E-01	3.06E-01	3.06E-01	3.06E-01	2
Pyrene	16.308	1.11E-02	1.20E-02	1.05E-02	1.11E-02	2
Benz(a)anthracene	19.059	3.70E-01	4.00E-01	3.80E-01	3.50E-01	2
Chrysene	19.146	3.40E-02	2.20E-02	2.30E-02	2.20E-02	2
Benzo(b)fluoranthene	21.335	2.60E-02	2.60E-02	2.60E-02	2.60E-02	2
Benzo(k)fluoranthene	21.383	1.20E-02	1.50E-02	1.20E-02	1.20E-02	2
Benz(a)pyrene	21.929	3.40E-02	3.30E-02	3.40E-02	3.20E-02	2
Dibenz(a,h)anthracene	23.915	1.30E-02	1.60E-02	1.30E-02	1.30E-02	2
Indino(1,2,3-cd) pyrene	24.004	2.30E-02	2.30E-02	2.30E-02	2.30E-02	2
Benzo(g,h,i)perylene	24.314	1.10E-02	1.10E-02	1.20E-02	1.10E-02	2

APrx- (828) Post office roasted beef meat, APLrx- (829) Polo roasted beef meat, ALrx- (830) Lagos Str. roasted beef meat, APbrx- (831) Pompomari by-pass roasted beef meat, MAC>2- Maximum Acceptable Concentration [7].

APgx site. Although pyrene is a PAH, it's generally considered less harmful than BaP. The stark contrast between these two compounds highlights how cooking conditions and potential sources of contamination can lead to significant differences in PAH levels.

Table 2 shows the results obtained from roasted beef meat from sites AP (Post office), APL (Polo), AL (Lagos Street), and APb (Pompomari Bypass). Benzo(a)anthracene recorded the highest PAH (4.00E-01) from APLrx while phenanthrene recorded the lowest PAH (1.00E-02) from APbgx.

The PAH results offer some eye-opening insights into the levels of polycyclic aromatic hydrocarbons found in roasted beef from four different locations: AP (Post Office), APL (Polo), AL (Lagos Street), and APB (Pompomari by-pass).

One of the most striking findings was that benzo(a)anthracene (BaA) was at its highest concentration of 4.00E-01 µg/kg from the APLrx site. BaA is a significant PAH linked to potential cancer risks, therefore the detection of-elevated levels of BaA in roasted beef raises some red flags. This suggests that factors such as the type of fuel used for roasting, duration of beef cooking or even local pollution may play a role here. Regular consumption of beef from this location, it could pose a health concern. On a brighter note, phenanthrene was found at the lowest concentration of 1.00E-02 µg/kg at the APB site. Although phenanthrene is a PAH it is generally considered less toxic than BaA. This low level implies that the roasting practices or environmental conditions at APB might be more favorable in keeping PAHs at bay.

The differences in PAH concentrations between these sites highlight the importance of understanding the cooking methods used. For instance, if APL uses techniques that generate a lot of smoke or specific types of charcoal that produce more PAHs, this could explain why BaA levels are higher there. This information could be invaluable for improving grilling practices and ensuring that the delicious roasted beef we enjoy is safe to eat!

Table 3 shows the results obtained from roasted lamb meat from sites AP (Post office), APL (Polo), AL (Lagos Street) and APB (Pompomari bypass). Benzo

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Table 3. Concentration of some polycyclic aromatic hydrocarbons in roasted lamp meat samples.

PAHs	RT	Concentration (µg /kg)				(MAC>)
		Code FDS 832	Code FDS 833	Code FDS 834	Code FDS 835	
Naphthalene	5.116	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2
2-methyl Naphthalene	7.049	1.80E-02	2.00E-02	1.30E-02	2.00E-02	2
Acenaphthylene	9.337	1.90E-02	1.30E-02	2.03E-02	2.03E-02	2
Acenaphthene	9.796	2.06E-02	2.06E-02	2.06E-02	2.06E-02	2
Fluorene	11.012	2.05E-02	1.50E-02	2.05E-02	2.05E-02	2
Anthracene	13.176	2.00E-01	1.50E-01	2.00E-01	2.00E-01	2
Phenanthrene	13.271	1.05E-02	1.05E-02	1.02E-02	1.05E-02	2
Fluoranthene	15.847	2.00E-01	3.06E-01	3.06E-01	2.06E-01	2
Pyrene	16.308	1.10E-02	2.11E-02	2.10E-02	1.80E-02	2
Benz(a)anthracene	19.059	3.00E-02	3.00E-02	2.00E-02	2.50E-02	2
Chrysene	19.146	2.20E-02	2.20E-02	2.20E-02	3.20E-02	2
Benzo(b)fluoranthene	21.335	3.60E-01	3.80E-01	1.20E-02	2.60E-02	2
Benzo(k)fluoranthene	21.383	3.36E-02	1.20E-02	4.20E-01	3.38E-01	2
Benz(a)pyrene	21.929	3.30E-02	3.40E-02	2.40E-02	3.30E-02	2
Dibenz(a,h)anthracene	23.915	1.30E-02	1.30E-02	1.30E-02	1.90E-02	2
Indino(1,2,3-cd) pyrene	24.004	2.30E-02	2.30E-02	2.30E-02	1.90E-02	2
Benzo(g,h,i)perylene	24.314	2.10E-02	1.10E-02	1.10E-02	1.70E-02	2

APry- (832) Post office roasted beef meat, APLry- (833) Polo roasted beef meat, ALry- (834) Lagos Str. roasted beef meat, APbry-(835) Pompomari by-pass roasted beef meat, MAC>2- Maximum Acceptable Concentration [7].

(b) fluoranthene recorded the highest PAH (3.80E-02) in sites APry and APLry while benz(k)fluoranthene recorded the highest PAH (4.20E-01) at ALry and APBry. Phenanthrene recorded the lowest PAH (1.02E-02) from ALry.

The PAH results for roasted lamb meat from the four sites—AP (Post office), APL (Polo), AL (Lagos Street), and APB (Pompomari Bypass)—offer valuable insights into the potential health implications of consuming meat from these locations.

Notably, benzo(b)fluoranthene (BbF) was found at the highest levels (3.80E-02 µg/kg) at both APry and APLry sites. BbF is a significant PAH that has been associated with carcinogenic effects, highlighting the potential health risks for consumers of roasted lamb from these areas. The presence of BbF in these locations could stem from factors like the roasting temperature, type of fuel used, or even environmental contaminants in the area. In contrast, benz(k)fluoranthene (BkF) recorded the highest PAH concentration of 4.20E-01 µg/kg from both ALry and APBry. This is of particular concern because BkF is also considered carcinogenic [19]. The elevated levels of BkF may indicate specific roasting conditions or environmental pollutants that contribute to higher PAH formation during cooking [21]. This could indicate differences in practices or local pollution levels in the areas surrounding AL and APB compared to AP and APL.

Interestingly, phenanthrene was measured at the lowest concentration (1.02E-02 µg/kg) at the ALry site. Although phenanthrene is generally less toxic compared to BbF and BkF, its low concentration could suggest that this site either employs better roasting practices that limit PAH formation or has fewer environmental contaminants affecting the lamb meat [20]. These results underscore the importance of examining cooking methods, fuel sources, and environmental conditions at each site to better understand the sources of PAH. It may be beneficial to promote safer cooking practices, such as using lower temperatures or different fuel sources, particularly in areas where BbF and BkF concentrations are elevated. Regular monitoring of PAH levels in foods can help inform consumers and policymakers about the potential health risks

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associated with PAH exposure through diet [17].

Benzo[a]pyrene (BaP) is a well-known polycyclic aromatic hydrocarbon (PAH) that arises during the incomplete combustion of organic materials, including meat. Its formation is particularly significant in cooking methods such as grilling and roasting, where high temperatures and smoke can lead to the production of BaP. Studies have indicated that the consumption of grilled and roasted meats can contribute to dietary exposure to carcinogenic compounds [21]. Lopez et al. [22, 23] had previously observed that grilling beef, pork, poultry and fish at high temperature can lead to formation of benzo(a)pyrenes which are Carcinogens. It is the most common PAH that causes cancer in animals. This may account for the reason why benzopyrene recorded highest across all samples locations (AP, APL, AL, and APB). Farhadin et al. [20] had reported on presence of benzopyrene in grilled fish and meat samples at concentration between 0.70-0.73 µg /kg. While this is in close agreement with the findings of this study, it constrasts with the report by Pierre et al. [24] on smoked fish samples sold in Abobo Abidjan. Benzo[a]pyrene may be bio transformed in humans and animals to 3-OH benzo[a]pyrene. Rey-Salgueiro et al. [25, 26] reported that 3,4-benzopyrene, found in smoked products, served as an indicators of the possible presence of other PAHs and has been repeatedly used as a quantitative index of chemical carcinogens in foods. Wei [27, 28] reported that benzoapyrene (BaP) may be implicated in esophageal cancer risk. Erhabor et al. [29] reported the presence of Benz (a) anthracene in fresh fish samples at a range of 0.001-0002 which was less than what found for the roasted meat. However, Nnaji and Ekwe [30] reported higher values for smoked fish. This indicated that fumes from flames can contribute to higher levels of PAHs.

Benzo[a]anthracene (BaA) and benzo[k]fluoranthene (BkF) are polycyclic aromatic hydrocarbons (PAH) commonly found in the environment and produced through incomplete combustion processes. Similar to other PAHs, BaA and (BkF) are of concern due to their potential carcinogenic effects, particularly when they enter the human food chain through grilled or roasted meats. Understanding its formation in cooking methods is crucial for assessing dietary exposure and associated health risks [31]. BaA and (BkF) formation in meats are influenced by various factors, including cooking temperature, duration, and the type of meat. High-temperature cooking methods, such as grilling and roasting, can lead to BaA and(BkF) generation due to the pyrolysis of fats and proteins [32]. Guan et al. [14] and Schwack et al. [33] found that grilled meat samples could exhibit BaA levels ranging from 1.0 to 5.0 µg/g, and (BkF) levels from 0.5 to 3.0 µg/g, which were notably higher than those found in boiled or steamed versions of the same meat. The direct contact with flames and smoke generated during grilling contribute to the deposition of PAH (BaA and BkF) onto the meat surface [34]. Research has demonstrated that grilled meats typically contain higher concentrations of BaA and BkF than roasted meats [35]. For example, López et al. [22] reported that grilled chicken skin had BaA concentrations approximately three times higher than those of roasted chicken skin, while grilled beef showed concentrations approximately twice as high as those found in roasted beef under similar cooking conditions. The difference in cooking methods can be attributed to the charring that occurs during grilling, which enhances PAH formation [37].

The carcinogenic potential of BaA and BkF has been recognized in various studies, linking a high dietary intake of PAHs, including BkF, to an increased cancer risk [35]. The International Agency for Research on Cancer (IARC) classifies BaA as a Group 2B carcinogen, indicating that it is possibly carcinogenic to humans and BkF as a Group 3 carcinogen, indicating insufficient evidence to classify it as carcinogenic to humans but suggesting a need for caution. Wong et al. [36] highlighted an association between elevated BaA levels in grilled meat consumption and increased risks of lung and gastrointestinal cancers, emphasizing the importance of monitoring cooking methods. Several strategies can be employed to reduce the PAHs (BaA and BkF) levels in grilled meats. Marination is an effective approach; Chen et al. [38] found that marinating meats can result in a significant reduction (up to 60%) in BaA and (up

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to 50%) in BkF concentrations. Additionally, using indirect grilling techniques—where the meat is not placed directly over flames can minimize PAH formation, as well as cooking meat at lower temperatures can also help to reduce PAH formation. Regulatory bodies, including the European Food Safety Authority [7], have established limits on acceptable PAH levels in food products to safeguard public health. Compliance with these regulations is essential, especially for processed meats that are commonly prepared through grilling and roasting. Public awareness campaigns can promote healthier cooking practices to minimize PAH exposure.

So far, our findings revealed that benz (a) pyrene and Benz (a) anthracene were the most abundant PAHs, accompanied by benz (b) and benz (k) fluoranthene. The International Agency for Research on Cancer (IARC) has reported that benzo[a]pyrene and benz[a]anthracenes are probably carcinogenic to humans [11]. The accumulation of these PAHs occurs in meat due to different types of exposure. If grilled food is in direct contact with the flame, pyrolysis of the drippings from meat or fish generates PAHs that can be deposited on its surface [39]. Even without direct contact, fat dripping onto the flame or hot coals generates these compounds which are carried back onto the surface of the food. Rodriguez et al. [40] suggested that using a meat thermometer will ensure that the lamb is cooked to a safe internal temperature. Several factors have been found to influence the levels of PAH's found in meat samples including food composition and processing conditions. The composition of food, particularly the abundance of fat, protein, and carbohydrates in meat products, plays a pivotal role in the formation of PAHs. Processing conditions, specifically the methods employed for cooking or preserving meat, are also significantly associated with PAHs production. Type of fuel, direct or indirect grilling, roasting, type of meat and distance from the heat source [41, 39].

Cancer risk has been widely accepted as the most significant health concern associated with PAH-contaminated food. Toxicological studies have shown that certain PAHs can also produce mutagenic/ genotoxic, reproductive and developmental, immunotoxic, cardiovascular [41, 42]. The literature has shown that natural plant extracts, such as green tea, grape seed and rosemary extracts, can help reduce the formation of PAHs, including benz [a] anthracene, in roasted meat [43].

4. Conclusions

The investigation of polycyclic aromatic hydrocarbons (PAHs) in grilled beef meat from four distinct sites—AP (Post Office), APL (Polo), AL (Lagos Street), and APB (Pompomari Bye-pass) revealed significant disparities in PAH concentrations. Benz(a)pyrene was identified as the predominant PAH, with a concerning concentration of 5.6E-01 μg/kg detected at the APgx site. This compound is classified as a probable human carcinogen, raising serious concerns about the safety of grilled beef from this location, especially for frequent consumers. Conversely, pyrene exhibited the lowest PAH level at 1.00E-02 μg/kg from the same site, indicating variability in PAH concentrations across different compounds. Despite all PAHs reported being below the standard acceptable limit of 2.0μg/kg, elevated levels of benz(a)pyrene at site APgx may pose a significant health risk to consumers, particularly those who frequently consume grilled beef from this area. As benz(a)pyrene is a probable carcinogen, this finding underscores the potential long-term health implications of consuming meat with high PAH levels, necessitating increased awareness of the risks associated with such dietary choices.

To mitigate the formation of harmful PAHs during grilling, it is recommended that consumers adopt safer grilling practices. These include reducing the charring of meat, using cleaner fuel sources, and implementing cooking methods that minimize PAH formation. These practices can help lower the risk of exposure to harmful PAHs and improve overall food safety. This study highlights the variability of PAH concentrations in grilled beef across different locations and emphasizes the urgent need for ongoing monitoring and intervention strategies to enhance food safety. By addressing the identified concerns and promoting healthier cooking practices, we can protect public health regarding the consumption of grilled

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meat and encourage greater public awareness and regulatory measures to inform consumers about the potential health risks associated with high-PAH areas.

Disclaimer (artificial intelligence)

Author(s) hereby state that no generative AI tools such as Large Language Models (ChatGPT, Copilot, etc.) and text-to-image generators were utilized in the preparation or editing of this manuscript.

Authors' contributions

All the authors contributed in the work design, collection of samples and analysis and also preparation of the manuscript.

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Availability of data and materials

All data will be made available on request according to the journal policy

Conflicts of interest

The authors declare no conflict of interest.

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