International Journal of Biotechnology and Microbiology
www.biotechnologyjournals.com
Online ISSN: 2664-7680
Received: 03 -01-2025, Accepted: 04-02-2026, Published: 19-02-2026
Volume 8, Issue 1, 2026, Page No. 42-47

Bacteriological quality and polycyclic aromatic hydrocarbon contamination of ready to eat smoked and spiced meat (Suya) in Warri and its environs: Implications for consumer food safety

Eunice A Odesiri-Eruteyan, Bobby D Enakireru*
Department of Environmental Management and Toxicology, Federal University of Petroleum Resources, P.M.B, Effurun, Delta State, Nigeria

Abstract
Suya, a popular ready-to-eat (RTE) smoked and spiced meat widely consumed in Nigeria, is valued for its taste and accessibility. However, concerns about its safety have emerged due to possible contamination with harmful bacteria and polycyclic aromatic hydrocarbons (PAHs) resulting from poor handling and unsuitable processing methods. This study evaluated the bacteriological quality and PAH concentrations of *Suya* samples obtained from four different locations in Warri and its environs. Microbiological analysis was carried out using standard techniques. The pour plate method was used to determine total plate count, coliform count, and *Escherichia coli* levels. Isolated bacteria were identified through Gram staining and biochemical tests. PAH levels were measured using standard chemical analysis procedures. Results showed that total viable counts ranged from 2.14 ± 0.03 ×10⁶ cfu/g to 4.81 ± 0.06 ×10⁶ cfu/g, Coliform counts ranged from 1.27 ± 0.03 ×10⁴ cfu/g to 2.93 ± 0.03 ×10⁴ cfu/g and Fecal Coliform (E. coli) levels were particularly notable, ranging from 0.00 ± 0.00 ×10² cfu/g (not detected) at Location B to 4.60 ± 0.06 ×10² cfu/g at Location D. These microbial levels exceeded acceptable limits, indicating possible fecal contamination. Identified bacterial species included *Staphylococcus aureus*, *Bacillus* spp., *Escherichia coli*, and *Enterobacter aerogenes*. PAHs analysis revealed relatively high concentrations, with the highest levels recorded for Acenaphthylene (1.01 mg/kg), Phenanthrene (0.09 mg/kg), and Benzo[a]pyrene (0.03 mg/kg). While generally above regulatory limits, the presence of Benzo[a]pyrene raises concern due to its carcinogenic potential. Promoting proper handling practices, enhancing hygiene standards, and optimizing smoking methods are essential to minimizing health risks and ensuring the safety of RTE smoked and spiced meats.

Keywords: Food safety, bacterial contamination, polycyclic aromatic hydrocarbons (pahs), ready-to-eat meat, hygiene practices

Introduction

Ready -to- eat smoked and spiced meat has become popular in many places in Nigeria, as well as in Warri Metropolis in Delta State. People like these meat products because they are so suitable and tasty. In areas where other sources of protein cost a lot or are not easy to find, smoked meat is a key part of many diet routines throughout the world (Adeleye, 2015) [3]. By smoking meat, it improves its flavor and shelf life and many purchasers like the exceptional taste the process gives to it (Fafioye *et al*., 2017). Selling smoked meat helps support the living of countless small-scale traders (Eze *et al*., 2018). Smoked meat trading also benefits the economies by giving jobs and income to many families (Adebayo-Tayo *et al*., 2018) [2]. However, the safety of these foods is a treat due to potential contamination with harmful bacteria and polycyclic aromatic hydrocarbons (PAHs), believing to have be introduced during wrong handling or cooking methods. Bacteriological contamination causes foodborne sickness, while PAHs are notorious for being both carcinogenic and toxic (Oyeyemi and Oladipo, 2019; Farombi, *et al*., 2018) [14, 23].

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic compounds and toxic chemical compounds formed during incomplete combustion of organic materials. Fat falling onto hot surfaces or open flames during smoking may produce PAHs which build up on the meat. Because they are carcinogenic, consuming a lot of these compounds can cause serious health problems. Understanding the human health impact of eating smoked meat requires looking at the levels of PAH (Farombi, *et al*., 2018; WHO, 2022) [14]. Suya, a popular ready-to-eat delicacy in Nigeria, is a spicy, smoked meat dish commonly sold by street vendors. Originating from Northern Nigeria, this highly cherished delicacy is prepared from thinly sliced beef or other meats, marinated in spices, and roasted over an open flame or charcoal. Suya's widespread consumption in the society highlights its importance as a nutritive main food. (Akano and Abolagba, 2020) [4]. In spite of its prominence, the processing and handling of suya raise significant public health treats. Several studies have highlighted contamination risks associated with its preparation and sale, particularly from poor hygiene practices, exposure to environmental pollutants, and improper storage.

The demand for the ready-to-eat (RTE) smoked and spiced meats have increased as a result of their taste and suitability. Nevertheless, bacteriological safety with these foods is a bit apprehensive, largely because strict hygiene standards for food processing and storage cannot be met in many developing countries (Eze *et al*., 2022). Ensuring public health safety and maintaining consumer confidence in these products relies heavily on bacteriological assessment of these foods.

Traditionally, the smoking process used in preserving meats, involves exposing the meats to smoke from burning wood or other materials. This process imparts a smoky flavor and dries the meat, aiding in preservation. Still, the conditions under which the meat is smoked — such as the type of wood used, the duration of smoking, and the temperature, can influence the safety and quality of the final product (Adams & Moss, 2020) [1]. Suitable storage and post-

smoking are very important for microbial safety of the meat. Inappropriate storage can generate extra microbes which makes the meat unfit for consumption (Gilbert & Harrison, 2019) [15]. The growth of spoilage and pathogenic bacteria can be influenced by factors such as temperature, humidity, and packaging materials. (Ingham *et al*., 2016). Common bacterial contaminants in smoked meat include *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., and *Listeria monocytogenes* (Bahrndorff *et al*., 2019). These pathogens can cause serious illnesses, ranging from gastrointestinal disturbances to severe systemic infections. Microbial contamination can occur at various stages of meat processing, including handling, smoking, packaging, and storage. Inadequate cooking temperatures, cross-contamination, and poor hygiene practices are significant contributors to the bacterial load in smoked meat products (Okonko *et al*., 2013) [22].

The safety of ready to eat smoked and spiced meat requires compliance to regulatory standards and the implementation of effective quality control measures. A lot of countries have established guidelines and standards for the allowable quantities of microbial contaminants in meat products. These standards are designed to shield consumers from foodborne illnesses and to ensure the overall quality and safety of the products (Nordmann *et al*., 2022).To control the quality of smoked meat, the use of Hazard Analysis and Critical Control Points (HACCP) systems, frequent microbial testing, and appropriate training for personnel involved in the handling and processing of meat (Buchanan & Gibbons, 2020) [7]. Implementing these procedures can help identify critical points in the processing chain where contamination might occur and take corrective actions to mitigate these risks (Willey *et al*., 2015) [26].

As meat products are potentially prone to contamination with harmful bacteria and polycyclic aromatic hydrocarbons (PAHs), the safety and quality of ready-to-eat smoked and spiced meat products in Warri Metropolis, Delta State, Nigeria, have become significant public health concerns. The main aim of this research was to assess the bacteriological quality and the presence of polycyclic aromatic hydrocarbons (PAHs) in ready-to-eat smoked and spiced meat products (Suya) in Warri Metropolis, Delta State, Nigeria.

Materials and Methods

Sample Collection

Meat samples were collected from four strategic locations in Warri and its metropolis for comparison. The samples were collected in triplicates and placed in labeled sterile polyethylene bags and immediately taken to a microbiology laboratory, where they were stored in a refrigerator for further analysis.

Bacterial Analyses

Bacterial enumeration was carried out using standard bacteriological protocols to determine the total plate count, coliform count, and *Escherichia coli* (*E. coli*) count, following the pour plate method (APHA, 2018). The isolates were subsequently identified using morphological, Gram stain and biochemical tests.

A 1g portion of the meat sample was introduced into 9 ml of normal saline and serially diluted. Thereafter, 1 ml of the diluted samples was inoculated onto different media, swirled to ensure even distribution, and incubated at 37°C for 24–48 hours. Pure isolates from the corresponding agar slants were characterized and identified based on morphological and biochemical characteristics (Buchanan and Gibbons, 2020) [7]. Identification was conducted according to Bergey's Manual of Determinative Bacteriology.

Polycyclic Aromatic Hydrocarbon Assessment

Samples of smoked and spiced meats were collected from various locations and stored in clean, sterile, hermetically sealed containers to prevent contamination and delivered to a chemical laboratory. The meat samples were then minced or homogenized to ensure uniformity, and 5–10 g of each sample was weighed for analysis.

Organic solvents like hexane, acetone, or methanol were used to extract PAHs. Techniques such as Soxhlet extraction or ultrasound-assisted extraction (UAE) were employed to isolate PAHs from the sample matrix. The extracts were then cleaned using solid-phase extraction (SPE) or column chromatography to remove impurities.

For analysis, Gas Chromatography-Mass Spectrometry (GC-MS) or High-Performance Liquid Chromatography (HPLC) equipped with a fluorescence or UV detector was used. The instruments were calibrated with known PAH standards, such as benzo[a]pyrene and anthracene, to quantify PAH concentrations in the samples. Finally, the detected PAH levels were compared against regulatory limits, such as the European Union standards for benzo[a]pyrene or total PAHs in food.

Statistical Analysis.

Descriptive statistics (mean and standard deviation) were used to present the data.

Results and Discussion

The bacteriological assessment of meat samples collected from four sampling locations revealed distinct variations in the concentration of indicator organisms, as shown in Table 1. Total Viable Count (TVC) with values ranged from 2.14 ± 0.03 $\times 10^6$ cfu/g at Location B to 4.81 ± 0.06 $\times 10^6$ cfu/g at Location D. Similarly, total Coliform counts ranged from 1.27 ± 0.03 $\times 10^4$ cfu/g at Location B to 2.93 ± 0.03 $\times 10^4$ cfu/g at Location D. Fecal Coliform (E. coli) levels were particularly notable, ranging from 0.00 ± 0.00 $\times 10^2$ cfu/g (not detected) at Location B to 4.60 ± 0.06 $\times 10^2$ cfu/g at Location D.

Table 1: Bacterial mean counts of various Meat Samples collected from different Locations.

Parameter	Location A	Location B	Location C	Location D	Unit
Total Coliform	1.92 ± 0.03	1.27 ± 0.03	2.51 ± 0.04	2.93 ± 0.03	$\times 10^4$cfu/g
Fecal Coliform (*E. coli*)	1.10 ± 0.03	0.00 ± 0.00	2.70 ± 0.06	4.60 ± 0.06	$\times 10^2$ cfu/g
Total Viable Count	2.78 ± 0.04	2.14 ± 0.03	3.96 ± 0.05	4.81 ± 0.06	$\times 10^6$cfu/g

Note: All values are expressed as mean± standard error.

The results of the biochemical tests are presented in Table 2. Twelve isolates were characterized and identified; nine were rod-shaped, while three were cocci. Additionally, five isolates were Gram-positive, and seven were Gram-negative.

The identified isolates included *Pseudomonas aeruginosa*, *Escherichia coli*, *Bacillus* sp., *Staphylococcus* sp., *Proteus vulgaris*, and *Enterobacter aerogenes*. Among these, *E. coli* and *Staphylococcus aureus* were the dominant organisms.

Table 2: Biochemical Characterization and Identification of Isolates

Isolate Identity	Morphological Test		Biochemical Test										Sugar Fermentation			Species Name
		Shape		Catal ase	Coagulase	Oxidase	Spore	Methyl red	Indole production	HIS production	Cirt ate utilization	Starch hydrolysis	Lactose Ferm.	Sucrose ferm.	Glucose ferm.	
Location A	-	Rod	+	+	-	-	-	+	+	-	-	-	+	+	+	*Escherichia coli*
	+	Coccus	.-	+	-	-	-	-	-	-	-	-	+	-	+	*Staphylococcus aureus*
	-	Rod	+	+	-	-	-	+	+	+	-	-	-	+	+	*Proteus vulgaris*
Location B	+	Coccus		+		-			-	-	-	-	+		+	*Staphylococcus aureus*
	+	Rod	+	+			+				-	+		+	+	*Bacillus spp*
Location C	-	Rod	+	+	-	-	-	-	-	-	+	-	+	-	+	*Enterobacter aerogenes*
	-	Rod	+	+	-	-	-	+-	+	-	-	-	+	+	+	*Escherichia coli*
	-	Rod	-	+	-	+	-	-	-	-	-	-	-	-	-	*Pseudomonas aeruginosa*
Location D	+	Coccus	-	+	-	-	-	-	-	-	-	-	+	-	+	*Staphylococc e aureus*
	-	Rod	+	+	-			+	+				+	+	+	*Escherichia coli*
	+	Rod	+	+			+					+		+	+	*Bacillus spp*
	-	Rod	*	+	-	-	-	-	-	-	+	-	+	-	+	*Enterobacter aerogenes*

Keys: Sp. Specie, + Positive – Negative.

Polycyclic Aromatic Hydrocarbon Analyses

Table 3 present the concentrations of polycyclic aromatic hydrocarbons (PAHs) detected in samples A and B. These values, measured in milligrams per kilogram (mg/kg), indicate the amount of each PAH present in the food samples, a standard unit used in environmental and chemical analyses to assess contaminant levels in food. Benzo[a]pyrene was 0.02 mg/kg and 0.03 mg/kg in both samples A and B. Indeno [1,2,3-cd] pyrene was 0.01 mg/kg and 0.03mg/kg in samples A and B respectively.

The Concentrations of Targeted Polycyclic Aromatic Hydrocarbon Compounds for Sample A and B

S/N	Compound	Sample A Concentration	Sample B Concentration
1	Acenaphthylene	1.01 mg/kg	0.02mg/kg
2	Acenaphthene	0.01 mg/kg	0.01mg/kg
3	Fluorene	0.22 mg/kg	0.04mg/kg
4	Phenanthrene	0.09 mg/kg	0.08mg/kg
5	Anthracene	0.12 mg/kg	0.10mg/kg
6	Fluoranthene	0.02 mg/kg	0.01mg/kg
7	Pyrene	0.02 mg/kg	0.02mg/kg
8	Benzo[c]phenanthrene	0.01 mg/kg	0.01mg/kg
9	Benzo[a]phenanthrene	0.01 mg/kg	0.02mg/kg
10	Benzo[j+k+b]fluoranthene	0.00mg/kg	0.01mg/kg
11	Benzo[a]pyrene	0.02 mg/kg	0.03mg/kg
12	Benzo[e]pyrene	0.01 mg/kg	0.02mg/kg
13	3-Methylcholanthrene	0.01 mg/kg	ND
14	Indeno[1,2,3-cd]pyrene	0.01 mg/kg	0.03mg/kg
15	15] Benzo(ghi)perylene	0.01 mg/kg	0.03mg/kg
16	Dibenz(a,l)pyrene	0.02 mg/kg	0.02mg/kg

Discussion

This study highlighted the varying bacterial loads found in smoked and spiced meat across different locations, revealing the influence of several environmental factors such as moisture content, pH level, temperature, ingredient quality, and processing conditions (Eze *et al*., 2022). These factors likely contribute to the differences observed in bacterial presence from one location to another.

Smoking plays a crucial role in reducing moisture content in meat, which helps inhibit bacterial growth to some extent. However, if the meat is not adequately dried after smoking, or if moisture gets reintroduced during the spicing process, conditions can become favorable for bacteria to thrive (Fafioye *et al*., 2017). In fact, high moisture levels create an environment where bacteria can proliferate more easily.

The pH level of smoked and spiced meat also affects microbial growth. When meat is treated with acidic spices, the resulting lower pH creates a less hospitable environment for many bacteria. Still, some acid-tolerant strains, like *Escherichia coli*, can persist even in these acidic conditions,

posing a potential food safety risk (Egbebi and Muhammad, 2021).

Temperature is another critical factor in preventing bacterial growth. The heat from smoking can reduce bacterial populations, but this only works effectively if the process is properly controlled. If the meat is smoked at insufficient temperatures or for too short a duration, harmful pathogens may survive (Ingham *et al*., 2016).

Spices and seasonings, while enhancing flavor, can inadvertently introduce bacteria if they are not handled or stored correctly. Contaminated spices can become a source of pathogens, leading to bacterial growth during processing and storage. To minimize these risks, it is essential to use high-quality ingredients and follow strict hygiene practices throughout handling and preparation (Egbebi and Muhammad, 2021).

This study also revealed that the ready-to-eat meats were contaminated, with bacterial loads exceeding acceptable limits. According to international food safety standards set by the Food and Agriculture Organization (FAO), the Codex Alimentarius Commission, and European Commission Regulation (EC) No 2073/2005 on Microbiological Criteria for Foodstuffs, acceptable limits for ready to eat meat are as follows: Aerobic Plate Count (APC) ≤ 100,000 CFU/g (colony-forming units per gram), Coliforms ≤ 100 CFU/g, and *E. coli* ≤ 100 CFU/g. These standards provide globally recognized guidelines to ensure food safety. Exceeding these limits indicates poor microbial quality and raises concerns about hygiene practices.

The bacterial isolates identified in this study included *Proteus vulgaris*, *Escherichia coli*, *Bacillus* species, *Staphylococcus* species, *Pseudomonas aeruginosa*, and *Enterobacter aerogenes*. Similar findings have been reported by Odey *et al*. (2013) [21], Yusuf *et al*. (2019) [28], Moshood and Taiwo (2012) [19], and Hassan *et al*. (2014) [16], who also isolated these organisms from ready to eat meat. The presence of these bacteria underscores the potential health risks associated with consuming such products.

Coliforms and *E. coli* are widely recognized as indicators of food quality and hygiene. Coliforms specifically signal contamination during processing, while the detection of fecal coliforms points to fecal contamination and an increased risk of enteric pathogens. The presence of *E. coli* is particularly concerning, as it reflects the overall hygiene of the meat processing environment. Meat can become contaminated with *E. coli* through contact with infected handlers, contaminated water, or fecal matter.

Another notable finding was the presence of *Bacillus* species, which are spore-forming bacteria capable of surviving high temperatures. These organisms can lead to food spoilage, affecting the meat's flavor, texture, and aroma by producing off-flavors, foul odors, and changes in texture, making the meat unpalatable and reducing its shelf life. Additionally, the occurrence of *Bacillus* species may indicate the presence of other harmful microorganisms.

Staphylococcus aureus was the most frequently detected organism, especially in "suya". Its prevalence is likely due to improper handling by vendors. As a normal part of the human skin flora, *Staphylococcus aureus* can easily contaminate food through poor hygiene practices. When conditions are unsanitary, the bacteria can proliferate, posing a significant risk of foodborne illness. Therefore, its presence in ready-to-eat meat serves as a warning sign of inadequate hygiene among food handlers.

Pseudomonas aeruginosa, another opportunistic pathogen, was also identified. Its presence in suya may result from cross-contamination or environmental exposure during handling and storage. Likewise, the detection of *Enterobacter* species and *Proteus vulgaris* points to poor sanitary conditions throughout the meat handling process. Overall, these findings highlight the need for improved hygiene practices and stricter safety measures during meat processing, handling, and storage to protect public health.

The study also revealed noticeable differences in PAH concentrations between the two sampled sources, suggesting that cooking methods or environmental factors might play a role in PAH formation. For instance, acenaphthylene levels in Sample A are strikingly higher at 1.01 mg/kg compared to just 0.02 mg/kg in Sample B. Such variation points to potential differences in grilling techniques or conditions that could influence PAH production.

A particularly concerning finding is the presence of benzo(a)pyrene, a well-known carcinogen, detected at 0.02 mg/kg in Sample A and 0.03 mg/kg in Sample B. These values have exceeded acceptable levels. Even at low concentrations, exposure to this compound poses serious health risks, highlighting the need for careful monitoring (IARC, 2010). The European Union has established maximum levels for polycyclic aromatic hydrocarbons (PAHs) in ready-to-eat meat products to ensure consumer safety. Maximum levels for PAHs in ready-to-eat meat for traditionally smoked meat are 0.002mg/kg(or 2µg/kg) for Benzo[a]pyrene(BaP) and 12.0µg/kg or 0.012mg/kg for sum of PAH4 (BaP, BaA, BbF and CHR). PAH4 or PAH8 are indicators of PAH occurrence and toxicity in food (EU, 2005).

PAHs are notorious for their cancer-causing potential, and consuming foods with elevated PAH levels has been linked to a higher risk of developing cancer (Wang *et al*., 2019). Compounds like fluoranthene and phenanthrene, also detected in the samples, add to the concern. Frequent exposure to these substances could contribute to long-term health issues, making their presence in food a matter of public health significance.

The variations in PAH levels between the samples could be attributed to different cooking practices commonly used in suya preparation. Factors such as grilling temperature, smoking duration, and the type of fuel used can significantly impact PAH formation (El-Far, 2016) [10]. The higher PAH concentrations observed in Sample A suggest that the cooking techniques applied may have intensified PAH production. These findings underscore the urgent need for stricter regulations regarding PAH levels in food products, particularly in urban areas where grilling and smoking meats are common practices. Equally important is raising consumer awareness about the dangers of high PAH exposure. Educating people on safer cooking techniques such as avoiding charring, using controlled heat, and ensuring proper ventilation while grilling could significantly lower PAH intake and promote healthier food choices (Pokorny & Toma, 2018) [24].

Conclusion

The bacteriological and polycyclic aromatic hydrocarbons (PAHs) assessment of ready-to-eat smoked and spiced meat in Warri and its environs revealed the presence of both pathogenic and spoilage bacteria, which could contribute to contamination and affect the sensory quality of the meat

including its flavor, texture, and aroma. This, in turn, increases the risk of foodborne illnesses. While the economic benefits of the smoked meat business are recognized, it is crucial to regularly assess processing, packaging, and distribution practices. The PAH concentrations found in this study exceeded acceptable limits. This highlights the importance of monitoring and minimizing PAH levels in foods. Public health guidelines recommend reducing exposure to PAHs to mitigate these risks. To reduce PAH formation during the smoking process, efficiency strategies should include adopting low-temperature smoking methods and using modern, controlled smoking equipment that regulates temperature and smoke exposure. The use of alternative smoking materials and techniques such as hardwoods that produce fewer PAHs or liquid smoke, which can also help to reduce risks associated with traditional smoking practices.

Declaration of Competing Interest

The authors certify that they have NO affiliation with or involvement in any organization or entity with any financial in the subject matter discussed in this manuscript.

Acknowledgements

I appreciate the authorities and staff of Federal University of Petroleum Resources, Effurun (FUPRE) (Environment Management and Toxicology Department). I want to express my special thanks to all of the persons who put their effort during field work and laboratory analyses. Their support is deeply valued and gratefully acknowledged.

Data availability: Data will be made available on request.

References

1. Adams MR, Moss MO. Food microbiology. The Royal Society of Chemistry, Thomas Graham House, Service Park, Cambridge, UK, 2020, 432-442.
2. Adebayo-Tayo BC, Onilude AA, Patrick UG. Mycofloral of smoke-dried fishes sold in Uyo, Eastern Nigeria. World Journal of Agricultural Sciences,2008:4(3):346-350.
3. Adeleye OA. Conservation needs of fisheries resources and reorientation for sustainable captive and culture practices. In Proceedings of the 10th Annual Conference of the Fisheries Society of Nigeria, 2015, 230-235.
4. Akano AT, Abolagba OJ. Mircobiological safety of street vended suya in Southern Nigeria. Journal of Food Safety and Hygiene,2020:6(1):45-53.
5. America Public Health Association. Standard methods for the Examination of water and wastewater, 19th Edition, 2018.
6. Bahrndorff S, Rangstrup-Christensen L, Nordentoft S, Hald B. Foodborne disease prevention and broiler chickens with reduced campylobacter infection. Emerging Infectious Diseases,2013:19(3):425-430.
7. Buchanan RE, Gibbons NE. Bergey's manual of determinative bacteriology (8th ed.). The Williams and Wilkins Co., Baltimore, 2020.
8. Codex Alimentarius Commission. Recommended International Code of Hygienic Practice for Meat. CAC/RCP 58-2005, 2005.
9. Egbebi AO, Seidu KT. Microbiological evaluation of Suya (dried smoked meat) sold in Ado and Akure, South West Nigeria. European Journal of Experimental Biology,2011:1(4):1-5.
10. El-Far G. The influence of cooking methods on the formation of polycyclic aromatic hydrocarbons in meat. Food Chemistry,2016:213:326-331.
11. European Commission (EU). Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union, 2005.
12. Eze EA, Eze CN, Amaeze VO, Eze CN. Fishes and smoked meat delicacies as sources of multidrug resistant bacteria and parasitic worms. African Journal of Agricultural Research,2013:8(22):2799-2805.
13. Fafioye OO, Fagbohun TR, Olubanjo OO. Fungal infestation and nutrient quality of traditionally smoke-dried freshwater fish. Turkish Journal of Fish and Aquatic Sciences,2008:8(1):7-13.
14. Farombi EO, Adedara IA, Ajayi BO. Health implications of PAHs in smoked foods. African Journal of Biochemistry,2018:12(3):145-153.
15. Gilbert U, Harrison A. Occurrence of enterotoxin-producing Staphylococcus aureus in meat markets in Nigeria. Journal of Food Infection,20019:56(1):25-35.
16. Hassan JO, Olasunkanmi IT, Salihu M. Bacteriological quality of ready-to-eat roasted meat (suya) in some locations in Bauchi State, Nigeria. Nigerian Journal of Microbiology,2014:28(2):2761-2768.
17. Ingham SC, Fanslau MA, Burnham GM, Ingham BH, Norback JP, Schaffner DW. Predicting pathogen growth during short-term temperature abuse of raw pork, beef, and poultry products: Use of an isothermal-based predictive tool. Journal of Food Protection,2007:70(6):1446-1456.
18. International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Some non-heterocyclic polycyclic aromatic hydrocarbons and some related exposures. Lyon, France: IARC, 2010, 92.
19. Moshood AY, Taiwo AM. Bacteria associated with ready-to-eat roasted beef (suya) in Ilorin Metropolis, Nigeria. International Journal of Food Safety,2012:14:12-16.
20. Nordmann P, Poirel L, Dortet L. Rapid detection of carbapenemase-producing Enterobacteriaceae. Emerging Infectious Diseases,2012:18(9):1503-1507.
21. Odey MO, Etim UE, Arong GA. Microbial analysis of street-vended suya meat in Calabar, Cross River State, Nigeria. International Journal of Current Microbiology and Applied Sciences,2013:2(9):47-52.
22. Okonko IO, Odu NN, Igboh IE. Microbiological analysis of Kilishi sold in Port Harcourt, Nigeria. New York Science Journal,2013:6(7):37-43.
23. Oyeyemi OT, Oladipo OO. Hygienic practices among suya vendors: Implications for food safety. Nigerian Journal of Public Health,2019:16(2):76-85.
24. Pokorny J, Toma S. Consumer education on food safety: The role of local agencies and organizations. Journal of Food Safety,2018:38(3):12402.

25. World Health Organization (WHO). Guidelines for the Safe Production of Animal-Based Foods, 2020.
26. Willey JM, Sherwood LM, Wolverton CJ. Prescott, Harley, and Klein's microbiology (7th ed.). McGraw-Hill Companies Inc., New York, 2015, 268-273.
27. World Health Organization (WHO). Polycyclic aromatic hydrocarbons in food, 2022.
28. Yusuf MO, Bello M, Ameh JA. Microbial quality of suya meat in Birnin Kebbi, Nigeria. Nigerian Veterinary Journal,2019:40(3):267-272.