

Microbial contamination and public health risks of raw cow and goat meat in informal markets: evidence from Abeokuta Metropolis, Nigeria

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ABSTRACT: Informal markets remain critical sources of animal protein across low- and middle-income countries (LMICs), yet they are often characterised by inadequate hygiene, poor infrastructure, and weak regulatory oversight. These conditions create hotspots for microbial contamination of meat, posing significant food safety and public health threats. This study assessed the bacterial load, pathogenic profiles, and public health risks associated with raw cow (beef) and goat meat sold in two major open markets in Abeokuta metropolis, Nigeria. A total of eight (n = 8) 100-gram samples of raw meat were aseptically collected from thigh muscle portions of slaughtered cattle and goats (beef and goat), at morning and evening sales from Kuto and Lafenwa markets. Standard plate count methods were employed for enumeration, while morphological and biochemical techniques were used for bacterial characterisation. Statistical analyses (ANOVA, frequency distributions) were applied to compare microbial loads across meat types, locations, and sale periods. The results show that bacterial loads exceeded international safety thresholds ($\geq 1 \times 10^6$ CFU/g) across all samples, ranging from 9.0×10^7 to 7.0×10^9 CFU/g. Goat meat exhibited significantly higher microbial loads than beef ($p < 0.05$), while evening samples consistently recorded higher counts than morning samples ($p < 0.05$). Lafenwa market samples demonstrated greater contamination compared to Kuto. Predominant isolates included *Staphylococcus* spp. (57.1%), *Proteus* spp. (14.3%), *Salmonella* spp. (14.3%), *Pseudomonas aeruginosa* (7.1%), and *Enterobacter* spp. (7.1%). The detection of enteric and opportunistic pathogens highlights systemic hygiene failures within informal meat supply chains and reinforces their role as under-recognised nodes for foodborne disease and antimicrobial resistance transmission. In conclusion, raw beef and goat meat sold in Abeokuta's open markets are heavily contaminated with pathogenic bacteria, posing significant risks of foodborne infections and a potential contribution to antimicrobial resistance (AMR). Urgent interventions are required, including routine microbial surveillance, provision of cold-chain infrastructure, and stringent hygiene enforcement for meat handlers.

Keywords: Antimicrobial resistance, bacterial load, food safety, informal markets, Nigeria, raw beef, raw goat meat.

INTRODUCTION

Meat is one of the most significant sources of animal protein in human diets worldwide, providing high-quality

proteins, essential amino acids, vitamins, and micronutrients critical for growth, immunity, and metabolic

regulation. Beyond macronutrient composition, meat also supplies vital micronutrients such as heme iron, zinc, and B-complex vitamins, all of which are crucial for neurological functions, oxygen transport, and enzymatic activity (Stadnik, 2024). In many developing nations, including Nigeria, beef and goat meat constitute a large proportion of household protein intake due to their affordability and cultural significance (Adenuga and Montowska, 2023).

Beef, derived from cattle, is the most widely consumed red meat globally. According to the Food and Agriculture Organisation (FAO), global beef consumption in 2023 exceeded 71 million tonnes, with sub-Saharan Africa accounting for approximately 6% of the total demand (FAO, 2023). Goat meat (mutton/chevon), on the other hand, has gained increasing recognition as a leaner and healthier red meat alternative, with lower fat and cholesterol levels than beef or lamb, making it particularly appealing to health-conscious consumers (Ivanović *et al.*, 2016). In Nigeria, goat meat consumption is also shaped by socio-cultural and religious practices, particularly during festivities such as Eid celebrations and Christmas (Ahmad, 2022).

Despite its nutritional importance, meat is also one of the most perishable and hazardous food commodities due to its high water activity, near-neutral pH, and nutrient richness, which together provide an ideal substrate for microbial colonisation and proliferation (Abdullahi and Abdullahi, 2023). Pathogenic microorganisms can be introduced at multiple stages along the meat supply chain—from animal slaughter, evisceration, and dressing to handling, storage, and distribution. Factors such as poor abattoir sanitation, unsterilized cutting equipment, inadequate refrigeration, and prolonged exposure during open-air retailing have been widely implicated in microbial contamination (Uzoigwe *et al.*, 2021).

Globally, the World Health Organisation (WHO) estimates that unsafe food contributes to 600 million cases of foodborne illness annually, resulting in 420,000 deaths, with the highest burden observed in Africa and Southeast Asia (WHO, 2021). Among food commodities, meat and meat products are consistently implicated as leading vehicles for foodborne outbreaks, commonly involving *Salmonella* spp., *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Campylobacter* spp., and *Staphylococcus aureus* (Fayemi *et al.*, 2021). These pathogens not only cause acute gastroenteritis but may also lead to severe systemic conditions such as haemolytic uraemic syndrome, septicaemia, or meningitis.

In Nigeria, meat retailing is dominated by informal open markets, which supply the majority of households with raw beef, goat meat, and other animal proteins. Unlike in developed countries, where meat is typically processed under regulated industrial conditions with cold-chain distribution systems, Nigerian meat is often slaughtered in under-equipped abattoirs and transported without refrigeration to market stalls where it is displayed openly for several hours (Osemwowa *et al.*, 2021). Butchers frequently handle meat with bare hands, use unsterilized

knives, and cut on contaminated wooden or metallic surfaces, creating conditions for rapid bacterial colonization (Awojimi *et al.*, 2022).

The absence of cold storage facilities in most markets means that meat is sold under ambient tropical conditions, which accelerate bacterial growth (Deji-Agboola *et al.*, 2018). This is particularly concerning in urban centres such as Abeokuta, where meat is displayed in high-volume markets like Kuto and Lafenwa, serving thousands of consumers daily. Studies in similar Nigerian cities have reported bacterial loads far exceeding international safety thresholds of $\leq 1 \times 10^6$ CFU/g, with frequent isolation of *Salmonella* spp., *Proteus* spp., *Staphylococcus aureus*, and *Escherichia coli* (Oku *et al.*, 2023).

The health risks of consuming contaminated meat are multi-layered. At the individual level, exposure to enteric pathogens can result in diarrhoeal diseases, which remain a leading cause of morbidity and mortality in Nigeria, particularly among children under five years (WHO, 2021). At the community level, outbreaks of foodborne diseases impose significant economic burdens through healthcare costs, productivity losses, and reduced consumer confidence in food safety systems (Osiyemi *et al.*, 2018).

While several studies have documented bacterial contamination in Nigerian meats, there remains a paucity of comparative analyses between different meat types (cow vs. goat) and between major market locations in medium-sized cities such as Abeokuta. Most existing research has been concentrated in megacities such as Lagos, Abuja, or Port Harcourt, leaving critical gaps in regional surveillance. Furthermore, few studies have systematically compared morning versus evening sales, despite anecdotal evidence suggesting that prolonged display time increases microbial load (Lawan *et al.*, 2021).

By examining microbiological risks within Abeokuta's informal meat markets, this study contributes locally generated evidence to the global challenge of ensuring safe meat supply in rapidly urbanizing low- and middle-income settings. Therefore, this study aims to systematically assess the microbiological safety of raw beef and goat meat sold in major informal markets within Abeokuta Metropolis.

MATERIALS AND METHODS

Study area and market selection

This study was conducted in Abeokuta Metropolis, the capital of Ogun State, southwestern Nigeria. Abeokuta is a rapidly urbanising city with a population of over one million people, and it serves as a major trade hub for livestock and meat products. Two of the largest informal meat markets—Kuto and Lafenwa—were selected based on their high consumer patronage, daily sales volume, and role as distribution centres to surrounding communities. Both markets operate in open-air environments with minimal cold-chain facilities and limited regulatory oversight.

Study design and sampling strategy

A comparative cross-sectional design was adopted to assess bacterial load variation by meat type, market location and time of sale. A total of eight (8) composite meat samples were collected from eight different meat sellers across the two markets –four from Kuto and four from Lafenwa. Each market contributed two beef samples (one in the morning and one in the evening) and two goat meat samples (one in the morning and one in the evening).

Morning samples were obtained between 7:00 am and 9:00 am, approximately 2-3 hours after slaughter, while evening samples were obtained between 4:00 and 6:00 pm after extended exposure on open stalls. The design allowed for comparative evaluation across both meat type and duration of exposure to ambient conditions.

Composite sampling was adopted to maximize representativeness across key exposure variables while maintaining feasibility for exploratory microbiological risk assessment.

Sample collection and handling

Meat samples were aseptically purchased directly from butchers' stalls. Approximately 100 g of raw beef (from the hindquarter) or goat meat (from the thigh) was excised using sterile knives and immediately wrapped in sterile aluminium foil. Each sample was placed in a pre-labelled sterile zip-lock bag, stored in an insulated icebox containing ice packs, and transported within an hour to the Microbiology Laboratory of Crescent University, Abeokuta. Strict aseptic measures were followed to avoid extraneous contamination during transportation.

Isolation and enumeration of bacteria

Each meat sample was homogenised in sterile conditions. Ten grams (10 g) of meat was aseptically weighed and blended in 90 mL of sterile peptone water to yield a 10^{-1} dilution. Serial dilutions up to 10^{-5} were prepared. From each dilution, 1 mL was inoculated into Petri dishes using the pour plate method with Nutrient Agar (NA) and MacConkey Agar (MCA). Plates were incubated at 37°C for 24–48 hours. Colony-forming units (CFU/g) were enumerated using a digital colony counter, and counts were adjusted by multiplying by the dilution factor. The Total Viable Count (TVC) was expressed as CFU per gram of meat sample. Counts were compared against international microbiological safety standards ($\leq 1 \times 10^6$ CFU/g for raw meat, FAO/WHO).

Morphological characterisation of isolates

Colonial characteristics such as shape, size, elevation,

colour, edge, opacity, and surface texture were recorded. Discrete colonies were purified through repeated streaking and subculturing until pure isolates were obtained. The isolates were characterised based on Gram staining, colony morphology (shape, elevation, margin, colour, opacity), and a suite of biochemical tests including catalase, oxidase, indole, citrate utilisation, urease production, triple sugar iron (TSI), and carbohydrate fermentation patterns. Identification was concluded using standard taxonomic schemes as outlined in Bergey's Manual of Determinative Bacteriology.

Data analysis and statistical methods

Microbial counts were log-transformed before statistical analysis to normalise data distribution. Comparisons of mean bacterial loads between: meat types (beef vs goat), market locations (Kuto vs Lafenwa), and time of sale (morning vs evening) were performed using Analysis of Variance (ANOVA) at a 95% confidence level. Post-hoc Tukey tests were applied where significant differences were found. Frequency distributions of bacterial species were calculated as percentages of total isolates. All analyses were conducted using SPSS v26.0 (IBM Corp., Armonk, NY, USA). A p-value of <0.05 was considered statistically significant.

RESULTS

Total viable bacterial counts (TVC) in beef and goat meat

The mean total viable counts (TVC) of bacteria isolated from beef and goat meat samples collected in Kuto and Lafenwa markets are presented in Table 1. Across all samples, bacterial counts exceeded the international microbiological safety limit of $\leq 1 \times 10^6$ CFU/g (FAO/WHO standard).

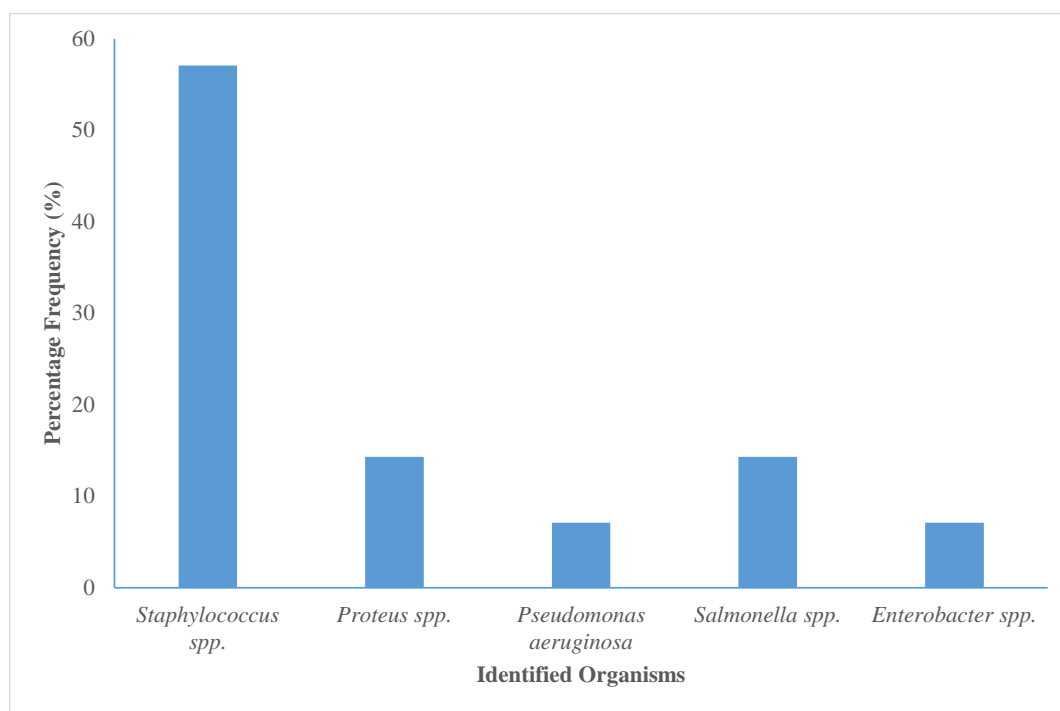
Counts ranged from 9.0×10^7 CFU/g (beef, Kuto morning) to 7.0×10^9 CFU/g (beef, Kuto evening). Goat meat consistently recorded higher bacterial loads, suggesting greater exposure to contamination during slaughtering and retail handling relative to beef at both markets, with the highest contamination observed in goat meat from Lafenwa in the morning (6.5×10^9 CFU/g).

Statistical analysis (ANOVA) revealed significant differences in bacterial counts across meat types ($F = 12.4$, $p = 0.004$), market locations ($F = 9.8$, $p = 0.009$), and time of sale ($F = 15.7$, $p = 0.002$). Post-hoc tests showed that goat meat had significantly higher bacterial counts than beef ($p < 0.05$), and evening samples exhibited significantly higher loads than morning samples ($p < 0.05$). Lafenwa market samples demonstrated significantly greater contamination than Kuto ($p < 0.05$).

Out of 14 isolates, six (42.9%) were Gram-positive cocci

Table 1. Total viable counts of bacteria in raw beef and goat meat from Kuto and Lafenwa markets.

Location	Meat type	Time	Mean TVC (CFU/g)	95% CI
Kuto	Beef	Morning	9.0×10^7	$7.8-10.3 \times 10^7$
Kuto	Beef	Evening	7.0×10^9	$6.7-7.3 \times 10^9$
Kuto	Goat	Morning	4.68×10^9	$4.4-4.9 \times 10^9$
Kuto	Goat	Evening	2.53×10^9	$2.3-2.7 \times 10^9$
Lafenwa	Beef	Morning	2.85×10^8	$2.6-3.0 \times 10^8$
Lafenwa	Beef	Evening	5.0×10^8	$4.7-5.3 \times 10^8$
Lafenwa	Goat	Morning	6.5×10^9	$6.1-6.9 \times 10^9$
Lafenwa	Goat	Evening	4.43×10^9	$4.1-4.7 \times 10^9$

**Figure 1.** Bacterial occurrence and its percentage frequency.

consistent with *Staphylococcus* spp., while eight (57.1%) were Gram-negative rods, including *Proteus* spp., *Pseudomonas aeruginosa*, *Salmonella* spp., and *Enterobacter* spp. Catalase activity was universal, whereas oxidase activity was positive in 4 isolates (28.6%). Urease and H₂S production were common among *Proteus* and *Salmonella* isolates. Glucose fermentation was observed in 92.9% of isolates, while lactose fermentation was positive in 13 isolates.

Staphylococcus spp. emerged as the most predominant organism, accounting for 57.1%; *Proteus* spp. and *Salmonella* spp. each accounted for 14.3% of isolates. *Pseudomonas aeruginosa* and *Enterobacter* spp. were least represented (7.1% each). *Salmonella* spp. was exclusively found in evening samples from Lafenwa. *Proteus* spp. appeared more frequently in goat meat than in beef, as reported in Figure 1.

DISCUSSION

This study found uniformly high bacterial contamination in raw beef and goat meat sold in Kuto and Lafenwa markets, with Total Viable Counts (TVCs) ranging from 9.0×10^7 to 7.0×10^9 CFU/g, far exceeding commonly accepted safety thresholds for raw meat ($\leq 1 \times 10^6$ CFU/g). Goat meat carried consistently higher loads than beef, evening samples were more contaminated than morning samples, and Lafenwa market samples were, on average, more laden with bacteria than those from Kuto. The isolates recovered were dominated by *Staphylococcus* spp. (57.1%), with *Proteus* spp., *Salmonella* spp., *Pseudomonas aeruginosa*, and *Enterobacter* spp. also present.

The exceptionally high TVCs mirror prior findings from Nigerian studies of informal markets. Osemwowa *et al.*

(2021) reported significantly elevated mesophilic counts in Nigerian markets compared with Finnish controls, with many Nigerian samples exceeding EU microbiological limits; the TVC magnitudes reported in that comparative study are consistent with the levels observed here. Similarly, Oku *et al.* (2023) and Lawan *et al.* (2021) documented TVCs often above 10^6 CFU/g in urban Nigerian markets and specifically highlighted higher counts in samples collected later in the day—parallel to our finding that evening samples were more contaminated. Together, these studies point to a reproducible pattern: in open-air market systems without refrigeration, time-on-stall strongly predicts contamination.

The higher contamination in goat (chevon) versus cattle meat seen here accords with some published reports (Ivanović *et al.*, 2016; Awojimi *et al.*, 2022) that attribute species differences to slaughter/processing practices and carcass size—goat carcasses are often handled differently, sometimes in less formal facilities, and may be exposed to more handling per unit mass. However, literature is not unanimous: some studies report comparable loads between beef and goat where handling conditions are similar. Thus, the pattern observed here likely reflects localised handling and market practices rather than an intrinsic species susceptibility.

The dominance of *Staphylococcus* spp. is consistent with multiple Nigerian and African studies (Oku *et al.*, 2023; Uzoigwe *et al.*, 2021) that report staphylococci as one of the most frequent isolates from retail meat. This strongly indicate that poor handler hygiene represents a dominant contamination pathway in informal meat markets. The recovery of *Salmonella* spp. is concordant with prevalence reports from Nigerian surveys (Fayemi *et al.*, 2021; Oludairo *et al.*, 2022) that found *Salmonella* in a substantial fraction of beef and ready-to-eat meat products. That *Salmonella* and Enterobacteriaceae species were concentrated in evening and Lafenwa samples here mirrors the report linking poor abattoir sanitation, contaminated equipment, or cross-contamination during transport with enteric pathogens (Uzoigwe *et al.*, 2021; Olu-Taiwo *et al.*, 2021).

Findings from this study align with a growing body of evidence across sub-Saharan Africa that unsafe meat in informal markets constitutes a persistent health hazard. However, this study makes a unique contribution by providing comparative data across meat type, market location, and time of sale, highlighting practical intervention points.

From a One Health perspective, the convergence of animal handling practices, human hygiene behaviours and environmental exposure observed in this study illustrates how informal meat markets function as interconnected ecological systems for pathogen persistence.

Although antimicrobial resistance profiling was beyond the scope of this study, the isolation of genera frequently associated with multidrug resistance underscores the urgent need to integrate microbiological surveillance with

AMR monitoring in informal meat systems (Fayemi *et al.*, 2021; Oludairo *et al.*, 2022). They also emphasise informal markets as ecological niches for AMR dissemination—our findings strengthen that concern by demonstrating abundant reservoirs of potentially resistant taxa in widely consumed meat.

Conclusion

This study provides compelling evidence that raw beef and goat meat sold in informal markets in Abeokuta, Nigeria, are heavily contaminated with bacteria at levels far exceeding international microbiological safety standards. The consistently higher loads in goat meat compared to beef, the significant rise in contamination during evening sales, and the higher counts in Lafenwa relative to Kuto market collectively underscore the critical role of species-specific handling, market infrastructure, and duration of ambient exposure in shaping microbial risks.

The predominance of *Staphylococcus* spp., coupled with the detection of *Salmonella* spp., *Proteus* spp., *Enterobacter* spp., and *Pseudomonas aeruginosa*, indicates multiple pathways of contamination, including poor handler hygiene, faecal exposure, and environmental vectors. These pathogens are of serious public health concern, with the potential to cause foodborne illness, systemic infections, and, through the vehicle of contaminated meat, to contribute to the growing antimicrobial resistance (AMR) crisis.

Addressing these challenges requires a multi-pronged approach: strengthening regulatory enforcement, upgrading market and abattoir infrastructure, training meat handlers, implementing consumer awareness campaigns, and embedding microbial surveillance systems into Nigeria's food safety framework. Furthermore, aligning national efforts with the One Health paradigm is essential to curbing the dual threats of foodborne diseases and antimicrobial resistance.

In conclusion, this study not only underscores the urgent need for food safety reforms in Nigeria's informal meat sector but also situates the issue within the global discourse on food security and AMR. By bridging local evidence with international policy imperatives, it calls for coordinated action across government, academia, and community stakeholders to ensure safer meat consumption, protect public health, and contribute to global health security.

Addressing these risks is not only essential for protecting local consumers but also for strengthening global efforts to curb foodborne diseases and antimicrobial resistance in an increasingly interconnected food system.

Recommendations

Based on the findings of this study, the following recom-

mendations are proposed to address the microbial safety challenges associated with raw beef and goat meat sold in informal markets in Abeokuta and similar contexts across Nigeria:

1. Enforce strict hygienic practices among meat handlers through regular training and supervision at abattoirs and open markets.
2. Introduce compulsory hand-washing and protective gear (gloves, aprons, head covers) for all meat sellers to reduce human-mediated contamination.
3. Provide cold storage and covered stalls in open markets to minimise bacterial proliferation during prolonged exposure.
4. Implement routine microbial monitoring of meat products by local health authorities to track contamination trends and compliance with safety standards.
5. Upgrade slaughterhouse and market sanitation facilities, including provision of potable water, disinfectants, and waste disposal systems.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

- Abdullahi, B. U., & Abdullahi, H. D. (2023). Isolation and characterisation of some micro-organisms associated with slaughtered cow meat at Eke-Oko, Anambra State. *International Journal of Organic and Medicinal Development Research*, 2(1), 65-80.
- Adenuga, B. M., & Montowska, M. (2023). The Nigerian meat industry: An overview of products' market, fraud situations, and potential ways out. *Acta Scientiarum Polonorum Technologia Alimentaria*, 22(3), 305-329.
- Ahmad, A. K. (2022). Socio-economic impacts of "Īd-Al-Adhā"(festival of sacrifice) for the people of Odeda Local Government of Ogun State, Nigeria. *NIU Journal of Social Sciences*, 8(2), 193-202.
- Awojimi, I., Adesida, O., Adediran, O. A., Awodoyin, O. R., & Omojola, A. B. (2022). Microbial quality of fresh beef from different slaughter facilities in Oyo state, Nigeria. *Agricultural and Food Science Journal of Ghana*, 15(1), 1594-1604.
- Deji-Agboola, A., Sunmola, N., Osiyemi, J., Makanjuola, S., Akinduti, P., Ejilude, O., & Osiyemi, E. (2018). Incidence of Enterotoxigenic Escherichia coli in Slaughter Houses in Sagamu, Nigeria. *Journal of Advances in Microbiology*, 9(3), 1-8.
- FAO (2023). Meat market review: Overview of global meat production and trade. Food and Agriculture Organisation of the United Nations. Retrieved from <https://doi.org/10.4060/cc7724en>.
- Fayemi, O. E., Akanni, G. B., Elegbeleye, J. A., Aboaba, O. O., & Njage, P. M. (2021). Prevalence, characterization and antibiotic resistance of Shiga toxigenic Escherichia coli serogroups isolated from fresh beef and locally processed ready-to-eat meat products in Lagos, Nigeria. *International Journal of Food Microbiology*, 347, 109191.
- Ivanović, S., Pavlović, I., & Pisinov, B. (2016). The quality of goat meat and it's impact on human health. *Biotechnology in Animal Husbandry*, 32(2), 111-122.
- Lawan, M. K., Temala, A., Bello, M., & Adamu, J. (2011). Effects of time of meat purchase on the level of microbial contamination of beef from retail points in Samaru market, Zaria, Nigeria. *Sokoto Journal of Veterinary Sciences*, 9(1), 18-21.
- Oku, I., Oyadougha, T. W., & Emmanuel, D. Y. (2023). Microbial Examination of Bacteria Isolated from Raw Beef Samples Sold in Opolo Market, Yenagoa Metropolis, Bayelsa State, Nigeria. *Journal of Applied Veterinary Sciences and Environmental Management*, 27(9), 2009-2014.
- Oludairo, O. O., AK, B., OB, D., & JO, A. (2022). Isolation and Antimicrobial Resistance Phenotype of Salmonella species from Ready-to-Eat Roasted Meat (Suya) in Ilorin, Kwara State, Nigeria. *Journal of Applied Veterinary Sciences*, 7(4), 67-73.
- Olu-Taiwo, M., Obeng, P., & Forson, A. O. (2021). Bacteriological analysis of raw beef retailed in selected open markets in Accra, Ghana. *Journal of Food Quality*, 2021(1), 6666683.
- Osemwowa, E., Omoruyi, I. M., Kurittu, P., Heikinheimo, A. and Fredriksson-Ahomaa, M. (2021). Bacterial quality and safety of raw beef: A comparison between Finland and Nigeria. *Food Microbiology*, 100, 103860.
- Osiyemi, J., Osinupebi, O., Akinduti, P., Ejilude, O., Makanjuola, S., Sunmola, N., & Osiyemi, E. (2018). Antibiotic resistance profile of methicillin-resistant Staphylococcus aureus in Abeokuta, Nigeria. *Journal of Advances in Microbiology*, 9(2), 1-9.
- Stadnik, J. (2024). Nutritional value of meat and meat products and their role in human health. *Nutrients*, 16(10), 1446.
- Uzoigwe, N. E., Nwifo, C. R., Nwankwo, C. S., Ibe, S. N., Amadi, C. O., & Udujih, O. G. (2021). Assessment of bacterial contamination of beef in slaughterhouses in Owerri zone, Imo state, Nigeria. *Scientific African*, 12, e00769.
- World Health Organisation (2021). *WHO estimates of the global burden of foodborne diseases*. World Health Organisation.