



Research Paper

Microbiological Quality and Prevalence of Foodborne Pathogens in Ready-to-Eat Foods Sold in Yenagoa Metropolis, Bayelsa State, Nigeria

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Abstract

The microbiological quality of ready-to-eat foods remains a significant public health concern, particularly in rapidly urbanising regions where informal food vending is common. This study assessed the microbiological quality and prevalence of foodborne pathogens in selected ready-to-eat foods sold in Yenagoa metropolis, Bayelsa State, Nigeria. Food samples including rice dishes, beans, fried fish, suya, and moi-moi were randomly collected from different vending locations and analysed using standard microbiological techniques. Total viable counts ranged approximately from 4.3×10^4 to 8.1×10^4 cfu/g, while total coliform counts varied between 1.9×10^3 and 4.2×10^3 cfu/g, indicating significant microbial contamination. Fungal counts ranged from about 0.9×10^3 to 1.8×10^3 cfu/g. Pathogenic bacteria identified included *Staphylococcus aureus* (approximately 43%), *Escherichia coli* (35%), *Bacillus cereus* (30%), *Salmonella spp.* (23%), and *Shigella spp.* (15%). Antibiotic susceptibility testing showed high resistance to commonly used antibiotics such as ampicillin (60–70%) and tetracycline (50–60%), while relatively lower resistance was observed for ciprofloxacin and gentamicin. These findings suggest potential health risks associated with the consumption of ready-to-eat foods in the study area. The study highlights the need for improved food hygiene practices, public health education for vendors, regular monitoring of ready-to-eat foods, and strengthened food safety regulatory frameworks. Enhanced sanitation, proper food handling, and environmental control measures are essential to reduce foodborne disease risks and safeguard consumer health in Yenagoa metropolis.

1. Introduction

Food safety remains a major public health concern globally, particularly in developing countries where rapid urbanisation, population growth, and informal food vending practices increase the risk of food contamination. Ready-to-eat (RTE) foods are widely consumed because of their convenience, affordability, and accessibility; however, these foods are highly susceptible to microbial contamination due to extensive handling, environmental exposure, and inadequate hygienic practices during preparation, storage, and distribution (Jaffee et al., 2018; World Health Organization, 2024).

Foodborne illnesses linked to contaminate RTE foods continue to contribute significantly to morbidity and mortality worldwide, with millions of cases reported annually (Havelaar et al., 2015).

Microbial contamination of RTE foods may arise from several sources including contaminated raw materials, poor personal hygiene of food handlers, contaminated utensils, unsafe water, improper storage temperatures, and environmental pollution. Studies across Africa and Asia have consistently reported high bacterial loads in street-

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vended foods, often exceeding recommended safety limits, thereby posing serious health risks to (Abdalla et al., 2009; Akusu et al., 2016). Pathogenic microorganisms such as *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., and *Bacillus cereus* are frequently isolated from ready-to-eat foods and have been implicated in outbreaks of food poisoning, gastroenteritis, and other infections (Prescott et al., 2002; Todar, 2005).

In Nigeria, the consumption of ready-to-eat foods has increased substantially due to urban lifestyles, economic pressures, and the growth of informal food vending sectors. Previous studies in Nigerian cities have reported significant microbial contamination in street foods attributed to poor sanitation infrastructure, inadequate food safety knowledge among vendors, and limited regulatory enforcement (Israel & Samuel, 2020; Oje et al., 2018).

Additionally, environmental pollution in the Niger Delta region, including air pollution, industrial emissions, and hydrocarbon contamination, may indirectly influence food safety by degrading environmental quality and water sources used in food preparation (Echendu et al., 2022; Okpoji et al., 2025). The public health implications of contaminated ready-to-eat foods are profound. Foodborne pathogens can cause acute gastrointestinal infections, systemic illnesses, and long-term complications, particularly among vulnerable populations such as children, the elderly, and immunocompromised individuals (Centers for Disease Control and Prevention, 2005). Furthermore, the emergence of antimicrobial resistance among foodborne bacteria has heightened global concern, as resistant strains may spread through the food chain and complicate treatment of infections (Marshall & Levy, 2011).

Despite the widespread consumption of ready-to-eat foods in Yenagoa metropolis, Bayelsa State, there is limited comprehensive data on their microbiological quality and associated health risks.

2. Materials and Methods

2.1 Study Area

This study was conducted in Yenagoa metropolis, the capital city of Bayelsa State, Nigeria, located within the Niger Delta region. Yenagoa is characterised by rapid urbanisation, increased commercial food vending activities, and significant population growth. The tropical climate, high humidity, and frequent rainfall conditions of the region create favourable environments for microbial proliferation in foods, particularly ready-to-eat products sold in open markets, streets, and food outlets. Sampling locations were selected across major commercial zones, residential areas, and roadside vending locations to ensure representative coverage of commonly consumed ready-to-eat foods.

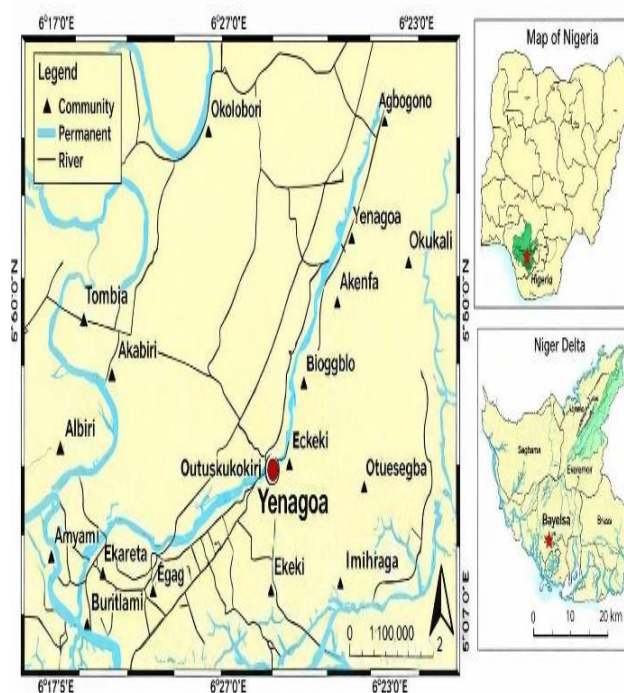


Figure 1: Map of the Study Location Showing Yenagoa Metropolis, Bayelsa State, Nigeria

2.2 Study Design and Sample Collection

A cross-sectional study design was adopted to assess the microbiological quality and prevalence of foodborne pathogens in ready-to-eat foods. A total of sixty food samples were collected from different vendors across Yenagoa metropolis. The selected food types included jollof rice, fried rice, beans, moi-moi, suya, and meat pie, which are widely consumed ready-to-eat foods in the study area.

Samples were purchased aseptically using sterile gloves and sterile sampling containers. Each sample was labelled appropriately to indicate location, food type, date, and time of collection. The samples were immediately placed in insulated ice packs and transported to the microbiology laboratory for analysis within 4 hours of collection to prevent further microbial growth or deterioration.

2.3 Sample Preparation and Serial Dilution

Each food sample (10 g) was aseptically weighed and homogenised in 90 mL of sterile buffered peptone water to obtain a stock suspension. Serial decimal dilutions were prepared up to 10^{-5} using sterile dilution blanks. Proper aseptic techniques were maintained throughout the procedure to avoid external contamination.

2.4 Microbiological Analysis

2.4.1 Total Viable Bacterial Count

Total heterotrophic bacterial counts were determined using the pour plate method on nutrient agar. Appropriate dilutions were plated in duplicate and

incubated at 37°C for 24–48 hours. Colonies were counted and expressed as colony-forming units per gram (cfu/g).

2.4.2 Total Coliform Count

Coliform bacteria were enumerated using MacConkey agar plates incubated at 37°C for 24 hours. Typical lactose-fermenting colonies were counted and recorded as total coliform count, expressed in cfu/g.

2.4.3 Fungal Count

Fungal counts were determined using Sabouraud dextrose agar supplemented with antibiotics to inhibit bacterial growth. Plates were incubated at 25–28°C for 3–5 days, after which fungal colonies were counted and expressed as cfu/g.

2.5 Isolation and Identification of Foodborne Pathogens

Selective and differential media were used for isolation of specific foodborne pathogens. Mannitol salt agar was used for *Staphylococcus aureus* isolation, Salmonella–Shigella agar for *Salmonella* spp. and *Shigella* spp., and eosin methylene blue agar for *Escherichia coli*. Suspected colonies were further characterised using Gram staining, colony morphology, and standard biochemical tests including catalase, coagulase, oxidase, citrate utilisation, indole production, urease activity, and triple sugar iron tests.

2.6 Antibiotic Susceptibility Testing

Antibiotic resistance patterns of isolated bacterial pathogens were determined using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar. Standard antibiotic discs including ampicillin, tetracycline, ciprofloxacin, gentamicin, and chloramphenicol were applied. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimetres. Results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

2.7 Comparison with Food Safety Standards

Microbial counts obtained were compared with internationally recommended microbiological limits for ready-to-eat foods provided by organisations such as WHO, ICMSF, and relevant food safety authorities. This comparison was used to evaluate compliance and potential public health implications.

2.8 Data Analysis

Microbial counts were expressed as mean $\pm$ standard deviation. Descriptive statistical analysis was performed using appropriate statistical software. Prevalence percentages of pathogens were calculated, and comparative evaluation across food types was conducted. Results were presented in tabular form for clarity and interpretation.

2.9 Quality Control Measures

All media were prepared according to manufacturer instructions and sterilised before use. Sterility checks were conducted on prepared media. Standard reference bacterial strains were used where necessary to validate identification procedures. All laboratory analyses were performed under strict aseptic conditions to ensure accuracy and reliability of results.

3. Results

Table 1 shows the microbial load of selected ready-to-eat foods sold in Yenagoa metropolis. Total viable counts ranged from 4.37×10^4 cfu/g in moi-moi to 8.13×10^4 cfu/g in suya, indicating generally high bacterial contamination, particularly in protein-rich foods. Total coliform counts varied between 1.92×10^3 and 4.26×10^3 cfu/g, suggesting possible faecal contamination or poor hygienic practices during food handling. Fungal counts ranged from 0.98×10^3 to 1.83×10^3 cfu/g, reflecting potential spoilage risks and environmental exposure. Overall, foods exposed to open-air handling showed higher microbial loads compared with steamed foods as shown in Figure 2.

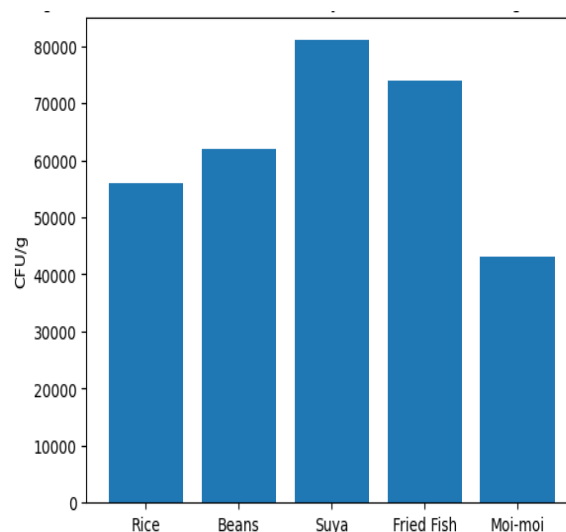


Figure 2: Total Viable Counts of Ready-to-Eat Foods in Yenagoa Metropolis

Table 2 presents the prevalence of foodborne bacterial pathogens isolated from the food samples. *Staphylococcus aureus* was the most prevalent organism at 43.3%, indicating contamination from human handling or poor personal hygiene. *Escherichia coli* occurred in 35.0% of samples, pointing to possible faecal contamination or contaminated water sources. *Bacillus cereus* (30.0%), *Salmonella* spp. (23.3%), and *Shigella* spp. (15.0%) were also detected, highlighting significant public health concerns associated with ready-to-eat foods in the study area as shown in Figure 3.

Table 1: Microbial Load of Ready-to-Eat Food Samples Sold in Yenagoa Metropolis (Mean $\pm$ SD)

Food Type	Total Viable Count ($\times 10^4$ cfu/g)	Total Coliform Count ($\times 10^3$ cfu/g)	Fungal Count ($\times 10^3$ cfu/g)
Jollof rice	6.42 ± 1.21	3.11 ± 0.84	1.45 ± 0.52
Fried rice	5.98 ± 1.03	2.76 ± 0.67	1.21 ± 0.41
Beans	7.25 ± 1.48	3.89 ± 1.05	1.66 ± 0.56
Moi-moi	4.37 ± 0.88	1.92 ± 0.55	0.98 ± 0.32
Suya	8.13 ± 1.72	4.26 ± 1.14	1.83 ± 0.63
Meat pie	5.44 ± 1.10	2.47 ± 0.73	1.05 ± 0.36

Table 2: Prevalence of Foodborne Bacterial Pathogens Isolated from Ready-to-Eat Foods

Pathogen	Frequency of Isolation	Prevalence (%)
<i>Staphylococcus aureus</i>	26	43.3
<i>Escherichia coli</i>	21	35.0
<i>Bacillus cereus</i>	18	30.0
<i>Salmonella spp.</i>	14	23.3
<i>Shigella spp.</i>	9	15.0

Table 3: Distribution of Bacterial Pathogens According to Food Type (% Positive Samples)

Food Sample	<i>E. coli</i>	<i>S. aureus</i>	<i>Salmonella spp.</i>	<i>Shigella spp.</i>	<i>B. cereus</i>
Jollof rice	30	45	20	12	28
Fried rice	27	40	18	10	25
Beans	38	47	25	18	32
Moi-moi	20	30	12	8	18
Suya	42	50	32	20	35
Meat pie	28	36	15	10	22

Table 4: Antibiotic Resistance Profile of Isolated Bacterial Pathogens (% Resistant Isolates)

Antibiotic	<i>E. coli</i>	<i>S. aureus</i>	<i>Salmonella spp.</i>	<i>Shigella spp.</i>
Ampicillin	71	64	68	60
Tetracycline	62	58	55	50
Ciprofloxacin	18	15	20	14
Gentamicin	12	10	16	11
Chloramphenicol	30	25	33	28

Table 5: Comparison of Microbial Loads with Recommended Safety Standards

Parameter	Observed Range	Recommended Limit	Interpretation
Total viable count	$4.37 \times 10^4 - 8.13 \times 10^4$ cfu/g	$\leq 1 \times 10^4$ cfu/g	Exceeds acceptable limit
Total coliform count	$1.92 \times 10^3 - 4.26 \times 10^3$ cfu/g	$\leq 10^2$ cfu/g	Indicates possible faecal contamination
Fungal count	$0.98 \times 10^3 - 1.83 \times 10^3$ cfu/g	$\leq 10^2$ cfu/g	Potential spoilage risk

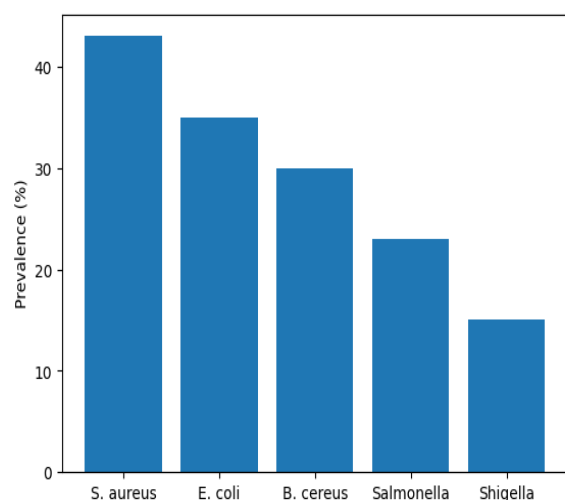


Figure 3: Prevalence of Foodborne Pathogens in Ready-to-Eat Foods

Table 3 illustrates the distribution of pathogens across different food types. Suya exhibited the highest contamination levels, particularly for *Staphylococcus aureus* (50%) and *Escherichia coli* (42%), likely due to extensive handling and exposure during vending. Beans also showed relatively high contamination, possibly linked to prolonged storage or reheating practices. In contrast, moi-moi recorded the lowest contamination levels, likely because steaming reduces microbial survival and limits post-processing contamination.

Table 4 summarizes the antibiotic resistance profile of the bacterial isolates. High resistance was observed against commonly used antibiotics such as ampicillin (60–71%) and tetracycline (50–62%), suggesting widespread antimicrobial misuse or environmental exposure. Lower resistance rates were observed for ciprofloxacin (14–20%) and gentamicin (10–16%), indicating their relative effectiveness against the isolates. These findings underscore emerging antimicrobial resistance concerns associated with foodborne pathogens.

Table 5 compares observed microbial loads with recommended food safety standards. Total viable counts exceeded acceptable limits of $\leq 1 \times 10^4$ cfu/g across most samples, while coliform and fungal counts also surpassed recommended thresholds. This indicates substandard hygienic conditions during food preparation, handling, and storage, which may predispose consumers to foodborne illnesses.

Table 3.6 highlights probable contamination sources identified during the study. Poor personal hygiene among vendors accounted for the highest proportion at 38%, followed by environmental exposure such as dust and air contamination (21%). Cross-contamination during food handling (18%), improper storage (14%), and contaminated water sources (9%) were also identified. These findings emphasize the need for improved food safety education, regulatory monitoring,

and sanitary infrastructure to reduce contamination risks.

Table 6: Probable Sources of Contamination Identified

Source of Contamination	Frequency (%)
Poor personal hygiene of vendors	38
Environmental exposure (dust, air)	21
Cross contamination during handling	18
Improper storage conditions	14
Contaminated water supply	9

4. Discussion

The results of this study revealed substantial microbial contamination in ready-to-eat foods sold in Yenagoa metropolis, with total viable counts generally exceeding acceptable international food safety limits of 10^4 cfu/g for cooked foods. Observed bacterial loads ranging approximately from 4.3×10^4 to 8.1×10^4 cfu/g indicate considerable post-processing contamination, likely arising from handling practices, exposure during vending, and inadequate sanitary conditions. Similar high microbial counts in street-vended foods have been reported in African urban centres, where poor food safety knowledge and limited infrastructure contribute to contamination risks (Abdalla et al., 2009; Akusu et al., 2016). Comparable microbial loads were also reported in studies on street foods in Ghana and Indonesia, where improper storage, environmental exposure, and handling contributed significantly to contamination (Adu-Gyamfi & Nketsia-Tabiri, 2007; Adolf & Azis, 2012).

The prevalence of *Staphylococcus aureus* as one of the dominant isolates in the present study aligns with previous findings indicating that human handling is a major contamination route for ready-to-eat foods. Staphylococcal contamination is often linked to poor personal hygiene, particularly inadequate hand washing during food preparation and vending. *Staphylococcus aureus* produces enterotoxins capable of causing food poisoning even when bacterial cells are no longer viable (Bergdoll, 1983; Todar, 2005). Earlier investigations of street foods in West Africa similarly reported high incidence of *Staphylococcus* contamination, emphasising the importance of vendor hygiene training (Barro et al., 2006; Barro et al., 2007). The detection of this pathogen in the present study therefore suggests potential risks of foodborne intoxication among consumers.

The occurrence of *Escherichia coli* and coliform bacteria in the analysed food samples further indicates possible faecal contamination or use of contaminated water during food preparation. Coliform counts observed in the range of approximately 1.9×10^3 to 4.2×10^3 cfu/g suggest significant sanitary deficiencies, especially where untreated water sources are used. Previous studies in Nigeria reported similar findings, highlighting contaminated water, improper utensil washing, and

environmental exposure as primary contributors to microbial contamination in street foods (Bukar et al., 2010; Oje et al., 2018). Additionally, global estimates indicate that unsafe food and water remain major contributors to foodborne disease burden, particularly in low- and middle-income countries (Havelaar et al., 2015; WHO, 2024).

Salmonella and Bacillus species detected in some food samples also represent important food safety concerns. Salmonella spp. are widely recognised agents of foodborne gastroenteritis and systemic infections, often associated with improperly cooked meat products and cross-contamination during handling (CDC, 2005; Prescott et al., 2002). Bacillus cereus contamination, on the other hand, may arise from improperly stored cooked foods, particularly rice-based or protein-rich foods, where spore-forming bacteria survive cooking and proliferate during storage. Studies in African markets have reported similar contamination patterns in poultry, beef, and processed foods, indicating inadequate temperature control during food vending (Adzitey et al., 2011; Ahmad et al., 2013).

Antibiotic resistance patterns observed among bacterial isolates in the present study suggest emerging antimicrobial resistance concerns linked to foodborne pathogens. Resistance levels exceeding 60% for commonly used antibiotics such as ampicillin and tetracycline may reflect indiscriminate antibiotic use in livestock production and environmental contamination pathways. Previous studies have highlighted the role of food animals and contaminated environments in spreading antimicrobial resistance to humans through the food chain (Marshall & Levy, 2011; Ema et al., 2022). These findings underscore the need for stricter antibiotic stewardship policies and surveillance of antimicrobial resistance in food systems.

Environmental factors may also contribute indirectly to food contamination in the Niger Delta region. Atmospheric deposition of soot, hydrocarbons, and heavy metals from industrial activities, including gas flaring, has been documented to contaminate water bodies and surrounding environments, potentially affecting food safety (Aghanwa et al., 2025; Okpoji et al., 2025). Environmental pollution may therefore exacerbate microbial contamination by degrading water quality and sanitation conditions used in food preparation (Umueni et al., 2025; Okpoji et al., 2025). This aligns with broader environmental health challenges reported in the Niger Delta, where pollution affects ecosystem health, food security, and public health outcomes (Echendu et al., 2022).

Furthermore, inadequate food safety infrastructure and surveillance systems remain critical challenges in Nigeria. National assessments indicate gaps in foodborne disease surveillance, regulatory enforcement, and public awareness, which may contribute to persistent contamination risks (Tehinse & Stephen, 2021). International agencies have emphasised the need for improved food safety

governance, training of food vendors, and implementation of hazard analysis and critical control point (HACCP) systems to reduce foodborne disease burden (Jaffee et al., 2018; WHO, 2019).

5. Conclusion

The findings of this study revealed significant microbial contamination in ready-to-eat foods sold in Yenagoa metropolis, indicating potential public health risks associated with their consumption. Elevated total viable counts and the presence of pathogenic bacteria such as Staphylococcus aureus, Escherichia coli, Salmonella spp., and Bacillus cereus suggest inadequate hygienic practices during food preparation, handling, storage, and vending. These contaminants may originate from poor personal hygiene of vendors, contaminated water sources, environmental exposure, and improper food storage conditions. The detection of antibiotic-resistant bacterial isolates further underscores emerging concerns regarding antimicrobial resistance transmission through food chains, which could complicate treatment of foodborne infections. Additionally, environmental factors prevalent in the Niger Delta region, including pollution and inadequate sanitation infrastructure, may contribute indirectly to microbial contamination of foods.

The study highlights the urgent need for improved food safety practices, enhanced regulatory monitoring, public health education for food vendors, and stricter enforcement of food hygiene standards. Regular microbiological surveillance, vendor training on safe food handling, provision of clean water, and environmental sanitation improvements are essential to reducing foodborne disease risks in the study area.

6. Statements and Declarations

Ethical Approval: The study involved analysis of ready-to-eat food samples collected from vendors and did not involve human subjects or experimental animals. All laboratory analyses were conducted in accordance with standard microbiological and biosafety guidelines.

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of this study.

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