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Isolation And Identification Of Bacteria Associated With Food Samples From Different Vendors In Eruwa, Oyo State Nigeria

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Abstract

Objective: Ready-to-eat foods are important sources of affordable nutrition but may become contaminated during preparation and handling. This study investigated the bacterial contaminants associated with ready-to-eat foods (rice, beans, and yam) sold by selected food vendors in Eruwa, Oyo State, Nigeria, to assess their microbiological safety and potential public health risks.

Results: Food samples were aseptically collected from three randomly selected vendors. Nineteen bacterial isolates were recovered and identified using standard morphological and biochemical methods. The isolates comprised *Escherichia coli* (8; 42.1%), *Staphylococcus aureus* (6; 31.6%), *Staphylococcus epidermidis* (2; 10.5%), *Citrobacter freundii* (2; 10.5%), and *Klebsiella aerogenes* (1; 5.3%). The predominance of E. coli indicates possible faecal contamination resulting from poor hygiene, contaminated water, or improperly washed raw ingredients. The presence of *Staphylococcus spp.* and other opportunistic bacteria further suggests inadequate food handling and poor personal hygiene among vendors. These findings demonstrate that ready-to-eat foods sold in Eruwa are susceptible to bacterial contamination and may pose significant public health risks. Improved food safety practices, regular vendor training, routine inspections, and enhanced consumer awareness are recommended to reduce the incidence of food borne diseases.

Keywords: Ready-To-Eat Foods, Bacterial Contamination, Foodborne Pathogens, Hygiene, Food Vendors, Public Health

INTRODUCTION

Street-vended food has become an important component of the food industry in many developing countries, including Nigeria. These foods are prepared and sold by vendors along streets and at various public locations to provide affordable, convenient, and readily accessible meals that meet the nutritional

and energy requirements of consumers. Beyond Africa, street-vended foods are also widely consumed in countries such as India because of their low cost and easy accessibility, particularly in urban centres (Akhilan *et al*., 2020).

Despite their economic and nutritional importance, street-vended foods can serve as vehicles for the transmission of pathogenic microorganisms, including bacteria, fungi, and viruses, when proper food safety practices are not observed (Jay *et al*., 2005 and Assefa *et al*., 2015). Among these microorganisms, bacteria are the most frequently implicated in foodborne diseases because of their rapid multiplication under favourable environmental conditions. Many pathogenic bacteria, including *Escherichia coli*, can multiply within 20 minutes under optimal laboratory conditions. Foodborne pathogens generally proliferate rapidly when foods are kept within the temperature danger zone (approximately 5°C–60°C), particularly when moisture content is high and foods are exposed to the environment for prolonged periods. Common bacterial pathogens associated with foodborne illnesses include *Salmonella enterica* serovar Typhi (*Salmonella Typhi*), *Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, Shigella species, Pseudomonas* species, and *Serratia marcescens*. Globally, bacteria account for the majority of reported foodborne disease outbreaks. Poor adherence to food safety regulations by some street-food vendors increases the risk of contamination. Consequently, bacterial contamination of food remains a major public health concern, particularly in developing countries where hygiene standards and food safety regulations are often inadequate (World Health Organization [WHO], 2020).

Food contamination can occur at any stage of the food chain, from production and processing to preparation and consumption, due to poor handling practices, contaminated water, unsanitary utensils, inadequate storage, or exposure to polluted environments (Adams and Moss, 2008). In many developing communities, street-vended foods are prepared and sold in open environments where they are easily exposed to dust, insects, rodents, and other sources of microbial contamination. Although these foods are popular because they are inexpensive and readily available, the conditions under which they are prepared often compromise their microbiological safety (Tambekar *et al*., 2008). The production and consumption of contaminated foods are particularly common in rural communities such as Eruwa, where access to potable water is limited and knowledge of food hygiene may be inadequate. Furthermore, even properly cooked foods can become re-contaminated through contact with raw foods, contaminated utensils, or improper handling. When pathogenic bacteria multiply to infectious levels, they may cause severe foodborne illnesses and, in some cases, death (Ahmed *et al*., 2008).

Salmonella Typhi is a Gram-negative bacterium responsible for typhoid fever, a disease that continues to impose a significant health burden in many developing countries (Jain and Sharma, 2024). Contamination of street-vended foods with S. Typhi may occur through the use of contaminated water, poor sanitation, dirty utensils, unhygienic vending environments, improper waste disposal, insect vectors such as flies, and handling food with unwashed hands (Tambekar *et al*., 2009).

Klebsiella pneumoniae is an opportunistic Gram-negative bacterium widely recognized as a major cause of hospital-acquired infections. It is also considered an emerging foodborne pathogen capable of causing pneumonia, septicaemia, liver abscesses, urinary tract infections, and diarrhoea (Othman, 2015). The organism is commonly found in the intestinal tract of humans and animals, and contamination of soil, vegetables, meat, fish, and dairy products can occur through improper disposal of human and animal waste.

Escherichia coli is a normal inhabitant of the intestinal tract of humans and warm-blooded animals. While most strains are harmless, pathogenic strains such as enterohaemorrhagic *E. coli* can cause severe abdominal cramps, bloody diarrhoea, vomiting, and, in severe cases, haemolytic uraemic syndrome.

Consumption of contaminated food or water remains the principal route of transmission (Edeh, 2012).

Serratia marcescens is a Gram-negative bacterium belonging to the family Enterobacteriaceae. Although it is widely recognized as an opportunistic pathogen and a spoilage microorganism, its presence in foods may indicate microbial contamination and poor hygienic practices during food preparation or storage.

Staphylococcus aureus is one of the leading causes of bacterial food poisoning. It is commonly found on human skin, in the nasal passages, and in infected wounds. During growth in food, *S. aureus* produces heat-stable enterotoxins that remain active even after the bacteria have been destroyed by cooking. Foods requiring extensive manual handling and those left at room temperature for prolonged periods are particularly susceptible to contamination and toxin production (Edeh, 2012, Jain and Sharma, 2024). Therefore, maintaining good personal hygiene during food preparation is essential for preventing food contamination and reducing the risk of diseases such as food poisoning, bloodstream infections, conjunctivitis, pneumonia, urinary tract infections, and meningitis (Wagner, 2001).

An additional public health concern is the increasing emergence of antimicrobial-resistant foodborne bacteria. Several bacterial species have developed resistance to antibiotics that were previously effective against them. For example, methicillin-resistant *Staphylococcus aureus* (MRSA) has become a significant multidrug-resistant pathogen associated with both hospital-acquired and community-acquired infections, thereby limiting treatment options and increasing disease burden (Banerjee *et al*., 2020).

Foodborne diseases continue to represent a major public health challenge in developing countries, where a substantial proportion of diarrhoeal diseases are associated with contaminated food and water (Alharbi *et al*., 2019). This study was therefore undertaken to assess the pathogenic bacterial load of street-vended foods sold in Eruwa, Oyo State, Nigeria. Eruwa is a rapidly developing town with numerous food vendors serving students, traders, and residents. However, inadequate access to potable water, poor waste management practices, and limited awareness of food hygiene among some vendors may increase the risk of bacterial contamination. Consumption of contaminated foods may result in diseases such as diarrhoea, typhoid fever, cholera, and other foodborne infections that continue to pose significant public health challenges. Therefore, the isolation and identification of bacterial species present in street-vended foods will provide valuable information on their microbiological quality and contribute to the development of appropriate public health interventions aimed at improving food safety and reducing the burden of foodborne diseases.

MATERIALS AND METHODS

Study Area

This study on the isolation and identification of bacteria from selected food samples obtained from different food vendors in Eruwa was conducted in the Microbiology Laboratory of the Department of Science Laboratory Technology, Adeseun Ogundoyin Polytechnic, Eruwa, Oyo State, Nigeria, between July and September 2025. The study aimed to isolate and identify pathogenic bacteria present in selected food samples and relate the isolated bacteria to possible food-borne illnesses, thereby providing information relevant to public health and food safety.

Eruwa is located at latitude 7.53365°N and longitude 3.41796°E. It is the headquarters of Ibarapa East Local Government Area of Oyo State, Nigeria, and lies approximately 75 km southeast of Ibadan. The town is inhabited mainly by farmers, traders, artisans, civil servants, and students of Adeseun Ogundoyin Polytechnic. Food vending is a common commercial activity within the town, especially around markets, schools, and motor parks. Eruwa was selected for this study because of the increasing number of food vendors and the high patronage of street-vended foods by residents.

Population of the Study

The target population comprised food vendors operating within Eruwa town. These included vendors selling cooked foods such as rice, beans, yam, stew, and meat. Food vendors were randomly selected from major vending locations, including Oke-Ola, Orita, and Anko.

Sample Collection

A total of nine (9) food samples were collected from three randomly selected food vendors in Eruwa. Three food samples (rice, beans, and yam) were obtained from each vendor using a simple random sampling technique to minimize sampling bias. The samples were collected aseptically following the method described by Cheesbrough (2010). Sterile spoons were used to transfer each food sample into sterile, properly labelled polythene bags. The samples were immediately placed in an ice box and transported to the Microbiology Laboratory of Adeseun Ogundoyin Polytechnic, Eruwa, where microbiological analysis commenced within two hours of collection to minimize changes in the microbial population.

Isolation and Identification of Food-Borne Bacteria

Isolation and identification of bacteria were carried out under strict aseptic conditions using standard microbiological procedures.

Preparation of Culture Media

The culture media used for the study included Nutrient Agar (NA), MacConkey Agar (MAC), and Mannitol Salt Agar (MSA). The media were prepared according to the manufacturer's instructions and sterilized by autoclaving at 121°C for 15 minutes. After sterilization, the media were allowed to cool to approximately 45–50°C before being poured into sterile Petri dishes and allowed to solidify.

Serial Dilution

Ten grams (10 g) of each food sample was aseptically weighed and homogenized in 90 mL of sterile physiological saline (or sterile peptone water) to obtain a 10^{-1} dilution. Serial ten-fold dilutions were subsequently prepared up to 10^{-5} following the method of Cappuccino and Sherman (2014).

Inoculation and Incubation

Using a sterile micropipette, 0.1 mL aliquots from the appropriate dilutions were inoculated onto Nutrient Agar, MacConkey Agar, and Mannitol Salt Agar plates using the spread plate technique. The inoculated plates were incubated aerobically at 37°C for 24–48 hours.

Following incubation, colonies were counted using a digital colony counter, and bacterial counts were calculated and expressed as colony-forming units per gram (CFU/g) of food sample.

Isolation and Purification of Bacterial Colonies

Distinct colonies were selected based on colony morphology, including colour, size, shape, elevation, margin, and surface appearance. Representative colonies were repeatedly subcultured onto freshly prepared Nutrient Agar plates to obtain pure cultures. The pure isolates were maintained on Nutrient Agar slants and stored at 4°C until further identification.

Identification of Bacterial Isolates

Identification of bacterial isolates was based on colonial morphology, Gram staining characteristics, and biochemical test reactions using standard microbiological methods described by Cheesbrough (2010) and Prescott, Harley, and Klein (2008).

Morphological Examination

The colonial characteristics of each isolate, including colony colour, size, shape, margin, elevation, opacity, and surface appearance, were carefully observed and recorded.

Gram Staining

Gram staining was carried out according to the method described by Madigan (2018). Smears of bacterial isolates were prepared on clean grease-free glass slides, air-dried, heat-fixed, stained using the Gram staining technique, and examined under the oil immersion objective (×100) of a light microscope. The isolates were classified as Gram-positive or Gram-negative based on their staining reactions.

Biochemical Tests

Pure bacterial isolates were subjected to standard biochemical tests, including Catalase, Coagulase, Oxidase, Indole, Citrate Utilization, Urease, Methyl Red (MR), and Voges–Proskauer (VP) tests. The biochemical characteristics obtained were compared with standard descriptions in Bergey's Manual of Determinative Bacteriology to identify the bacterial isolates to the species level where possible.

Data Analysis

Data obtained from the study were analyzed using descriptive statistics, including mean, frequency, and percentage. Total viable bacterial counts were expressed as colony-forming units per gram (CFU/g). The results were presented in tables, and comparisons were made among the different food samples and food vendors to determine the samples with the highest bacterial load and the prevalence of bacterial isolates.

RESULTS AND DISCUSSION

The results showed that all street-vended food samples were contaminated with varying microbial loads (Table 1).

Table 2 showed the characteristics of the isolated bacterial species using biochemical tests which include catalase, coagulase, oxidase, motility, hydrogen sulphide production, indole, urease, phenol red, methyl red, Voges Proskauer and citrate test. The identified bacterial species were *Escherichia coli, Staphylococcus aureus, Staphylococcus epidermidis, Citrobacter freundii,* and *Klebsiella aerogenes*.

Table 1: Total Microbial Count On Different Growth Media

SAMPLE	TOTAL MICROBIAL COUNTS ($\times 10^4$ CFU/g)			
	EMB	**MAC**	**NA**	**BA**
AB	3.6	5.2	7.6	2.4
AR	4.8	2.0	7.2	3.2
AY	5.2	3.6	4.4	5.2
NB	3.2	2.4	2.8	7.2
NR	6.8	4.0	4.8	6.8
NY	7.6	2.8	2.4	8.0
PB	5.6	6.8	6.0	6.0

PR	6.4	4.8	3.2	4.0
PY	2.4	5.6	4.0	5.6

Key:

AB – Beans purchased from Anko market

AR – Rice purchased from Anko market

AY – Yam purchased from Anko market

NB - Beans purchased from New Eruwa market

NR- Rice purchased from New Eruwa market

NY- Yam purchased from New Eruwa market

PB – Beans purchased from Adesun Ogundoyin Polytechnic, Eruwa

PR- Rice purchased from Adeseun Ogundoyin Polytechnic, Eruwa

PY- Yam purchased from Adeseun Ogundoyin Polytechnic, Eruwa

Table 2: Biochemical profile of the isolates

Location	Sample	Isolate	Shape	Gram	Catalase	Coagulase	Oxidase	Motility	H_2S	Indole	Urease	Phenol red	MR	VP	Citrate	Mac	BA	EMB	SS	MSA	Organisms
Anko	**Beans**	AB1	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
		AB2	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
		AB3	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
	Rice	AR1	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
		AR2	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
	Yam	AY1	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
		AY2	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
New Eruwa	**Beans**	NB1	Bacilli	-	+	-	-	+	+	-	-	+	+	-	+	+	+	+	+	-	*Citrobacter freundii*
		NB2	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
	Rice	NR1	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
		NR2	Bacilli	-	+	-	-	+	+	-	-	+	+	-	+	+	+	+	+	-	*Citrobacter freundii*
	Yam	NY1	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
		NY2	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
		NY3	Cocci	-	+	-	-	-	-	-	+	+	-	+	+	+	+	+	+	-	*Klebsiella aerogenes*

Poly	**Beans**	PB1	Cocci	+	+	+	-	-	-	-	-	+	+	+	+	-	+	-	-	+	*Staphylococcus aureus*
		PB2	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
	Rice	PR1	Bacilli	-	+	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	*Escherichia coli*
	Yam	PY1	Cocci	+	+	-	-	+	+	+	+	-	-	+	-	-	+	-	-	+	*Staphylococcus epidermidis*
		PY2	Cocci	+	+	-	-	+	+	+	+	-	-	+	-	-	+	-	-	+	*Staphylococcus epidermidis*

Key:

MR – Methyl Red,

VP – Voges Proskauer,

Mac – Mac Conkey Agar,

BA – Blood Agar,

EMB – Eosin Methylene Blue Agar,

SS – Salmonella Shigella Agar,

MSA – Mannitol Salt Agar

Table 3 showed the frequency of occurrence of the isolated bacterial species; *Staphylococcus aureus* 6 (31.6%), *Escherichia coli* 8 (42.1%), *Citrobacter freundii* 2 (10.5%), *Klebsiella aerogenes* 1 (5.3%) and *Staphylococcus epidermidis* 2 (10.5%).

Table 3: Frequency Of Occurrence Of The Isolated Species

SN	Organism	Occurrence	Frequency (%)
1	*Staphylococcus aureus*	6	31.6
2	*Escherichia coli*	8	42.1
3	*Citrobacter freundii*	2	10.5
4	*Klebsiella aerogenes*	1	5.3
5	*Staphylococcus epidermidis*	2	10.5
	Total	19	100

DISCUSSION

Street vended food has remained largely unchecked in Nigeria, notwithstanding the sector's contribution to the nation's food security. Safe and nutritious street foods have a significant impact on food safety. This study was carried out to isolate and identify bacteria present in food sold by different food vendors in Eruwa, Oyo State, Nigeria. The study aimed to determine the bacteria types and their possible sources of contamination. A total of 9 food samples (rice, beans, and yam) were collected from three vendors across three locations in Eruwa, namely Anko market, New Eruwa and Adeseun Ogundoyin Polytechnic Campus Eruwa.

The microbiological analysis revealed varying microbial loads across all food samples. The highest bacterial count (8.0×10^4 CFU/g) was recorded in yam obtained from New Eruwa on Blood Agar, indicating microbiologically unacceptable quality of the food. This suggested contamination of the ready-to-eat food with a varying range of bacteria. Furthermore, beans from Anko also exhibited relatively high bacterial counts (7.6×10^4 CFU/g) on Nutrient Agar. This microbial load falls at the borderline in that they are within limits of acceptable microbiological quality ($<10^5$ CFU/g) but may indicate possible hygiene problems in the preparation of the food (ICMSF 2001). The highest bacterial growth (7.6×10^4 CFU/g) on EMB agar, and (6.8×10^4 CFU/g) on MacConkey agar were recorded in yam from New Eruwa and beans from Adesun Ogundoyin Polytechnic, Eruwa, respectively suggesting substantial contamination with Gram-negative enteric bacteria, including possible coliforms. These microbial loads are unacceptable by health standards as the presence of Enterobacteriaceae at high levels ($>10^4$ CFU/g) in cooked or processed foods suggests an overall poor general hygiene status of a food product (United Kingdom Health Security Agency, 2024). The relatively high microbial load observed may be associated with poor sanitary conditions, inadequate food handling practices, environmental exposure, or the use of contaminated water during food preparation, prolonged exposure of cooked food to ambient temperature, repeated handling by vendors, and inadequate protection from dust and flies during display. Similar observations have been reported in previous studies (Jay *et al*. 2005, Adams and Moss 2008, Assefa et al., 2015, Jain and Sharma 2024)

Biochemical characterization identified the bacterial isolates as *Escherichia coli*, *Staphylococcus aureus, staphylococcus epidermidis*, *Klebsiella aerogenes* and *Citrobacter freundii* which are recognized as important foodborne pathogens and opportunistic bacteria of public health concern. These findings

highlight the risk of microbial contamination in ready-to-eat foods sold by vendors and mirror reports from other Nigerian cities and developing countries where street-vended foods are major sources of foodborne illnesses as posited by Abdullahi, 2010; Oranusi and Braide, 2012.

The predominance of E. coli (42.1%) observed in this study agrees with reports by Omemu and Aderoju (2008), who also identified *E. coli* as one of the predominant contaminants in ready-to-eat foods. *E. coli* is widely regarded as an indicator of faecal contamination. Its presence suggests exposure of food to contaminated water, unwashed vegetables, or poor personal hygiene among food handlers (Chuklo, 2015). Similar studies in Abeokuta (Omemu and Aderoju, 2008) and Ibadan (Adepoju, 2015) have reported similar findings, underscoring a regional pattern of sanitation breach in food vending activities. The public health concern is aggravated by the fact that pathogenic strains of *E. coli* can cause severe gastrointestinal infections, including diarrhea and dysentery.

The isolation of Staphylococcus aureus (6 isolates; 31.6%) further underscores the role of food handlers in food contamination. This organism is often introduced through improper handling, sneezing, coughing, or contact with infected skin lesions (Agbudin, 2010). *Staphylococcus aureus* is capable of producing heat-stable enterotoxins that may persist even after reheating contaminated food. This highlights the importance of vendor hygiene, particularly after cooking to avoid food vulnerability to recontamination.

The occurrence of *Klebsiella aerogenes* 1 (5.3%) and *Citrobacter freundii* 2 (10.5%) indicates contamination from environmental sources, including soil, utensils, and storage conditions. Although these organisms are generally considered opportunistic pathogens, their presence in food is undesirable as they may cause illness in immunocompromised individuals. This aligns with findings by Mensah, (2002) in Ghana, who reported that exposure to dust and contaminated storage conditions contributed to bacterial contamination of street foods. The presence of *Staphylococcus epidermidis* 2 (10.5%) though less dangerous than its relative *Staphylococcus aureus,* is noteworthy as it indicates poor sanitation and hygiene and it is significantly important in food-borne illness. These organisms are mostly resident on the skin and in the environment, suggesting that food contamination may have occurred through direct contact with food handlers or exposure to dust. While they are less pathogenic, their presence still reflects lapses in hygiene practices.

Altogether, the study findings uphold previous reports that street-vended foods in Nigeria often harbor multiple pathogenic and opportunistic bacteria. However, variations exist across regions. For example, while this study identified *Escherichia coli* as the most prevalent contaminant, Adegun, (2015) reported higher detection rates of *Salmonella spp.* in Ibadan. Such differences may be attributed to geographical, seasonal, or sample-type variations, further emphasizing the importance of region-specific surveillance. This regional variation provided the motivation for conducting the present study in Eruwa.

CONCLUSION AND RECOMMENDATION

This study demonstrated that all street-vended food samples examined were contaminated with bacteria of public health importance. *Escherichia coli* was the predominant isolate (42.1%), followed by *Staphylococcus aureus* (31.6%). The presence of these organisms suggests contamination arising from poor personal hygiene, contaminated water, improper food handling, and unsanitary environmental conditions. These findings indicate that consumers of street-vended foods in Eruwa may be exposed to foodborne pathogens unless appropriate food safety measures are implemented. Continuous surveillance, vendor education, and enforcement of hygiene regulations are therefore essential to improve the microbiological safety of street foods.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. **Health education:** Food vendors throughout Eruwa should undergo regular training on food hygiene and safety practices, including hand washing, proper food storage, and utensil sanitation.
2. **Regular monitoring**: Health officers from local government authorities should carry out periodic inspections of food vending sites to ensure compliance with public health standards.
3. **Clean water supply**: Local government authorities should provide reliable access to potable water in markets and food vending areas to prevent the use of contaminated water for food preparation.
4. **Personal hygiene:** Food handlers should always wear protective clothing, such as aprons and hair nets, and avoid handling food when suffering from infections or having wounds.
5. **Environmental sanitation:** Food vending areas should be kept clean and free from flies, rodents, and dust to minimize contamination.
6. **Public awareness:** Public awareness campaigns should encourage consumers to patronize hygienic food vendors and report unsanitary food handling practices to the relevant authorities.

Further research:

Future studies should focus on antibiotic susceptibility testing of the isolated bacteria to determine their resistance patterns, as well as molecular identification for more accurate classification.

Contribution to knowledge

To the best of the researcher's knowledge, this is the first study to evaluate the microbiological quality of selected street-vended foods in Eruwa, Oyo State. The findings provide baseline data on the bacterial contaminants associated with ready-to-eat foods in the study area and offer evidence to support future surveillance, food safety interventions, and policy development aimed at improving public health.

Declarations

Human ethics and consent declaration

Not applicable.

Consent for publication

Not applicable.

Data availability declaration

The datasets on which the conclusion was made are available from the corresponding author upon reasonable request.

Competing interest

The authors declare that they have no competing interests

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Authors contribution

Atunwa S. O. designed the work, collected and analyzed the data and also prepared the manuscript. Atunwa S. O., Ogunleti O. V. and Ojo A. B. offered profound support during laboratory work. All authors read and approved the final manuscript.

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