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Bacteriological Assessment of Locally Prepared Beverage Drinks Sold in Aliero and Jega, Kebbi State, Nigeria

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Abstract

Beverage drinks produced and sold by street vendors and small-scale producers are an essential source of nutrition and livelihood for millions in developing countries. However, their preparation and sale often occur under unhygienic conditions and without adequate regulatory oversight, increasing the risk of foodborne pathogen transmission. This study aimed to evaluate the bacteriological quality of three commonly consumed, locally prepared beverages—*kunu*, *zobo*, and soymilk, sold in Aliero and Jega towns in Kebbi State, Nigeria. A total of 30 samples (15 from each town; 5 per beverage type) were collected and analyzed for total viable count (TVC), total coliform count (TCC), pH levels, and the presence of bacterial pathogens using standard microbiological methods. All beverage types exhibited high microbial loads, with mean TVC ranging from 2.9×10^5 to 6.5×10^6 CFU/mL and mean TCC ranging from 1.3×10^4 to 2.6×10^5 CFU/mL, both exceeding WHO/FAO permissible limits for ready-to-drink beverages. Among the beverages, soymilk recorded the highest microbial loads, whereas *zobo*, with a more acidic pH (4.1–4.2), showed relatively lower counts. The identified bacterial species included *Escherichia coli* (31.1%), *Staphylococcus aureus* (26.7%), *Salmonella* spp. (17.8%), *Shigella* spp. (13.3%), and *Pseudomonas aeruginosa* (11.1%). These findings indicate

significant microbial contamination, likely stemming from inadequate hygiene during processing, handling, and storage. The study underscores the critical need for enhanced sanitary practices, targeted public health education, regulatory enforcement, and routine microbial monitoring of street-vended beverages. Ensuring the microbiological safety of traditional drinks is imperative for safeguarding public health in low-resource settings.

Keywords: Bacteriological quality; *Kunu*; *Zobo*; Soymilk; Street-vended drinks; Kebbi State; Food safety.

INTRODUCTION

Street foods refer to ready-to-eat meals or drinks, including snacks that are sold for immediate consumption by street vendors or hawkers without the need for additional processing. These foods are widely accepted by consumers, especially in developing nations (Salamandane *et al*., 2023). With the rapid growth of the food industry, a broad range of street-vended food options has emerged, leading to a rising trend among consumers to eat out rather than prepare meals at home (Koumassa *et al*., 2025). Traditional beverages are drinks that originate from a specific region and are typically developed by the local people using age-old methods and ingredients sourced from locally available or home-grown materials. Nearly every country around the world has its unique traditional beverages, and Nigeria is no exception (Nwachukwu *et al*., 2022). Beverage drinks produced and sold by street vendors and small-scale producers serve as a vital source of both nutrition and livelihood for millions in developing nations (Imathiu, 2017). In Nigeria, popular traditional beverages such as kunun, zobo, fura da nono, and tiger nut drinks are commonly consumed because they are affordable, easily accessible, and deeply rooted in cultural traditions (Nwachukwu *et al*., 2022; Nwaiwu *et al*., 2020). Despite their popularity, these beverages are frequently prepared and marketed in unsanitary environments, often lacking proper regulatory supervision, thereby posing a significant risk for the spread of foodborne pathogens (Salamandane *et al*., 2023). These beverages are commonly sold commercially by hawkers and vendors on the streets and in shops located near public areas such as markets. They are also frequently served at special occasions such as weddings, parties, and funerals, largely due to their affordability and widespread appeal (Asante-poku *et al*., 2024). A notable characteristic of these types of products is that they are often produced without government oversight or adherence to established food safety standards. They may include

homemade, surrogate, or counterfeit alcoholic beverages, which can expose consumers to harmful substances and pose serious health risks (Capozzi *et al.*, 2020).

Kunu, also known as kunu-zaki, is an inexpensive traditional non-alcoholic fermented beverage with a characteristic sweet-sour flavor. It originated in Northern Nigeria but is now widely consumed throughout the country by people of all ages. The beverage is typically made from millet (*Pennisetum typhoideum*), although other grains such as sorghum (*Sorghum vulgare*), maize (*Zea mays*), rice (*Oryza sativa*), and ocha acha (*Digitalis exilis*) are also commonly used (Ndukwe *et al.*, 2023). Zobo is a popular locally made beverage in Nigeria, prepared from the dried calyces of the *Hibiscus sabdariffa* plant. It is an aqueous extract known for its vibrant red color and is widely favored for its refreshing taste (Adeniji, 2017). Traditional homemade soymilk is typically produced by soaking soybeans, followed by grinding, heating, and filtering through a mesh screen to obtain the milk. The final product is usually packaged in sachets or plastic bottles for consumption (Nwaiwu *et al.*, 2020).

The bacteriological safety of these beverages is a growing public health concern, especially in regions where food handling practices are poor and water sources used in production are likely to be contaminated(Chaves-López & Cordero-Bueso, 2022). Several studies have reported the presence of pathogenic microorganisms such as *Escherichia coli*, *Salmonella spp.*, *Staphylococcus aureus*, and *Shigella spp.* in similar street-vended drinks, posing a significant risk to consumers (Nwaiwu *et al.*, 2020; Omeremu *et al.*, 2019; Salamandane *et al.*, 2023). Despite this, many local producers remain unaware of the microbiological standards required to ensure the safety of their products. Several studies have evaluated the microbial quality of street-vended beverages in major Nigerian cities such as Kogi (Attah *et al.*, 2025), Maiduguri (Tanko *et al.*, 2024), Makurdi (Mnguchivir & Ogabanya, 2024) and Calabar (Effiong *et al.*, 2023), there is a lack of published data on the bacteriological quality of such drinks in semi-urban or rural settings like Aliero and Jega towns. This study addresses this gap by providing current data on the microbial load and potential pathogens present in locally prepared beverages in these areas. Therefore, this study aimed to assess the bacteriological quality of locally prepared beverage drinks sold in Aliero and Jega towns of Kebbi State, Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted in Aliero and Jega towns, located in Kebbi State, Northwestern Nigeria. Both towns are semi-urban areas where locally prepared beverage drinks are commonly sold by street vendors in markets, along roadsides, and in small shops.

Sample Collection

A total of thirty (30) samples comprising (5 kunu, 5 zobo, and 5 soymilk) from each of the two locations Jega and Aliero of locally prepared beverage drinks were collected in (August- October 2024). The samples were randomly obtained from street vendors and public marketplaces in both Aliero and Jega towns. Samples were collected in sterile, screw-capped containers and transported in an ice-packed cooler to the Biology Laboratory at Kebbi State University of Science and Technology Aliero for immediate analysis within 6 hours of collection. The selection of these local drinks was based on factors such as their popularity, accessibility, and susceptibility to bacteria associations and contamination. This selection represents the different types of local drinks that are commonly found sold in the Aliero and Jega towns.

Sample Preparation

Each beverage sample was thoroughly mixed, and 1 mL was aseptically transferred into 9 mL of sterile distilled water to prepare a 10^{-1} dilution. Further serial dilutions were made up to 10^{-5}, depending on the expected bacterial load (Cheesbrough, 2006).

P^H determination

The pH of each beverage sample was measured using a calibrated digital pH meter. Each sample (approximately 20 mL) was transferred into a clean beaker, and the electrode was rinsed with distilled water and gently blotted dry before immersion. The electrode was then inserted into the sample, and the pH reading was recorded once the value stabilized. All measurements were performed in triplicate, and the mean values were recorded (Muhammad & Farida, 2023).

Bacteriological Analysis

Total Viable Count (TVC)

Aliquots of 0.1 mL from appropriate dilutions were plated in duplicates on Nutrient Agar using the pour plate method. Plates were incubated at 37 °C for 24 hours. Colonies were counted and expressed as colony-forming units per milliliter (CFU/mL) of the sample (Cappuccino & Sherman, 2014).

Total Coliform Count (TCC)

MacConkey Agar was used for the enumeration of coliforms. Inoculated plates were incubated at 37 °C for 24 hours, and colonies showing typical coliform morphology (pink/red colonies) were counted and recorded as CFU/mL(Cappuccino & Sherman, 2014).

Isolation and Identification of Bacterial Isolates

Distinct colonies from Nutrient and MacConkey agar were sub-cultured onto selective and differential media such as Eosin Methylene Blue (EMB) agar, Mannitol Salt Agar (MSA), and Salmonella-Shigella (SS) agar. After incubation, isolates were identified based on colonial morphology, Gram staining, and a series of biochemical tests including catalase, coagulase, indole, citrate utilization, urease, oxidase, and triple sugar iron (TSI) tests (Cappuccino & Sherman, 2014; Cheesbrough, 2006)

Data Analysis

All experiments were performed in triplicates. Results were expressed as mean ± standard deviation. Data were analyzed using SPSS Version 24 and presented using tables and charts.

RESULTS

Bacteriological Load of Beverage Samples

Table 1 presents the mean pH, total viable count (TVC), and total coliform count (TCC) of locally prepared beverage samples kunu, zobo, and soymilk collected from Jega and Aliero towns in Kebbi State. In both locations, kunu and soymilk exhibited relatively high microbial loads, with TVC values ranging from 5.1×10^6 to 6.5×10^6 CFU/mL and TCC values ranging from 2.2×10^5 to 2.6×10^5 CFU/mL. Zobo had the lowest microbial load across both towns, with a TVC of 2.9×10^5 CFU/mL in Jega and 3.2×10^5 CFU/mL in Aliero, and a corresponding TCC of 1.3×10^4 CFU/mL and 1.5×10^4 CFU/mL,

respectively. The pH values ranged from 4.1 to 6.7, with zobo being the most acidic beverage and soymilk the least.

Table 1: Mean pH, Total Viable Count (TVC), and Total Coliform Count (TCC) of Beverage Samples from Jega and Aliero

Location	Beverage Type	pH (Mean ± SD)	TVC (CFU/mL) (Mean ± SD)	TCC (CFU/mL) (Mean ± SD)
Jega	Kunu	4.8 ± 0.2	$6.2 \times 10^6 \pm 0.3$	$2.4 \times 10^5 \pm 0.2$
	Zobo	4.2 ± 0.1	$2.9 \times 10^5 \pm 0.3$	$1.3 \times 10^4 \pm 0.2$
	Soymilk	6.4 ± 0.3	$5.1 \times 10^6 \pm 0.5$	$2.2 \times 10^5 \pm 0.3$
Aliero	Kunu	4.7 ± 0.2	$6.5 \times 10^6 \pm 0.4$	$2.6 \times 10^5 \pm 0.3$
	Zobo	4.1 ± 0.1	$3.2 \times 10^5 \pm 0.4$	$1.5 \times 10^4 \pm 0.1$
	Soymilk	6.7 ± 0.2	$5.6 \times 10^6 \pm 0.6$	$2.4 \times 10^5 \pm 0.2$

Key: TVC: Total Viable Count, TCC: Total Coliform Count, CFU/mL: Colony Forming Units per milliliter

Occurrence of Bacterial Isolate from beverage samples

Figure 1 presents the frequency and percentage distribution of bacterial isolates recovered from all beverage samples analyzed. *Escherichia coli* was the most prevalent isolate (31.1%), followed by *Staphylococcus aureus* (26.7%) and *Salmonella* spp. (17.8%). The presence of *Shigella* spp. (13.3%) and *Pseudomonas aeruginosa* (11.1%).

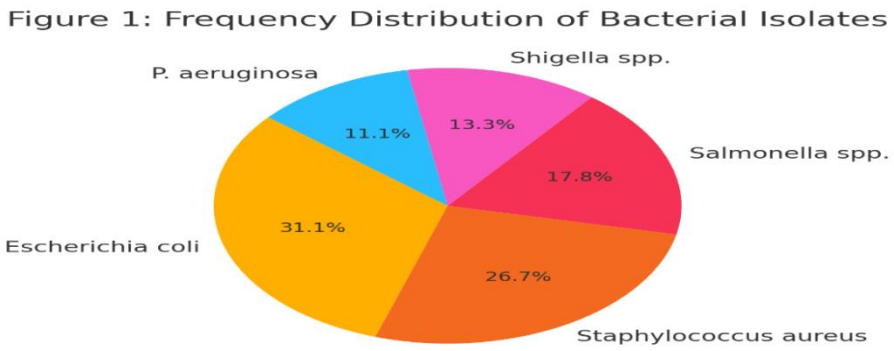

Figure 1: frequency distribution of bacterial isolates

Occurrence of Bacterial Isolate by Beverage Type

Figure 2 displayed the occurrence of each bacterial isolate across the different beverage types analyzed. The distribution of bacterial isolates across beverage types showed that *Escherichia coli* was most frequently isolated from soymilk (n = 7), followed by kunu (n = 5). *Staphylococcus aureus* was uniformly detected across all beverages (n = 4 per type), while *Shigella spp.* and *Pseudomonas aeruginosa* were less common.

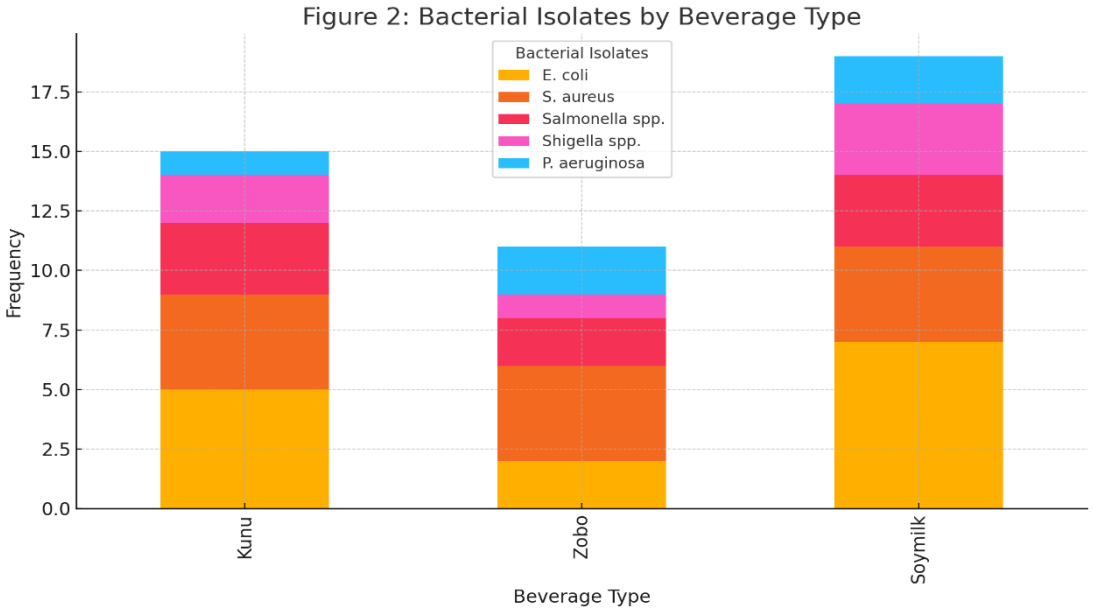

Figure 2: Bacterial Isolates by Beverage Type

Occurrence of Bacterial Isolate by Location

Figure 3 illustrates the distribution of bacterial isolates recovered from beverage samples collected in Jega and Aliero. The isolates were almost evenly distributed between the two locations, with Jega contributing 22 isolates and Aliero 23 isolates.

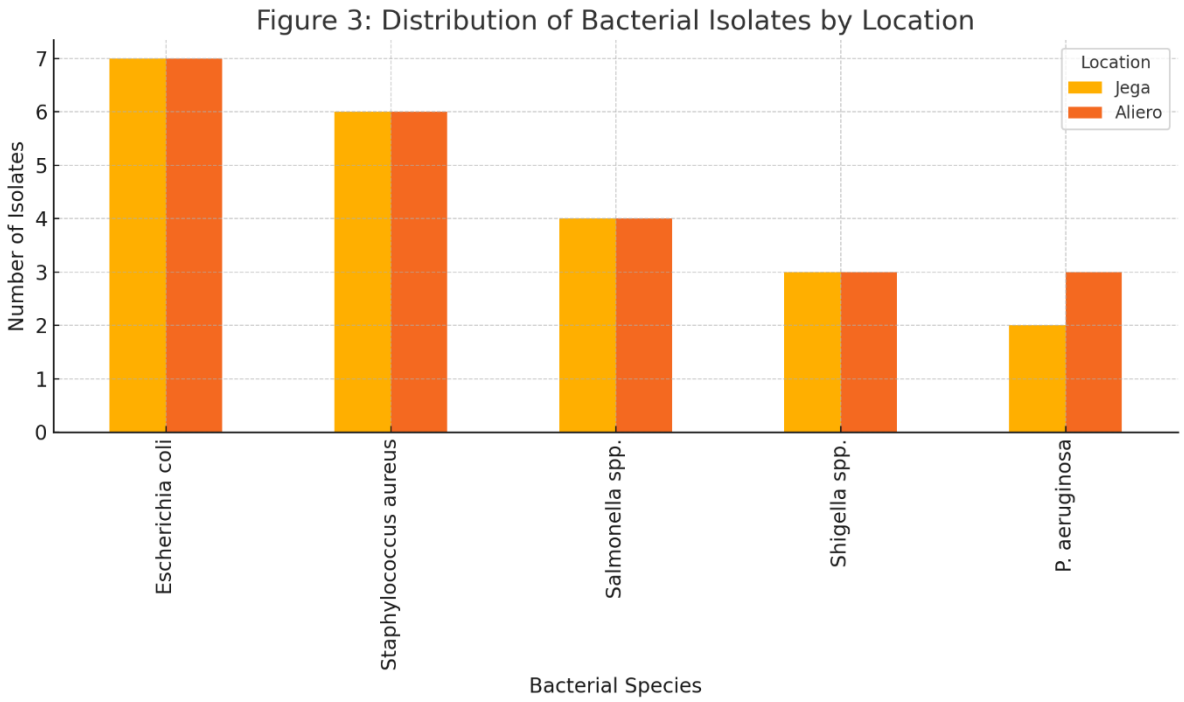

Figure 3: Distribution of Bacterial Isolates by Location

DISCUSSION

The microbiological analysis of kunu, zobo, and soymilk samples collected from Jega and Aliero towns were analysed in the present study. Evaluating the bacteriological quality of locally prepared beverages is essential for protecting consumers' health and detecting possible sources of foodborne infections.

The bacteriological analysis of the beverage samples revealed varying degrees of bacteriological contamination across the three beverage types and two locations. Among the samples analyzed, kunu and soymilk exhibited the highest microbial loads, with total viable counts (TVC) ranging from 5.1×10^6 to 6.5×10^6 CFU/mL and total coliform counts (TCC) from 2.2×10^5 to 2.6×10^5 CFU/mL. In contrast, zobo had significantly lower microbial counts, with TVC values between 2.9×10^5 and 3.2×10^5 CFU/mL, and TCC from 1.3×10^4 to 1.5×10^4 CFU/mL.

These values exceed the acceptable limits set by the WHO/FAO for ready-to-drink beverages, which recommend a maximum TVC of 10^5 CFU/mL (i.e., 1.0×10^5 CFU/mL) and coliform counts below 10^2 CFU/mL (i.e., 1.0×10^2 CFU/mL)(FAO & WHO, 2021).

The elevated microbial levels observed in this study are indicative of poor hygienic practices during the processing, handling, and storage of these beverages, as well as the possible use of contaminated water (Koumassa *et al*., 2025). These findings are consistent with earlier studies such as Ire et al., (2020), Seiyaboh et al., (2020), and Effiong et al., (2023), all of which reported similar bacteriological burdens in locally vended drinks in Nigeria. The pH values of the beverage samples varied with beverage type and correlated with the level of microbial contamination. Zobo exhibited the lowest pH values (4.1–4.2), creating an acidic environment less favorable for the growth of many pathogenic microorganisms. This likely contributed to its comparatively lower microbial counts. In contrast, soymilk had the highest pH values (6.4–6.7), which are close to neutral and thus more supportive of microbial growth. Kunu displayed moderately acidic pH values (4.7–4.8) but still exhibited high microbial loads. This suggests that factors other than pH such as poor hygiene, exposure to environmental contaminants, or cross-contamination during milling and packaging may have contributed to its high microbial content (Negassa *et al*., 2023).

The high prevalence of *E. coli* is a strong indicator of fecal contamination, which may result from unclean water sources, poor personal hygiene, or the use of contaminated utensils during beverage preparation (Bouafou *et al*., 2021). This finding is consistent with those of Effiong et al., (2023) and Seiyaboh et al., (2020), who reported the presence of *E. coli* from kunu and soymilk samples. The detection of *S. aureus* in over a quarter of the samples supports earlier work by Omeremu et al., (2019), who identified the organism in street-vended Zobo Drink Sold in Bayelsa State Nigeria. Since *S. aureus* is commonly transmitted through human contact, its presence likely reflects poor hygiene on the part of vendors or handlers, such as touching the beverages or containers with bare hands or coughing/sneezing near the products during packaging (Jaradat *et al*., 2020). The identification of *Salmonella spp.* and *Shigella spp.* Supports the results of Omeremu et al., (2019), Attah et al., (2025), and Mnguchivir & Ogabanya, (2024), who isolated similar enteric pathogens from traditional non-alcoholic drinks in Bayelsa State and Osara, Kogi State, Nigeria. These organisms are associated with gastroenteritis and dysentery and suggest either contamination of the raw materials or exposure to unsanitary conditions during processing and storage (Desalegn *et al*., 2025). *Pseudomonas aeruginosa*, though the least prevalent (11.1%), is an important opportunistic pathogen with environmental origins.

Its presence is indicative of poor sanitation, possibly during bottling or from contaminated surfaces and storage containers (Qin *et al*., 2022).

The higher prevalence of *E. coli* and *S. aureus* is indicative of fecal and handling-related contamination, likely due to poor hygiene during production and packaging processes. This finding aligns with similar studies by Effiong et al. (2023) and Attah et al. (2025), which reported the frequent occurrence of these bacteria in street-vended beverages. Soymilk consistently harbored the highest number of isolates, indicating that it may be more susceptible to contamination due to its high nutrient content, which supports microbial growth.

When comparing isolates from the two study locations, *E. coli* and *S. aureus* were the most commonly detected bacteria in both Jega and Aliero, with similar proportions (around 30% each). This similarity suggests shared contamination sources or comparable hygienic practices among beverage producers in both towns. These findings are consistent with those of previous studies conducted in northern Nigeria, where the bacterial profiles of traditional beverages reflected poor environmental sanitation and inadequate food safety regulation (Nwaiwu *et al*., 2020; Omeremu *et al*., 2019).

CONCLUSION

The findings of this study reveal that locally prepared beverage drinks sold in the study locations are microbiologically contaminated beyond acceptable limits, posing significant public health risks. The presence of pathogenic bacteria indicates inadequate hygiene practices during the processing, handling, and storage of these beverages. The results from both locations show similar patterns, indicating systemic lapses in food safety practices rather than location-specific issues. To mitigate the health risks, it is essential that Local vendors should be educated on proper hygiene and food safety practices through community-based awareness and training programs. Additionally, Support in the form of training, micro-credit, and access to clean production environments should also be provided to help vendors improve product safety and quality. Implementing these measures can significantly enhance the microbiological safety of traditional beverages in Kebbi State and beyond.

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