



Comparing bacterial load and type present in Chapatti sold by different vendors at Shilabela Market, Geita District, Tanzania. A cross-sectional study.

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Page **ABSTRACT**

| 1 **Background:**

The study aims to compare bacterial load and type present in Chapatti sold by different vendors at Shilabela Market, Geita District, Tanzania.

Methodology:

A laboratory-based cross-sectional study was carried out in Chapatti market stalls of Shilabela Market from May to June 2025. The primary study population included chapati samples sold by vendors at Shilabela market, and the secondary study population included the chapati vendors operating in Shilabela market. Data were summarised into tables, bar graphs, and pie charts using Excel.

Results:

112 chapatti samples were collected from four separate vendors at Shilabela Market. Sample production was similar across vendors, with Vendor A and Vendor D having 28 samples (25.0% each), Vendor B having 29 (25.9%), and Vendor C contributing 27 samples (24.1%). The chapatti from Vendor D had the highest mean bacterial load at 5.7×10^5 CFU/g, with 46.4% of samples higher than the limit. Vendor C had the lowest mean bacterial load at 3.9×10^5 CFU/g and presumably the lowest proportion of samples above the limit. The microorganisms' species distribution differed among the four vendors at Shilabela Market. *Staphylococcus aureus* was the predominant isolate for Vendors A and D, who both had 50% of their samples contaminated. Vendor B had the highest prevalence of *Escherichia coli* (48.3%). Vendor C represented a mix and was present in a more balanced presence of *E. coli* with *S. aureus*.

Conclusion:

There was substantial historical variability in contamination, with some vendors having a greater presence of certain types of pathogens. Differences in levels of bacterial contamination may be largely attributed to vendor behaviour and hygiene practices.

Recommendations:

Consumers should be made aware of the potential health issues associated with consuming contaminated chapatti products through community sensitisation campaigns.

Keywords: Vendors at Shilabela Market, Variability in contamination, Bacterial load and type.

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Background

Food safety and nutrition, as well as food security, are inextricably linked, and an estimated 600 million people, which is almost 1 in 10 people in the whole world, fall ill after eating contaminated food, and 420,000 die every year. The US\$ 110 billion each year is lost in productivity as well

as medical expenses resulting from the unsafe food in the low and middle-income countries. Additionally, children under the age of 5 years carry 40% of foodborne disease burdens, with 125,000 deaths every year. (WHO *Food Safety*, 2025).

Quantifying and profiling bacterial loads and compositions in chapati is important for providing an understanding of food safety standards and health risk assessments regarding the microbiological safety of food. (Nnenna J. P. & Ogunekum, 2022). The enumeration of total viable counts (TVC) and the identification of specific organisms tell us something about what, how, and where the chapati has been prepared and the hygiene aspects involved, as well as possible environmental factors influencing hygiene. (Tamiru et al., 2024).

A scoping review for RTE foods in Africa found that 45.8% of the RTE foods were not microbiologically safe because they had TVCs and coliforms that were above safety limits. (Onohuean et al., 2025). This meta-analysis clearly points towards pan-continental contamination risks associated with inadequate training of vendors on hygiene practices and poor infrastructure in food supply. These hazards place chapati into a similar jurisdiction and allow a better understanding of the potential contamination risks. (Onohuean et al., 2025).

Studies of urban settings in Ethiopia indicated average total viable counts (TVC) of $\sim 5.4 \times 10^5$ CFU/g, with 34% of the samples being unacceptable ($>10^5$ CFU/g); both coliforms and staphylococcus species were detected. (Moges et al., 2025). This information demonstrates the potential susceptibility of chapati in the same environment. Additional East African studies of street vending found that total viable counts for street foods were between $1.7 \times 10^5 - 6.7 \times 10^6$ CFU/g and often contained *E. coli* and *Bacillus cereus*. The Tanzania study of Morogoro indicated that 67% of street foods in Morogoro exceeded acceptability limits, primarily due to *E. coli* (49%) and *B. cereus* (20%), which likely indicates trends for chapati as well as standards. ('Microbial Analysis of Street Food in Demerara-Mahaica, Guyana', 2025).

The high total viable count from the Morogoro street food indicates similar expectations would hold for chapati sold at Shilabela Market. Given the excessive coliform levels in street food, where similar products exceeded microbial standards ('Microbial Analysis of Street Food in Demerara-Mahaica, Guyana', 2025). By assessing CFU in chapati, local determination and assessment of food safety, and a pathway for policy and procedures can be developed. The aim of the study is to compare bacterial load and type present in Chapatti sold by different vendors at Shilabela Market, Geita District, Tanzania.

MATERIALS AND METHODS

Study design

This is a laboratory-based cross-sectional study that was carried out in Chapatti market stalls of Shilabela Market from May to June 2025. Chapatti slices were collected aseptically and conveyed to Sakamu Hospital Microbiology laboratory for microbiological analysis using standard analytical methods. This study design is cheap and easy, and enables faster data collection.

Study population

The primary study population included chapati samples sold by vendors at Shilabela market, and the secondary study population included the chapati vendors operating in Shilabela market

Study area

The study was conducted in a few selected Chapatti stalls located within Shilabela Market, Geita District, Tanzania. It ran in 30 days of June 2025.

Sample size determination

To calculate the minimum sample size, the formula below was used by Kish and Leslie (2000) (Althubaiti, 2022).

Using the formula;

$$N = \frac{z^2 pq}{d^2} \text{ (Kish, Leslie. 1965)}$$

Where:

N = required sample size

Z = standard normal value at 95% confidence level = **1.96**

P = estimated prevalence of bacterial contamination in street-vended foods, assumed at **75% (0.75)** based on previous similar studies and expert assumption

q = $1 - p = 0.25$

d = margin of error (precision) = **0.08** (8%)

Substituting the values

Hence $N = (1.96^2 \times 0.75 \times 0.25) / 0.08^2$

= 112 respondents

Thus, the sample size was determined to be 112 chapatti samples.

Sampling technique

Convenient sampling was done during the selection of Chapatti from vendors. This sampling technique was chosen because of the limitations due to the number of available stalls at the study site.

Study selection criteria

Inclusion criteria

Already made chapatti.

Stalls for which their owners verbally consented to participate in the study

Exclusion criteria

Raw materials (raw chapatti).

Quality assurance and quality control

Data quality was ensured through carrying out analysis following a standardised analytical technique. The data collected was thoroughly checked for completeness. All the steps were guided by a qualified laboratory technician and an institution supervisor. Other quality controls observed were:

Pre-Examination

Proper sample collection with minimised contamination was observed, i.e., sterilisation of sample bags, double packaging, and disinfection of hands before sample



handling.

A cool box was used in sample transportation to the laboratory.

Proper sample labelling for easy identification.

Proper storage of samples in the refrigerator at 4 to 8°C.

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Examination

Sample preparation was done on arrival at the laboratory or within a time span of 24 hours.

Sample verification before examination.

Aseptic microbiological techniques were observed during analysis.

Proper care and maintenance of equipment, e.g., incubator temperature maintenance log charts, were carefully observed.

Followed and adhered to protocol SOPs.

Post Examination

Verification of microbiological test results.

Recording of results.

Analysis, interpretation, and inference of results.

Writing of reports and documentation

Materials

A sterile normal saline solution to immerse the samples was prepared. Primary media, i.e., MAC, MSA, and BEA, onto which the samples will be cultured, peptone water, and NA for sub-culturing. Coagulase, Catalase, citrate, TSI, SIM, and Kovac's reagent for biochemicals, followed by NA and antibiotic discs for AST (Antimicrobial Susceptibility Testing), were also used.

Sample collection

Samples of 14 bags of different chapatti ingredients (approximately 1g of each) were collected from a randomly selected from different vendors. Generally, sample collection involved the following steps:

Sterile polythene bags were bought from shops, and surface sterilisation using 70% ethanol will always be done to prevent possible external contaminants.

The bags were double-packaged and transported to the sample collection site.

Disinfection of the hands using 70% ethanol was constantly done before handling the specimens, which were aseptically double packaged in sterile polythene bags.

The samples were then transported back to the laboratory in a cool box at 4°C to 8°C.

Laboratory analysis

Sample preparation

During sample preparation for analysis:

Using a sterile spatula, a spoonful of each sample was transferred to 10 mL of sterile normal saline in sterile tubes.

The tubes were covered with sterile aluminium foil and incubated at 37°C for 24 hours.

After inoculation on primary cultures, subculturing on NA was done.

Actual bacteria isolation

This followed the following steps: Different Gram staining forms from NA sub-cultures and different biochemical tests were carried out to identify the bacterium isolate to the species hierarchy. District Laboratory Practices 2 was used to identify the different bacteria isolated according to their biochemical tests.

Antimicrobial Susceptibility Patterns of the isolates

During this process, NA plates were prepared, and the Kirby-Bauer disc diffusion method of AST shall be used to determine the antimicrobial susceptibility patterns of the different isolates. The AST chart was used to interpret the zones of clearance. The different antibiotics included: tetracycline, Cefoxitin, Levofloxacin, Gentamycin, erythromycin, and linezolid.

Data management and analysis

Data management

All data that was collected in the study was handled in ways that allowed for data accuracy, integrity, and confidentiality. Specifically, the following steps were taken:

Sample identification where each chapatti sample was assigned a unique identification code in order to trace each sample and avoid errors in identification during analysis in the laboratory.

Lab records where microbiological data, including type of bacterial isolates and antibiotic susceptibility test results, were recorded in an organised and systematic way in laboratory logbooks, where it was then transferred into a Microsoft Excel spreadsheet for organisation and storage.

Questionnaires where data from chapatti vendors collected on hygiene and food handling were coded and entered into Excel for analysis.

Data backup where all electronic data was backed-up to a not accessible to the public password protected external

storage device and cloud storage to prevent loss of data.

Data analysis

Descriptive Statistics

Frequencies and percentages were calculated to show the prevalence of the different bacterial species isolated from the chapatti samples.

Summary tables were created to show the number and percentage of samples that were contaminated with each bacterial species.

Antibiotic Susceptibility Patterns

Results from the Kirby-Bauer disk diffusion method were interpreted according to CLSI standards.

Each bacterial isolate was classified either as sensitive (S), intermediate (I), or resistant (R) to each of the antibiotics used.

Excel was used to calculate the percentage of resistance for each antibiotic across all isolates, and the rate of multi-drug resistance (MDR) was determined by counting the number of isolates that are resistant to three or more classes of antibiotics.

Data Presentation

Data were summarised into tables, bar graphs, and pie charts using Excel to help visualise and interpret the findings.

Narratives accompanied the visuals to more clearly describe the trends/patterns and relationships seen in the data.

All analyses were summarised to address the study objectives and to discuss any public health relevance of the findings.

Ethical considerations

Ethical approval for the study was obtained from the Faculty of Health Sciences, University of Kisubi. An introductory letter was provided to the management of Shilabela Market, Geita District, Tanzania, and all study procedures were thoroughly explained to the participants. Informed consent was obtained from every vendor before participation, and all data will be anonymised to ensure confidentiality. Participants were informed of their right to withdraw from the study at any time without any penalty.

RESULTS

The comparison of bacterial load and type present in Chapatti sold by different vendors at Shilabela Market, Geita District, Tanzania.

The bacterial contamination of street foods likely varies to a large degree, depending upon vendor hygiene, handling, and external environmental conditions. In this section, we provide a comparison of the bacterial loads and species isolated from chapatti purchased from different vendors at Shilabela Market. Exploring these differences provides insight into vendor-specific risks and the factors contributing to their microbial contamination, which are critical for designing vendor-specific food safety interventions.

Sample Grouping by Vendor

The 112 chapatti samples were collected from four different vendors at Shilabela Market as follows:

Figure 1: Sample grouping by vendor

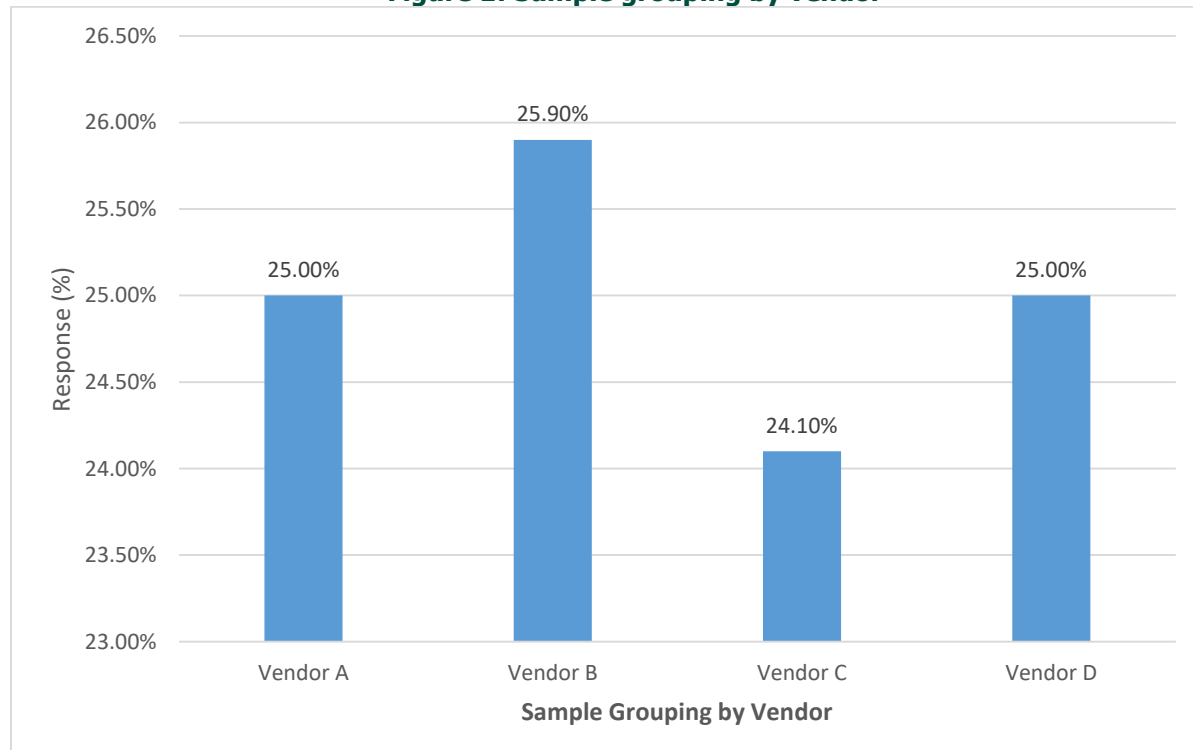




Figure 1: 112 chapatti samples were collected from four separate vendors at Shilabela Market. Sample production was similar across vendors, with Vendor A and Vendor D having 28 samples (25.0% each), Vendor B having 29 (25.9%), and Vendor C contributing 27 samples (24.1%). This equitable sampling created a representative selection of vendors operating in the market.

Total Viable Count (TVC) Results by Vendor

TVC was determined for each sample and expressed as Colony Forming Units per gram (CFU/g). The mean bacterial load and range for each vendor's chapatti samples were calculated.

Table 1: Total Viable Count (TVC) of bacteria in chapatti samples by vendor (N=112)

Vendor	Mean TVC (CFU/g)	Range (CFU/g)	% Samples Exceeding Acceptable Limit*
Vendor A	4.3×10^5	$1.1 \times 10^5 - 9.5 \times 10^5$	32.1%
Vendor B	5.2×10^5	$1.8 \times 10^5 - 1.2 \times 10^6$	41.4%
Vendor C	3.9×10^5	$8.0 \times 10^4 - 8.8 \times 10^5$	25.9%
Vendor D	5.7×10^5	$2.3 \times 10^5 - 1.4 \times 10^6$	46.4%

*Acceptable limit per ICMSF standards: $\leq 1 \times 10^5$ CFU/g

Table 1, the chapatti from Vendor D had the highest mean bacterial load at 5.7×10^5 CFU/g, with 46.4% of samples higher than the limit. Vendor C had the lowest mean bacterial load at 3.9×10^5 CFU/g and presumably the lowest proportion of samples above the limit. This supports the conclusion that some vendors exhibited variation in either

hygiene practices or possibly environmental conditions to limit bacterial contamination from environmental sources.

Bacterial Species Distribution by Vendor

The prevalence of the four main bacterial species isolated was compared across vendors.

Table 2: Bacterial Species Distribution by Vendor

Bacterial Species	Vendor A (n=28)	Vendor B (n=29)	Vendor C (n=27)	Vendor D (n=28)
<i>Staphylococcus aureus</i>	14 (50.0%)	12 (41.4%)	10 (37.0%)	14 (50.0%)
<i>Escherichia coli</i>	10 (35.7%)	14 (48.3%)	12 (44.4%)	9 (32.1%)
<i>Enterococcus</i> spp.	8 (28.6%)	6 (20.7%)	8 (29.6%)	8 (28.6%)
<i>Klebsiella</i> spp.	4 (14.3%)	4 (13.8%)	3 (11.1%)	4 (14.3%)

Table 2: The microorganisms' species distribution differed among the four vendors at Shilabela Market. *Staphylococcus aureus* was the predominant isolate for Vendors A and D, who both had 50% of their samples contaminated. Vendor B had the highest prevalence of *Escherichia coli* (48.3%). Vendor C represented a mix and was present in a more balanced presence of *E. coli* with *S. aureus*. *Enterococcus* and *Klebsiella* species were detected with lower frequency, but were still present at all vendors. While these differences in frequency patterns could indicate differences in handling and hygiene practices among

vendors, this highlights the necessary improvements for food safety practices.

Discussion

The study showed significant differences in the distribution of bacterial species between chapatti samples from the four vendors at Shilabela Market. *Staphylococcus aureus* was the most frequently seen contaminant in samples from Vendor A and D, and each reported contamination in 50% of the samples taken from A and D. This demonstrates a lack of

personal hygiene, which may include poor handwashing or direct (without barriers) hand contact with the food. *S. aureus* is often seen as part of the normal flora of the skin and nasal passages of humans, which could therefore easily contaminate food products during handling (Iao et al., 2023).

In the case of vendor B, there was the highest amount of contamination with *Escherichia coli* (n= 48.3%), which is known widely as a fecal contamination (showing evidence of food preparation or serving under poor conditions and sanitation) (Lv et al., 2025). This type of contamination suggests that it could be an environmental and or waterborne contaminant (for example, using contaminated water to wash utensils or work surfaces used to prepare food).

Vendor C had considerable coverage of contamination between *E. coli* and *S. aureus*; this may imply that mixed contamination may arise from differences in hygiene practices or cross-contamination during preparation or serving of the chapatti. There was also consistent contamination across vendors with *Enterococcus* and *Klebsiella* species; while lower in the distribution frequency, the concepts of consistent fecal contamination or environmental contamination could be validated. (Garcia-Llorens et al., 2024).

The differences are indicative of variances in food safety practice, such as personal hygiene, food handling, utensil sanitation, and possibly storage conditions as well. There have also been documented findings in other studies on street food that particular vendor hygiene behavior was the biggest factor in the extent of microbial contamination. (Chen et al., 2023).

These differences highlight the importance of personal hygiene education and food safety interventions specific to each vendor's practices. A consistent training session that focuses on hand hygiene, keeping food stored properly, using potable water, and sterilizing utensils from any contamination is essential to minimizing food contamination levels. Other options to reduce the risks of Street foods that are microbiologically contaminated include regular inspection and enforcement of local food safety laws. (Ogotu et al., 2022).

Conclusion

The comparison of bacterial loads and species distribution among the vendors revealed substantial historical variability in contamination, with some vendors having a greater presence of certain types of pathogens. Differences in levels of bacterial contamination may be largely attributed to vendor behaviour and hygiene practices; therefore, it is critical to develop vendor-specific interventions to address food safety issues.

Recommendations

Consumers should be made aware of the potential health issues associated with consuming contaminated chapatti products through community sensitization campaigns and encouraged to purchase only from vendors that actively demonstrate good hygiene practices.

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List of abbreviations and acronyms

CFU:	Colony Forming Units
AST:	Antimicrobial Susceptibility Testing
MDR:	Multi-Drug Resistant
WHO:	World Health Organization
CLSI:	Clinical and Laboratory Standards Institute
NA:	Nutrient Agar
MSA:	Mannitol Salt Agar
MAC:	MacConkey Agar
TSI:	Triple Sugar Iron

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The study was not funded.

Conflict of interest

The author did not declare any conflict of interest.

Data availability

Data is available upon request.

Author contribution

John Kakubi collected data and drafted the manuscript of the study

James Kasozi supervised the study

Habert Mabonga supervised the study

Author biography

John Kakubi is a bachelor's degree student of biomedical laboratory technology at the University of Kisubi.

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