



Bacteriological Isolates of Ready-To-Eat Chapati of Vendors in Selected Towns of Bushenyi District, Uganda

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ABSTRACT

Background: It is estimated that more than 90% of illnesses related to consumed foods in Uganda are due to bacteria such as *Escherichia coli*, *Salmonella* and *Staphylococcus aureus* that grow where food is handled unsafely. Ready-to-eat (RTE) chapati which is served as street food, is easily at risk for contamination. The main purpose of the study was to review the bacterial content in ready-to-eat chapati and to evaluate hygiene practices among vendors in selected towns of Bushenyi District in Uganda. **Methods:** A cross-sectional study was conducted on 86 vendors in three towns: Ishaka, Kizinda and Basajjabalaba. The samples of ready-to-eat chapati were gathered and evaluated using microbiological analysis. The total mesophilic bacteria, *Staphylococcus* spp., *Enterobacteriaceae* and *Salmonella* spp. were isolated using Standard Plate Count Agar, Mannitol Salt Agar, Violet Red Bile Glucose Agar and Xylose Lysine Deoxycholate Agar. I used gram staining, IMViC tests, catalase and oxidase reactions and also ran coagulase testing. Hygiene practices of vendors were reviewed with the aid of structured questionnaires. All statistical tests were carried out in SPSS v25 and findings were taken as significant when $P < 0.05$. **Results:** In 86 chapati analyzed samples, 46.5% were found contaminated. The average bacterial count was $8.22 \times 10^4 \pm 165,883.78$ CFU/g. The most prevalent isolates were *Bacillus* spp. (22.1%), *Rhodococcus* spp. (19.8%), and *Micrococcus* spp. (16.3%). Samples from Kizinda (62.5%) and Ishaka (61.5%) showed the highest contamination, compared to Basajjabalaba (19.4%) ($P = 0.001$). Higher contamination was significantly associated with inadequate hygiene practices. The hygiene practices were commonly poor, including inadequate handwashing (68.6%), lack of apron use (81.4%) and mostly cold water was used for cleaning the utensils (73.3%). Use of cold water for cleaning was significantly associated with bacterial contamination ($p = 0.029$). However, there is no independent factor predicted contamination through multivariate analysis. **Conclusion:** The chapati sold in Bushenyi District were highly bacterial contaminated, there is a strong link in substandard hygiene practices among chapati vendors. To reduce public health threats by food borne diseases, there are urgent interventions needed to target vender education, improved access of hygiene facilities, and regulatory enforcement.

Keywords: Bacterial Contamination, Ready-to-eat foods, Chapati vendors, *Bacillus* spp., *Micrococcus* spp., *Staphylococcus* spp., Spread plate technique, Food safety, Uganda

1. Introduction

Ready-to-Eat (RTE) foods are susceptible to microbial contamination when handled and stored improperly and consumed without further cooking. These consist of baked goods like chapati, fruits, meats, and cooked meals (Rane, 2011; Mengistu et al., 2022). Foods sold on the street are readily available and reasonably priced sources of nutrition in Uganda and other low-income nations, but they frequently lack proper safety supervision (Oranusi et al., 2011).



Foodborne infections continue to be a serious public health issue on a global scale. According to the World Health Organization (WHO), eating tainted food can cause more than 200 diseases, with vulnerable populations like children, the elderly, and people with compromised immune systems being disproportionately affected (Sarron et al., 2020). In underdeveloped nations, bacterial agents like *E. coli*, *Salmonella*, and *Staphylococcus aureus* are the leading causes of foodborne infections, often exacerbated by poor sanitation, lack of vendor training, and infrastructural limitations (Newell et al., 2010; Guzylack-Pirou & Ménard, 2021).

This study assesses bacteriological contamination in RTE chapati and hygiene practices of vendors in selected towns of Bushenyi District, Uganda. It aims to generate evidence that can guide public health policy and intervention strategies to reduce foodborne risks in informal food sectors.

2. Materials and Methods

2.1 Study Design and Area

This was a cross-sectional, laboratory-based study conducted in Bushenyi District, Uganda. Three urban centers Basajjabalaba, Ishaka, and Kizinda, were selected due to their dense population and popularity of street food vending.

2.2 Study Population and Sampling

The study included 86 chapati vendors, selected using stratified random sampling to ensure geographic and demographic diversity. Vendors were approached at their stalls and consented before participation.

2.3 Sample Collection

From each vendor, freshly prepared chapati was collected using sterile gloves and sealed in sterile plastic bags. Samples were transported in cool boxes to the Kampala International University microbiology lab within one hour, following WHO food sampling protocols.

2.4 Laboratory Analysis

2.4.1 Preparation and Dilution

Each chapati sample (1g) was homogenized in 9 mL of sterile buffered peptone water using a stomacher. Tenfold serial dilutions were made, and 0.1 mL aliquots were spread on agar plates.

2.4.2 Culture Media and Incubation

Total mesophilic bacteria: Standard Plate Count Agar, 24–48h at 37°C

Staphylococcus, *Bacillus*, *Enterococcus* spp.: Mannitol Salt Agar

Enterobacteriaceae: Violet Red Bile Glucose Agar (VRBG)

Salmonella, *Shigella*, *Proteus* spp.: Double enrichment method using peptone water, Rappaport Vassiliadis broth, and XLD agar

E. coli: Presumptive colonies from VRBG were confirmed on Eosin Methylene Blue (EMB) agar.

2.4.3 Identification of Isolates

Gram staining and biochemical tests (IMViC, catalase, oxidase, and coagulase) were used to identify bacterial species.



2.5 Data Analysis

Descriptive statistics were computed for prevalence and bacterial load. Associations between location, hygiene factors, and contamination were assessed using chi-square and ANOVA ($P < 0.05$). Data were processed using SPSS v25.

2.6 Ethical Considerations

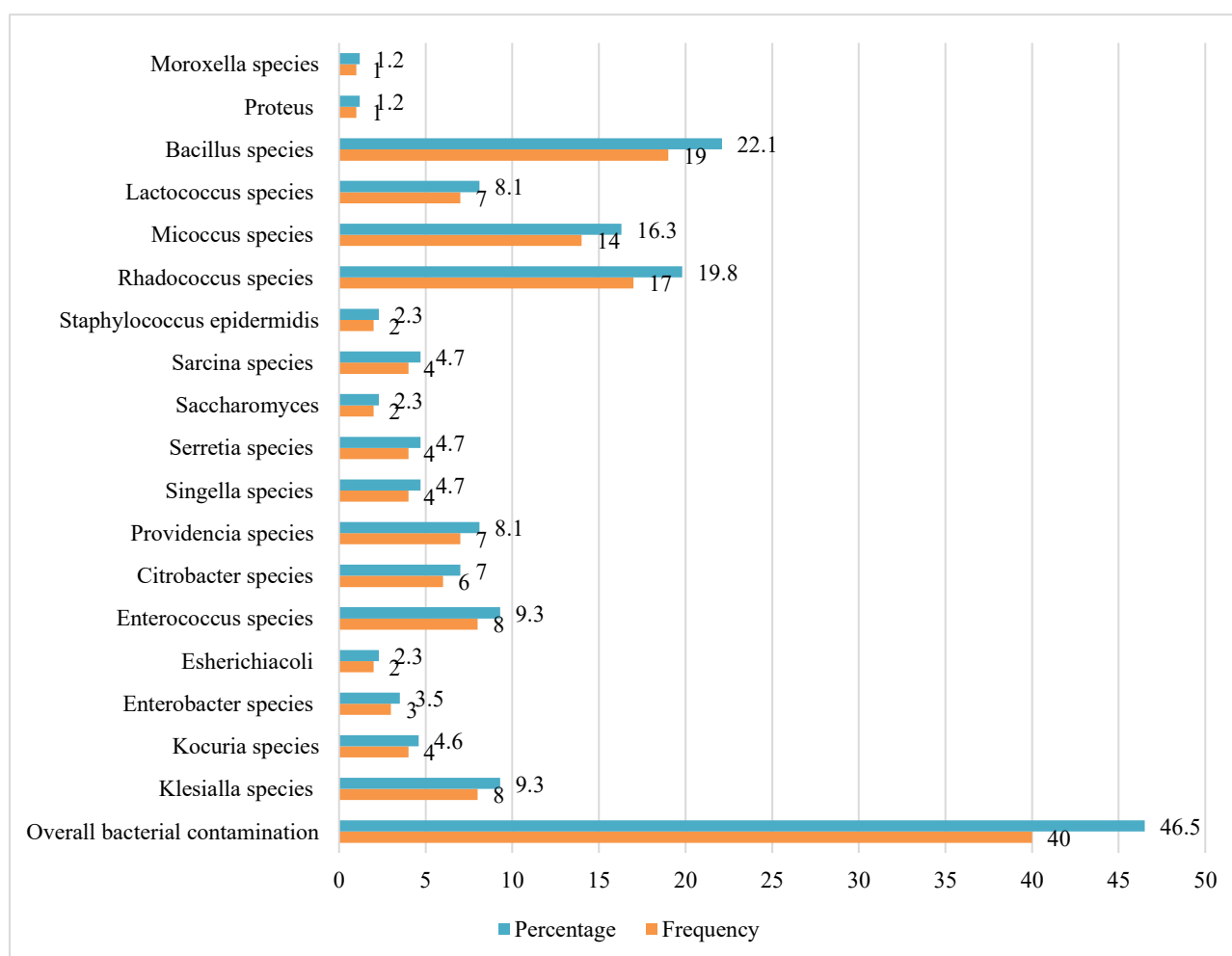
Ethical clearance was obtained from Kampala International University Western Campus Research Ethics Committee (KIU-REC). Written informed consent was acquired from participants. Confidentiality and anonymity were maintained.

3. Results

3.1 Prevalence of Bacterial Contamination

Out of 86 chapati samples, 40 (46.5%) showed bacterial contamination. The most frequently isolated organisms were *Bacillus* spp. (22.1%), *Rhodococcus* spp. (19.8%), and *Micrococcus* spp. (16.3%).

Figure 1. Percentage of Bacterial Isolates in Contaminated Chapati Samples



3.2 Contamination by Location

Chapati bacterial contaminations was high and recorded as follows 61.3% in Ishaka, 62.5% was in Kizinda and 19.4% was in Basajjabalaba.



Table 1. Bacterial contamination varied significantly across locations:

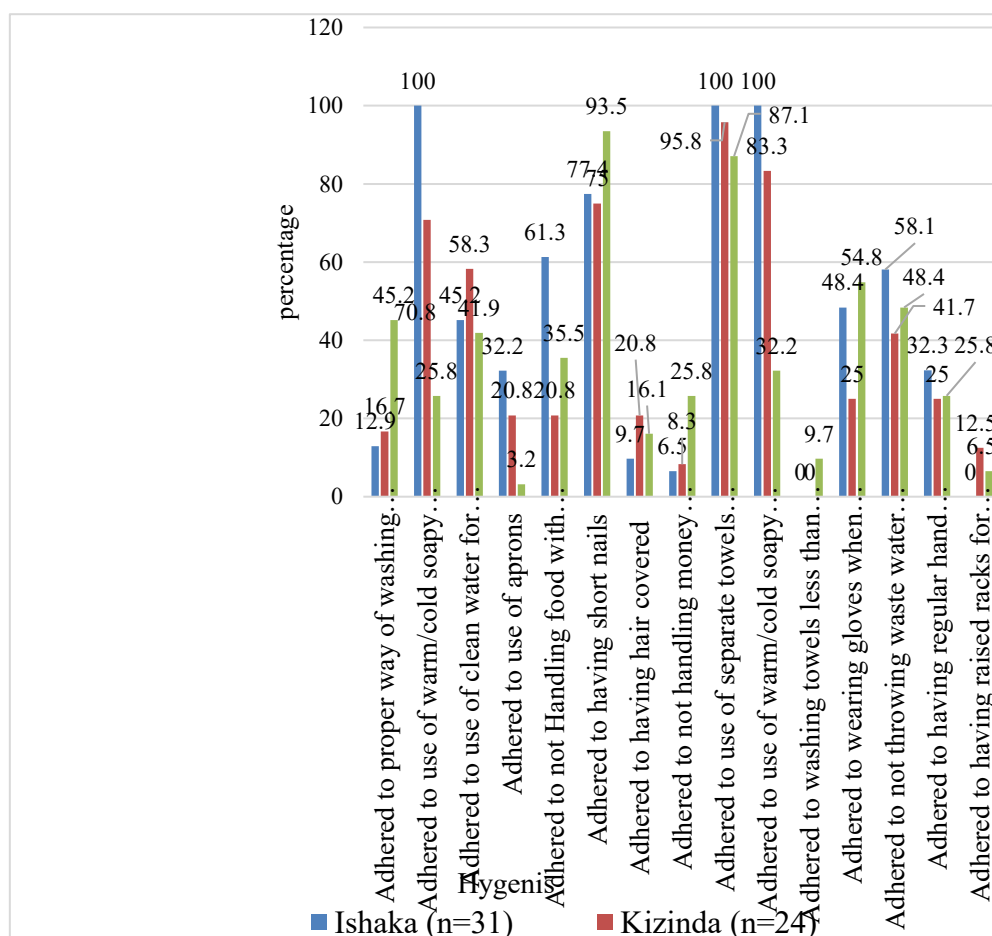
Town	Contaminated n (%)	Mean Bacterial Load (CFU/g \pm SD)	Chi-square	P-value
Ishaka (n=31)	19 (61.3%)	$13.36 \times 10^4 \pm 241,156.16$	14.377	0.001
Kizinda (n=25)	15 (62.5%)	$5.45 \times 10^4 \pm 71,766.46$		
Basajjabalaba (n=30)	6 (19.4%)	$3.37 \times 10^4 \pm 40,866.03$		
Total (n=86)	40 (46.5%)	$8.22 \times 10^4 \pm 165,883.78$		

3.3 Adherence of Chapati Vendors to Hygiene Practices in Basajjabalaba, Ishaka, and Kizinda Towns

The study's findings on vendor compliance with hygiene practices are shown in Figure 2. Overall, hygiene practice adherence was suboptimal across all three towns. The use of raised racks for drying utensils had the lowest compliance with 0% in Ishaka, 6.5% in Basajjabalaba, and 12.5% in Kizinda. Towel washing every two hours or less was also rare, with only 9% in Basajjabalaba and none in Ishaka or Kizinda reporting this practice.

Other poor hygiene indicators included low apron usage (32.2% Ishaka, 20.8% Kizinda, 3.5% Basajjabalaba) and poor handwashing habits after critical tasks (only 12.9% in Ishaka, 16.7% in Kizinda, and 45.2% in Basajjabalaba). Only a minority avoided handling money while serving food (6.5%, 8.3%, and 25.8%, respectively). Availability of regular handwashing facilities was limited (around 25–32% across towns). These findings indicate that basic hygiene practices are insufficiently followed, posing a serious public health concern.

Figure 2. Adherence of Chapati Vendors to Hygiene Practices in Basajjabalaba, Ishaka, and Kizinda Towns.





3.4 Potential Sources of Bacterial Contamination During Chapati Production

Table 2 presents both bivariate and multivariate analyses of potential contamination sources. Variables such as the approximate time gap between chapati preparation and sale and proximity of a toilet facility to the stall had p-values <0.2 in bivariate analysis and were included in the multivariate model.

However, in the multivariate logistic regression, none of the tested environmental or situational factors were independently associated with bacterial contamination. For example, having a toilet near the stall (aOR=6.41; p=0.091) or a longer time gap before selling chapati (aOR=0.66; p=0.382) showed trends but lacked statistical significance. This suggests that while multiple environmental factors exist, no single one was found to significantly predict contamination on its own in this sample.

Table 2. Bivariate and Multivariate Analysis of Potential Sources of Bacterial Contamination.

	Bacterial contamination		cOR(95%CI)	P-value	aOR(95%CI)	P-value
Potential sources of contamination	Not contaminated	Contaminated				
Primary source of water for chapatti preparation						
Well	1	1	0.83(0.05-13.83)	0.896	-	-
Tap water or well	5	4	1.04(0.25-4.22)	0.961	-	-
Tap water and borehole piped water (tap)	5	6	0.69(0.20-2.50)	0.572	-	-
	35	29	Ref.			
Approximate time gap between preparation and sale of chapatti						
Less than 6 hours	33	24	Ref.		Ref.	
More than 6 hours	13	16	0.59(0.24-1.46)	0.153	0.66(0.27-1.67)	0.382
How is the food served						
Using a polythene bag	39	35	Ref.			
Bare hands	3	1	2.69(0.27-27.09)	0.400	-	-
Using a polythene bag or bare hands	4	4	0.90(0.21-3.86)	0.887	-	-
Food storage temperature						
Suitable	6	3	Ref.			
Unsuitable	40	37	0.54(0.13-2.32)	0.408	-	-
Have knowledge of food laws regarding hygienic food vending						
Yes	40	36	Ref.			
No	6	4	1.35(0.35-5.17)	0.661	-	-
Unhygienic conditions (garbage and dirty waste) close to the stall						
Yes	28	23	1.15(0.49-2.72)	0.751	-	-
No	18	17	Ref.			
Toilet facility is close to the stall						
Yes	7	1	7.00(0.82-59.60)	0.075	6.41(0.75-55.14)	0.091
No	39	39	Ref.		Ref.	
The road is close to the stall						
Yes	43	39	0.37(0.04-3.68)	0.395	-	-
No	3	1	Ref.			
Houseflies present in the stalls						
Yes	1	1	0.87(0.05-14.32)	0.920	-	-
No	45	39	Ref.			

**Storage for prepared chapatti before selling**

Open on the stall	18	13	0.84(0.29-2.41)	0.752	-	-
Cupboards	15	10	Ref.			
Polythene bags	6	4	1.00(0.22-4.47)	1.000	-	-
Open on the stall and polythene bags	5	7	0.48(0.12-1.923)	0.299	-	-
Plastic bowls and cupboards	1	1	0.67(0.04-11.94)	0.783	-	-
Cupboards and polythene bags	0	3	N/A			

Open drainage is close to the stalls

Yes	18	13	1.34(0.55-3.25)	0.523	-	-
No	28	27	Ref.			

cOR= crude odds ratio, aOR= adjusted odds ratio, Ref= Reference category, CI= Confidence interval

3.5 Relationship Between Hygiene Practices and Bacterial Contamination

Table 3 details the association between hygiene behaviors and chapati contamination levels. In bivariate analysis, practices such as not wearing aprons, washing food utensils with cold water only, and handling money while serving food were associated with contamination.

After adjusting for confounders in multivariate analysis, only using cold water alone for utensil cleaning remained significantly associated with bacterial contamination (aOR=3.21; 95% CI: 1.06–9.71; p=0.039). This suggests a threefold increased risk of contamination among vendors using only water (without soap or heat) to clean utensils. Other factors, like apron use (aOR=3.22, p=0.085), showed elevated risk but were not statistically significant.

Table 3. Bivariate and Multivariate Analysis of Hygiene Practices and Bacterial Contamination.

Hygiene practices	Bacterial contamination					
	Not contaminated	contaminated	cOR (95%CI)	P-value	aOR (95%CI)	P-value
When do you wash your hands						
After using toilet, blowing my nose and handling food waste	20	25	0.30(0.10-0.91)	0.033	0.70(0.19-2.65)	0.600
After cleaning duties, changing soiled clothes, touching money and war food	1	1	0.38(0.02-6.99)	0.511	1.85(0.07-46.01)	0.709
After using toilet, blowing my nose, handling food waste, cleaning duties, changing soiled clothes, touching money and war food	16	6	Ref.		Ref.	
After touching and using charcoal	9	8	0.42(0.11-1.61)	0.206	0.92(0.19-4.38)	0.914
Types of water do you use to wash food service utensils						
Warm soapy water	4	0	N/A		N/A	
Cold soapy water	20	32	Ref.		Ref.	
Cold water alone	22	8	4.40(1.65-11.76)	0.003	3.21(1.06-9.71)	0.039
Observed dirty water for washing and rinsing the utensils						
Yes	23	22	0.82(0.35-1.91)	0.643	-	-
No	23	18	Ref.			
The vendor did not use aprons						
Yes	42	28	4.50(1.32-15.37)	0.016	3.22(0.85-12.15)	0.085



No	4	12	Ref.		Ref.		
Handled food with their bare hands							
Yes	29	22	1.40(0.59-3.31)	0.449	-		-
No	17	18	Ref.				
Had short nails							
Yes	40	31	1.94(0.62-6.02)	0.254	-		-
No	6	9	Ref.				
Hair was not covered							
Yes	38	35	0.68(0.20-2.27)	0.529	-		-
No	8	5	Ref.				
Handled money while serving food							
Yes	37	37	0.33(0.08-1.33)	0.120	0.53(0.11-2.65)	0.437	
No	9	3	Ref.		Ref.		
Use separate towels for different cleaning tasks							
Yes	43	38	Ref.				
No	3	2	1.33(0.21-8.36)	0.764	-		-
Method of washing the towels for cleaning							
Warm soapy water	5	1	Ref.				
Cold soapy water	21	32	0.31(0.01-1.20)	0.373	-		-
cold water alone	20	5	0.80(0.08-8.47)	0.853	-		-
1&2	0	2	N/A				
How often do you wash the towels							
Less than 2 hours	3	0	N/A		-		-
More than 2 hours	43	40	Ref.				
No	21	18					
Do you wear gloves when you have a wound							
Yes	21	17	1.18(0.50-2.79)	0.700	-		-
No	24	23	Ref.				
Throw waste water beside the stalls							
Yes	21	22	0.69(0.29-1.61)	0.388	-		-
No	25	18	Ref.				
Regular hand washing facilities are available							
Yes	13	11	Ref.				
No	33	29	0.96(0.31-2.48)	0.937	-		-
Are there raised racks for drying utensils							
Yes	3	2	Ref.				
No	43	38	0.75(0.12-4.76)	0.764	-		-

cOR= crude odds ratio, aOR= adjusted odds ratio, Ref= Reference category, CI= Confidence interval

4. Discussion

The present study identified notable levels of bacterial contamination in ready-to-eat chapati and a generally poor adherence to hygiene practices among vendors in Bushenyi District's urban centers. The high contamination rates align with findings from studies in Nigeria, Ethiopia, and Bangladesh, where street-vended foods often harbor *E. coli*, *Staphylococcus aureus*, and other coliform bacteria due to improper food handling, limited water sanitation, and lack of protective equipment like gloves and aprons (Mensah et al., 2002; Muinde & Kuria, 2005; WHO, 2015).



The very low rates of handwashing after critical tasks (e.g., after using the toilet or handling money) highlight a key behavioral gap. This correlates with increased bacterial presence in the food and has serious public health implications, especially in low-resource settings where diarrheal disease is prevalent and often foodborne (WHO, 2022).

The study also underscores that while multiple potential contamination sources exist (e.g., poor utensil storage, proximity to waste, and food handling methods), no single factor was independently significant after adjustment. This likely reflects the multifactorial nature of contamination, where compounding risky practices amplify the hazard.

Critically, washing utensils with cold water only was the strongest predictor of contamination, suggesting a simple yet powerful intervention point. Public health programs should emphasize using soap and/or hot water for cleaning utensils, as this significantly reduces microbial load.

Although not statistically significant, trends such as wearing aprons and avoiding money handling during food service were associated with reduced contamination. These may achieve significance in larger studies and should still be promoted as best practices under food safety guidelines.

The overall poor adherence to key hygiene practices like hair covering, towel hygiene, and the use of raised drying racks reflects systemic gaps in training and regulatory enforcement. These findings call for targeted vendor education, municipal policy reinforcement, and infrastructural support—including public handwashing stations and standardized food stalls.

Compared to international food safety benchmarks, the findings reveal an urgent need for capacity building in the informal food sector to prevent foodborne illness outbreaks, particularly in urbanizing areas of sub-Saharan Africa.

5. Conclusion

This study revealed that ready-to-eat chapati sold in Bushenyi District is commonly contaminated with potentially pathogenic bacteria, notably *E. coli* and *Staphylococcus aureus*. The contamination is significantly associated with poor hygiene practices, especially the use of cold water alone for utensil cleaning. Vendors across Basajjabalaba, Ishaka, and Kizinda towns displayed limited adherence to key food safety practices such as handwashing, utensil sanitation, wearing protective clothing, and using raised drying racks.

Although several potential environmental sources of contamination were observed—such as the presence of toilets near stalls and time gaps between preparation and sale—no individual factor emerged as an independent predictor in multivariate analysis. These findings suggest that comprehensive, complex interventions are needed to address food hygiene risks among informal food vendors.

6. Recommendations

Based on the study findings, the following recommendations are proposed:

- Targeted Health Education and Training:

Conduct community-based food hygiene and safety training for chapati vendors.

Integrate training into vendor licensing and renewal processes.

- Provision of Hygiene Facilities:

Local councils should establish public handwashing stations and access to hot water.

Encourage vendors to use raised racks, clean aprons, and hair coverings.

- Policy Enforcement:



Enforce existing food safety regulations through regular inspections.

Require mandatory hygiene certifications for food vendors.

- Behavior Change Campaigns:

Promote behavior change communication through posters, radio, and community outreach focusing on: Hand hygiene after toilet use and money handling, and importance of soap/hot water in utensil cleaning.

- Further Research:

Expand studies to include virological and parasitological analysis of RTE foods.

Investigate seasonal and regional variations in food contamination and hygiene behavior.

7. Declarations

Ethics approval and consent to participate in the study were approved by Kampala International University - Research Ethics Committee.

Data availability: Data can be obtained by contacting (corresponding author).

Competing interests: The authors declare that they have no conflicts of interest.

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Authors' contributions: Namutebi Jackline, conceptualization, methodology, original draft preparation, writing, Mathew Igwe, analyzed data reviewing, editing and supervision, Tamale Andrew conceptualization, supervision, reviewing and editing methodology and supervision, Nabona Jackim data handling, reviewing and editing methodology. All authors took part in the drafting of the final manuscript.

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