DOI: https://doi.org/10.20372/afnr.v4i2.2154
ISSN: 2520-7687 (Print) and 3005-7515 (Online)
Journal of Agriculture, Food and Natural Resources
J. Agric. Food Nat. Resour. May-Aug 2026, 4(2):01-09
Journal Home page: https://journals.wgu.edu.et

Original Research

Bacteriological Quality and Safety of Ready-to-Eat Street Vended Foods in Shambu Town, Horro Guduru Wollega Zone, Ethiopia

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Abstract

Street-vended foods provide affordable nutrition and economic opportunities but may pose significant public health risks when contaminated. This study assessed the food handling procedures, safety, and bacteriological quality of ready-to-eat street foods in Shambu Town, Ethiopia. A cross-sectional investigation was carried out involving N = 91 vendors and 45 food samples that are ready-to-eat (five food types gathered from three vending sites). Aerobic mesophilic bacteria (AMB), aerobic spore-forming bacteria (ASFB), Enterobacteriaceae, coliforms, and *Staphylococcus* spp. were enumerated using standard microbiological procedures. Bacterial isolates were identified biochemically, and the disk diffusion method was used to assess antimicrobial susceptibility. Most vendors were young (70.33% aged 21–30 years), female (63.73%), and had only primary education (50.55%). Critical food safety violations included food preparation at home without hygiene training (100%), handling food with bare hands (68.13%), failure to wear aprons (95.6%), and vending in dusty environments (65.93%). Mean AMB counts were highest in bread (5.45–5.46 log $CFUg^{-1}$), while *Staphylococcus* spp. counts peaked in potato samples (6.40 log $CFUg^{-1}$). Of the 45 bacterial isolates, *Staphylococcus* spp. (46.67%) predominated, followed by *E. coli* (24.44%), *Bacillus* spp. (15.56%), and *Salmonella* spp. (13.33%). High antimicrobial resistance was observed, particularly among *Staphylococcus* and *Salmonella* isolates, whereas all isolates remained susceptible to ciprofloxacin. The findings indicate that street-vended foods in Shambu Town are microbiologically unsafe and contaminated with multidrug-resistant bacteria. Strengthening vendor training, hygienic food handling, sanitation infrastructure, and antimicrobial resistance surveillance is recommended.

Article Information

Article History:
Received: 07-05-2026
Revised: 28-07-2026
Accepted: 05-08-2026

Keywords:
Antimicrobial resistance
Food handling practices
Food safety
Street-vended foods

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INTRODUCTION

Ready-to-eat foods and drinks made and/or sold by vendors in public areas are known as street-vended foods (FAO/WHO, 2017), constitute a critical component of the global food system. Street-vended foods feed millions of people daily and are highly affordable and easily accessible (Sharma, 2016). As a result, street food vending is a major source of income for many people in developing nations, especially women, who can earn money and learn entrepreneurial skills with a comparatively small initial investment (Sharma, 2016; Imathiu, 2017; Karondo & Tumaini, 2021). Street-vended meals play a significant socioeconomic role in many emerging nations with high unemployment, poor earnings, few job possibilities and social services, and fast urbanization. Consequently, street food consumption serves as a vital survival strategy for economically vulnerable urban populations.

The consumption of street food, while integral to urban livelihoods, poses significant public health risks due to pervasive unsafe practices. Street-vended foods prepared in open, unregulated environments are highly susceptible to contamination because of traditional cooking methods, inadequate temperature control, and poor personal hygiene (Imathiu, 2017; Kyalo, 2023). Because of the abuse of additives, the prevalence of pathogenic microorganisms, environmental pollutants, and poor hygiene practices, these foods are often associated with diarrheal diseases (Yongsi, 2018). Vendors consistently demonstrate

limited food safety knowledge and rely on rudimentary vending structures with limited access to running water. They often wash both their hands and utensils in the same bucket, frequently without soap, and dispose of wastewater into the streets and nearby solid waste, creating favorable conditions for flies and other disease vectors (Muendo *et al*., 2022; Kyalo, 2023). These unsanitary circumstances and methods raise the possibility of cooked food cross-contamination, which poses a serious risk to consumer health (Yasin *et al*., 2012).

Although street-vended foods are widely consumed, data on foodborne illnesses associated with these foods remain limited in many countries. However, research has repeatedly shown that street-vended foods include significant bacterial counts and dangerous pathogens (Bassitou *et al*., 2025). It has been demonstrated that street-vended foods in Ethiopia include medically significant germs, such as Shigella and Salmonella species (Chane, 2020). Despite the rapid expansion of street food vending in Shambu Town, no study has comprehensively assessed microbiological quality, antimicrobial resistance, and food handling practices. Furthermore, because contaminated foods can serve as reservoirs for resistant bacteria, the growth of antimicrobial-resistant foodborne pathogens has grown to be a significant global public health concern. Thus, the purpose of this study was to assess the food safety, antimicrobial resistance, and bacteriological quality of a few street-vended foods in Shambu Town, Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The investigation was carried out in Shambu Town, which is situated 315 kilometers northwest of Addis Ababa, Ethiopia, at latitude 9°34′ N and longitude 37°06′ E. Located at 2,503 meters (8,212 feet) above sea level in the temperate highland agro-ecological zone known locally as "Dega," Shambu has a cold climate with an average annual maximum temperature of 15.7°C and an average annual rainfall of 2,000 mm. The town has a total population of 67,279, of which 32,614 are men, according to the Shambu Town Administrative Office (2016 GC). This demographic and environmental backdrop influences the local demand for and customs surrounding street-vended cuisine.

Sampling and Data Collection

Active street food vendors that satisfied the study's inclusion requirements were chosen using a purposive sample technique. All of the current street food sellers in Shambu Town made up the target population. Using a 90% confidence level and an 8% margin of error, the Yamane (1967) method was used to determine the sample size. This resulted in a final sample of 91 street food sellers, regardless of their age or gender.

To capture variation in vending practices, three sites were purposively selected based on their high concentration of street food vendors and pedestrian activity: Dire Walabuma (Site 1; n = 30), Bus Station (Site 2; n = 30), and Hospital Area (Site 3; n = 31). These sites were selected to represent the major street food vending locations in Shambu Town.

All 91 vendors participated in the questionnaire survey to assess food handling practices. For the microbiological analysis, 45 vendors were randomly selected from the surveyed vendors, and one ready-to-eat food sample was collected from each selected vendor, resulting in a total of 45 food samples. The number of food samples analyzed was limited by available laboratory resources and budget.

In order to account for different literacy levels, a semi-structured questionnaire was used to gather data through in-person interviews. The instrument captured four core domains: (1) respondent demographics, (2) personal hygiene practices, (3) environmental sanitation conditions, and (4) food preparation methods. To ensure cultural and linguistic appropriateness, the questionnaire was first translated into the local Afan Oromo, then pre-tested on a small subset of vendors (n=10) not included in the final sample. Based on pre-test findings, ambiguous items were modified, and the final instrument was administered only after achieving semantic equivalence and face validity.

Sterilization of Materials

Every item was appropriately and sufficiently sanitized by covering them with aluminum foil and autoclaving them at 121ºC for 15 min. Every medium utilized was prepared in accordance with the manufacturer's instructions. Distilled water and prepared media were autoclaved for 15 min at 121ºC. Before and after usage, metal equipment, such as an inoculating loop, was heated to redness in an open flame. Before any analysis was done, the lab bench was routinely swabbed with 96% alcohol to sterilize it. Every isolation and inoculation was done near the flame to reduce contamination of the agar plates and tubes.

Collection of samples

Between March 2021 and June 2021 GC, collected 45 food samples from the three different vending sites in Shambu town: Dire Walabuma (site 1), Bus Station Area (site 2), and Hospital Area (site 3). These samples included five different street vended foods (SVF), including bread, boiled egg, potato, nifiro, and asambussa. Between 6 p.m. and 2 a.m., food samples were bought from vendors. The samples were collected approximately 2 h after cooking while being displayed for sale and stored at ambient temperature under the vendors' normal vending conditions. Additionally, food samples were collected from vendors using their own serving utensils and put in a sterile plastic bag and aluminum pan. The food samples were collected aseptically to prevent contamination, properly labeled, and delivered right away to the Plant Pathology Laboratory at Wollega University's Shambu Campus. The food samples were refrigerated at 4ºC till microbiological investigation was carried out. One to four h after the sample was collected, the analysis was carried out.

Microbiological Methods

Sample preparation

Each food sample, weighing about 2 kg, was taken from street sellers for microbiological quality and safety analysis. Each sample was place in a sterile blender, mortar and pestle to be thoroughly grounded. Ten grams of each sample were then mixed with ninety milliliters of buffered peptone water, and the mixture was homogenized in a flask for three to five min at 160 rpm using a shaker. Following homogenization, 1 milliliter of each homogenized sample was aseptically added to 9 milliliters of buffered peptone water, fully mixed with a vortex mixer, and well shaken. Test tubes were used to serially dilute the homogenates from 10-1 to 10-9. Each tube was mixed, and then a 0.1 ml suspension was transferred and spread out over agar substrate that had already solidified. Each plate containing 30 to 300 microbial colonies had its results recorded when the incubation period was over. The counted colonies were transformed to log $CFUg^{-1}$ after being expressed as colony forming units per gram ($CFUg^{-1}$). To obtain pure culture, colonies with distinct morphologies were chosen and sub-cultured.

Microbial Enumeration

Aerobic mesophilic bacterial count

A 0.1 ml aliquot from each sample's serial dilution was spread-plated on plate count agar (PCA) and cultured for 48 h at 32 °C (Weil *et al*., 2006). Counts were performed with countable plates (30–300 colonies per plate) using a colony counter and each count is expressed in log CFU g^{-1}.

Enterobacteriaceae count

After spread-plating 0.1 ml of the aliquot from the serial dilutions on MacConkey agar and incubating it at 37°C for 18 to 24 h, pink to red-

purple colonies that belonged to the Enterobacteriaceae family were counted (Spencer *et al*. 2007).

Coliform's count

One milliliter of the aliquot from the dilutions was spread-plated on Violet Red Bile agar (VBRA) plates that had already solidified. The plates were then incubated at 37°C for 18 to 24 h. Coliforms were then counted as purplish red colonies encircled by a reddish zone of precipitated bile (Weil *et al*., 2006).

Aerobic bacterial spore count

For aerobic bacterial counts, 10 ml of each serial dilution was heated in a water bath for 10 min at 80°C before being immediately cooled in tap water. A 0.1 ml aliquot of the appropriate dilution was put onto the pre-solidified surface of the plate count agar and incubated for 72 h at 32°C (Acco *et al*., 2003).

***Staphylococcus aureus* colony count**

Following serial dilution of each sample, 0.1 ml of the aliquot was spread out on Mannitol salt agar (MSA) and incubated for 48 h at 32°C. Golden yellow colonies on MSA plates were aseptically selected after staphylococci were counted. They were then placed in 5 milliliters of nutrient broth and incubated at 37ºC for 24 h to undergo additional purification. Next, a loop full of the nutrient broth culture was streaked on nutrient agar that had been supplemented with 0.75 percent NaCl, and it was once more incubated for 24 h at 37ºC. Lastly, the established microbiological techniques were used to characterize the different colonies (Acco *et al*., 2003). Initial biochemical tests, including catalase and coagulase tests, were performed on gram-positive coccus that were arranged in clusters under a microscope in order to isolate *Staphylococcus aureus*.

Isolation of *Salmonella* spp.

A 25 g portion of each sample was aseptically transferred into 225 mL of Buffered Peptone Water (BPW) and incubated at 37°C for 18–24 h for non-selective pre-enrichment. Subsequently, 0.1 mL of the pre-enriched culture was transferred into 10 mL of Rappaport–Vassiliadis (RV) broth and incubated at 42°C for 24 h for selective enrichment. A loopful of the enriched culture was then streaked onto Hektoen Enteric Agar (HEA) and incubated at 37°C for 24 h. Presumptive *Salmonella* colonies (blue-green colonies with or without black centers, depending on H_2S production) were selected and purified on nutrient agar. Confirmation of the isolates was performed using standard biochemical tests, including Triple Sugar Iron (TSI) agar, Lysine Iron Agar (LIA), Urea agar, Simmons Citrate agar, and Sulfide-Indole-Motility (SIM) medium, following standard microbiological procedures (Johnson and Case, 2007; ISO, 2017)

Bacterial characterization

Following enumeration of aerobic mesophilic bacteria, 10-15 colonies exhibiting distinct morphological characteristics (e.g., color, size, and shape) were randomly selected from countable plates and aseptically inoculated into 5 mL of nutrient broth. The cultures were incubated at 32°C for 24 h. Pure cultures were obtained by repeated streaking on nutrient agar and subsequently maintained on nutrient agar slants at 4°C until further characterization. Isolates were characterized and classified at the genus level according to Bergey's Manual of Systematic Bacteriology (Whitman, 2012).

A small portion of each purified isolate was subjected to Gram staining following the method of Gram (1884). Heat-fixed smears were examined microscopically under the oil immersion objective (100×) to determine Gram reaction and cellular morphology (Bello & Osho, 2013). Additional phenotypic characterization included motility (Shields & Cathcart, 2012), endospore staining (Schaeffer & Fulton, 1933), potassium hydroxide (KOH) test for Gram reaction, oxidative/fermentative (O/F) metabolism (Hugh & Leifson, 1953), and catalase activity (MacFaddin, 1980).

Gram-negative isolates were further differentiated using standard biochemical tests. Carbohydrate fermentation patterns, gas production, and hydrogen sulfide production were determined using Triple Sugar Iron (TSI) agar. Methyl Red (MR) and Indole tests were performed following incubation at 35±2◦C for 48–72 h and at 37◦C for 18–24 h, respectively. Acetoin production was assessed using the Voges–Proskauer (VP) test after incubation at 37◦C for 24 h with α-naphthol and potassium hydroxide (KOH) reagents. Citrate utilization was evaluated on Simmons citrate agar slants according to standard microbiological procedures.

Antimicrobial susceptibility testing for some pathogens

Using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar (MHA), antimicrobial susceptibility testing was carried out for specific bacterial pathogens isolated from street-vended food samples. The Clinical and Laboratory Standards Institute (CLSI) criteria were followed in the measurement and interpretation of the inhibition zones. Ampicillin (AMP, 10 µg), amoxicillin (AMC, 2 µg), gentamicin (CN, 10 µg), ciprofloxacin (CIP, 5 µg), chloramphenicol (C, 30 µg), and carbenicillin (CAR, 100 µg) were among the antimicrobial drugs examined. Antimicrobial drugs were chosen based on their efficacy, clinical relevance, antimicrobial spectrum, and local availability.

Data analysis

IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA) was used to rigorously analyze all quantitative data. In order to determine the degree of dispersion and confirm the existence of considerable variation in microbial counts across the food samples examined, the percentage coefficient of variation (% CV) was first computed. This information informed the suitability of following parametric tests. Descriptive statistics were generated for respondent characteristics and laboratory results. To determine whether microbial contamination levels differed significantly across the three vending sites (Dire Walabuma, Bus Station, and Hospital Area), one-way Analysis of Variance (ANOVA) was employed. This method was selected for its ability to compare mean values across more than two independent groups simultaneously. Statistical significance was established at a 95% confidence level, with $p < 0.05$ considered indicative of meaningful differences between site means. Where ANOVA revealed significant overall effects, post-hoc pairwise comparisons were conducted to identify which specific sites differed from one another.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of the Street Vendors

The sociodemographic traits of street sellers are shown in Table 1. Vendors between the ages of 21 and 30 made up the majority (70.33%), followed by those between the ages of 31 and 40 (16.48%). Females constituted the majority of vendors (63.73%) compared to males (36.30%). Regarding educational attainment, 50.55% had completed primary education. With respect to marital status, the majority (52.75%) were unmarried, whereas divorced vendors constituted the smallest percentage (2.19%).

The predominance of young adults among street food vendors may be attributed to the relatively low capital investment required for street food vending, making it an accessible source of self-employment for economically active young people. Likewise, the higher participation of women may reflect their traditional role in food preparation and small-scale food businesses, where street food vending serves as an important means of generating household income. These findings are consistent with previous Ethiopian studies, which also reported that street food vending is predominantly undertaken by young adults and women because of limited formal employment opportunities and the sector's low barriers to entry (Muleta & Ashenafi, 2001; Gizaw *et al*., 2014).

Table 1. Socio-demographic characteristics of street vendors in Shambu town

Variables	Category	Frequency (N = 91)	Percentage (%)
Age	<20	12	13.19
	21-30	64	70.33
	31-40	15	16.48
Sex	Male	33	36.30
	Female	58	63.73
Educational status	Illiterate	-	-
	Primary education	46	50.55
	Secondary education	45	49.45
Marital status	Married	38	41.76
	Unmarried	48	52.75
	Divorce	2	2.20
	Widowed	3	3.29

General Hygiene of Street vendors and the vended Foods

Table 2 shows that all vendors (100%) prepared food at home. Regarding water sources, 42.85% used well water for food preparation, while 81.32% used both tap and well water for cleaning utensils. All vendors (100%) cleaned utensils using only hands and water, without soap or detergents. During food sales, the majority (68.13%) handled food with bare hands. With respect to vending experience, 51.65% had 6–10 years of experience.

In the case of Table 3, the majority of vendors demonstrated satisfactory personal hygiene practices regarding fingernail status and hair covering. Specifically, 92.3% of vendors had trimmed fingernails, and 87.91% covered their hair during food vending. However, the majority (95.6%) did not wear a protective apron or any special clothing while serving food. Regarding environmental sanitation, dust was present at the majority of vending sites (65.93%), particularly around the bus station area. Furthermore, the survey revealed that none of the vendors had received formal training on food handling practices, and only a small proportion (10.99%) possessed basic information about foodborne diseases.

Table 2. Assessment of water source, utensil hygiene, and food handling practices among street vendors in Shambu Town.

Variables	Category	Frequency (N = 91)	Percentage (%)
Food preparation place	At home	91	100
	At work place	-	-
Source of water for food preparation	Tap water	25	27.5
	Well water	39	42.85
	Spring water	27	29.67
Water they used for cleaning utensils	Tap water	17	18.68
	Well water	74	81.32
	Spring water	-	-
Method of cleaning the utensils	By hands using water only	91	100
	With warm water and soap	-	-
Service ware	Fork/spoon only	-	-
	Bare hand	23	25.3
	Plastic bag	6	6.59
	Both bare hand and fork/spoon	62	68.13
Experience in vending foods (years)	<5	41	45.05
	6-10	47	51.65
	11-15	3	3.29

Table 3. Personal hygiene of vendors and environmental sanitation of vending sites in Shambu Town

Variables	Category	Frequency (N = 91)	Percentage (%)
Long fingernails	Yes	7	7.69
	No	84	92.31
Hair covering status	Yes	11	12.09
	No	80	87.91
Use of protective apron	Yes	4	4.40
	No	87	95.60
Dust presence	Yes	60	65.93
	No	31	34.07
Training on food handling practice	Yes		-
	No	91	100
Information on food borne diseases	Yes	10	10.99
	No	81	89.01

Microbial Counts

Bread had the highest mean aerobic mesophilic bacteria (AMB) count (5.45 log CFU g^{-1}), as shown in Table 4; however, this value did not differ substantially ($p > 0.05$) from those found in boiled egg, nifro, and asambusa. Asambusa and potato samples had the highest numbers of aerobic spore-forming bacteria (ASFB), with values of 3.96 ± 0.14 log CFU g^{-1} and 3.95 ± 0.03 log CFU g^{-1}, respectively. These data did not differ statistically from the ASFB count in the nifro sample ($p > 0.05$). The boiled egg had the highest Enterobacteriaceae count (3.97 ± 0.04 log CFU g^{-1}) and did not differ statistically significantly ($p > 0.05$) from the potato sample. Additionally, the potato sample had the highest levels of Staphylococcus spp. and coliforms, with values of 6.40 ± 0.08 log CFU g^{-1} and 3.99 ± 0.017 log CFU g^{-1}, respectively.

Table 4. Mean bacterial counts (log CFU g^{-1} ± SD) on selected food samples from vended street foods (SVF) at Site 1 (Around the Dire Walabuma).

Bacterial spp.	Vended street food samples				
	Bread	Boiled egg	Potato	Nifiro	Asambusa
AMB	5.45±0.02^{a}	5.23±0.18^{ab}	5.19±0.17^{bc}	5.27±0.03^{ab}	5.25±0.22^{b}
ASFB	3.92±0.03^{b}	3.85±0.03^{c}	3.95±0.03^{a}	3.94±0.03^{ab}	3.96±0.01^{a}
Enterobacteriaceae	3.93±0.05^{b}	3.97±0.04^{a}	3.94±0.02^{ab}	3.87±0.04^{c}	3.93±0.03^{b}
Coliform	3.75±0.06^{c}	3.85±0.05^{bc}	3.99±0.02^{a}	3.89±0.02^{b}	3.89±0.02^{b}
Staphylococci spp.	6.28±0.01^{b}	5.95±0.06^{c}	6.40±0.08^{a}	5.81±0.07^{e}	5.88±0.11^{d}

AMB=Aerobic mesophilic bacteria; ASFB =Aerobic spore forming bacteria; SD=Standard deviation

As summarized in Table 5, the highest aerobic mesophilic bacteria (AMB) count was recorded in the bread sample (5.45±0.01 log CFU g^{-1}). The maximum aerobic spore-forming bacteria (ASFB) count was observed in the Asambusa sample (3.96±0.04 log CFU g^{-1}), which was not statistically different ($p > 0.05$) from the value obtained for potato (3.95±0.03) and Nifro (3.94±0.03). Regarding Enterobacteriaceae, the highest count was found in the bread sample (3.99 ± 0.02 log CFU g^{-1}), showing no statistically significant difference ($p > 0.05$) from the value recorded in the potato sample.The highest coliform counts were detected in potato (3.97±0.02 log CFU g^{-1}) and asambusa (3.96±0.02 log CFU g^{-1}). Furthermore, the maximum *Staphylococcus* spp. count (6.46±0.01 log CFU g^{-1}) was observed in the potato sample, which did not differ significantly ($p > 0.05$) from the value in the bread sample.

Table 5. Mean bacterial counts (log CFU g^{-1} ± SD) on selected food samples from vended street foods (SVF) at Site 2 (Around the bus station).

Bacterial spp	Vended street food samples				
	Bread	Boiled egg	Potato	Nifiro	Asambusa
AMB	5.46 ±0.01^{a}	5.25±0.02^{b}	5.23±0.02^{c}	5.20±0.04^{bc}	5.23±0.04^{c}
ASFB	3.88±0.02^{b}	3.90±0.02^{b}	3.86±0.03^{c}	3.98±0.04^{a}	3.94±0.02^{ab}
Enterobacteriaceae	3.99±0.02^{a}	3.89±0.03^{bc}	3.95±0.03^{ab}	3.92±0.03^{b}	3.92±0.03^{b}
Coliform	3.75±0.03^{c}	3.84±0.04^{b}	3.97±0.02^{a}	3.91±0.03^{ab}	3.96±0.02^{a}
Staphylococci spp.	6.38±0.11^{ab}	6.24±0.03^{b}	6.46±0.01^{a}	5.97±0.03^{c}	5.95±0.06^{c}

AMB=Aerobic mesophilic bacteria; SD=Standard deviation; ASFB = Aerobic spore forming bacteria

As presented in Table 6, the highest aerobic mesophilic bacteria (AMB) and Enterobacteriaceae counts were both recorded in the bread sample, with values of 5.46 ± 0.01 log CFU g^{-1} and 3.969 ± 0.02 log CFU g^{-1}, respectively. The highest aerobic spore-forming bacteria (ASFB) counts were observed in the nifro (3.96 ± 0.01 log CFU g^{-1}) and asambusa (3.97 ± 0.01 log CFU g^{-1}) samples. These ASFB values did not differ significantly ($p > 0.05$) from the value obtained for the boiled egg sample. With the exception of the bread sample, all other sample values were statistically comparable ($p > 0.05$). Regarding *Staphylococcus* spp., no significant differences ($p > 0.05$) were observed among the bread, boiled egg, and potato samples. Similarly, the values recorded for nifro and asambusa were not statistically different from each other ($p > 0.05$).

Table 6. Mean bacterial counts (log CFU g^{-1} ± SD) on selected food samples from vended street foods (SVF) at Site 3 (around the Hospital).

Bacterial spp	Vended street food samples				
	Bread	Boiled egg	Potato	Nifiro	Asambusa
AMB	5.46±0.01^{a}	5.21±0.02^{b}	5.23±0.01^{b}	5.25±0.02^{b}	5.24±0.02^{b}
ASFB	3.88±0.04^{b}	3.94±0.02^{ab}	3.84±0.03^{bc}	3.96±0.01^{a}	3.97±0.01^{a}
Enterobacteriaceae	3.97±0.02^{a}	3.84±0.04^{c}	3.93±0.03^{b}	3.88±0.02^{bc}	3.91±0.02^{b}
Coliform	3.76±0.03^{d}	3.92±0.02^{ab}	3.94±0.02^{a}	3.94±0.02^{a}	3.95±0.03^{a}
Staphylococci spp.	6.01±0.24^{ab}	6.24±0.03^{ab}	6.42±0.01^{a}	5.95±0.02^{b}	5.99±0.05^{b}
CV	1.03	1.06	2.01	1.01	0.87

AMB=Aerobic mesophilic bacteria; ASFB = Aerobic spore forming bacteria; SD=Standard deviation

Colony Morphology and Biochemical Profiling

From ready-to-use food samples that were sold, 45 microbial isolates were found (Table 7). Biochemical characterization revealed that the majority of isolates (86.67%) were Gram-positive. All isolates exhibited circular colony morphology. Regarding colony color, 13.33% were colorless, 15.56% white, 24.44% dark red, and 46.67% yellow. Based on biochemical identification, the isolates were speciated as follows: *Staphylococcus* spp. constituted the predominant genus (46.67%), followed by *Escherichia coli* (24.44%), *Bacillus* spp. (15.56%), and *Salmonella* spp. (13.33%).

Table 7. Biochemical characterization of bacterial isolates from vended food samples.

Colony morphology	shape	Biochemical test: Gram rxn	Catalase	Indole	MR	VP	Citrate	Glu/ferm	Isolated organism	Number of isolation (Total = 45)
Circular, colorless	Bacilli	-ve	+	-	+	-	+/-	+	*Salmonella Spp.*	6
Circular, yellow	Cocci	+ve	+	-	+/-	+	+	+	*Staphylococci spp.*	21
Circular, white	Bacilli	+ve	-	-	-/+	-/+	+	+	*Bacillus spp.*	7
Circular, dark red	rods	+ve	+	+	+	-	-	+	*Escherichia coli spp.*	11

Antimicrobial Susceptibility Patterns of Isolated *Staphylococcus spp.* and *Salmonella spp.*

As summarized in Table 8, the antimicrobial susceptibility profile of *Staphylococcus spp.* isolates revealed marked variation across the antibiotics that were tested. High rates of resistance (80%) were observed for amoxicillin, ampicillin, and carbenicillin. Conversely, complete susceptibility (100%) was recorded for ciprofloxacin. For chloramphenicol, the isolates were equally divided between resistant (50%) and susceptible (50%). Similarly, half of the isolates (50%) exhibited intermediate susceptibility to gentamicin, while the remaining 50% were susceptible.

Table 8. Antimicrobial susceptibility profile of *Staphylococcus spp*. isolated from street-vended foods in Shambu town.

Antimicrobial Agents	Disc concentration (µg/ml)	Resistant(R) Frequency (%)	Intermediate(I) Frequency (%)	Susceptible(S) Frequency (%)
Amoxicillin	2	8(80%)	-	2(20%)
Ampicillin	10	8(80%)	-	2(20%)
Ciprofloxin	5	-	-	10(100%)
Chloramphenicol	30	5(50%)	-	5(50%)
Gentamycin	10	-	5(50%)	5(50%)
Carbaxyline	100	8(80%)	-	2(20%)

As summarized in Table 9, the antimicrobial susceptibility profile of the isolates revealed marked variation across the tested antibiotics. Complete resistance (100%) was recorded for amoxicillin and ampicillin, whereas all isolates (100%) were fully susceptible to ciprofloxacin. For chloramphenicol, 25% of the isolates were resistant, with the remaining 75% showing susceptibility.

Table 9. Antimicrobial susceptibility profile of *Salmonella spp.* isolated from street-vended foods in Shambu town.

Antimicrobial Agents	Disc concentration (µg/ml)	Resistant(R) Frequency (%)	Intermediate(I) Frequency (%)	Susceptible(S) Frequency (%)
Amoxicillin	2	8(100%)	-	-
Ampicillin	10	8(100%)	-	-
Ciprofloxin	5	-	-	8(100%)
Chloramphenicol	30	2(25%)	-	6(75%)
Gentamycin	10	-	3(37.5%)	5(62.5)
Carbaxyline	100	4(50%)	4(50%)	-

Gentamicin susceptibility testing revealed that 37.5% of the isolates were resistant, while 62.5% were susceptible. Regarding carbenicillin, the isolates were equally divided, with 50% exhibiting resistance and 50% demonstrating intermediate susceptibility.

DISCUSSION

The present study reveals distinct gender disparities in street food vending, with females constituting the majority of vendors (63.73%), predominantly aged between 21–30 years (70.33%). This finding aligns with the report of Ebrahim and Kibret (2025) in Dessie Town, Ethiopia, where female dominance in the sector was also observed. However, it sharply contrasts with the context of Thika Town, Kenya, where males dominated street food vending (Kyalo, 2023). This discrepancy may be attributed to regional differences in cultural norms, economic opportunities for women, and local regulatory frameworks. In the present study setting, vending may represent a flexible income-generating activity accessible to young women, whereas in Thika, the sector may be perceived as more physically demanding or requiring capital typically controlled by men.

Significant differences also emerged regarding water sourcing for food preparation. In the present study, only 42.9% of vendors used well water, a finding that disagrees markedly with Ebrahim and Kibret (2025), who reported that 94.1% of vendors employed tap water. This contrast likely reflects disparities in infrastructure access between the two study areas. The reliance on well water in the current setting raises concerns about potential microbial contamination, as unprotected wells are susceptible to fecal pollution from surface runoff and inadequate sanitation facilities. Consequently, this water source may contribute to the elevated *E. coli* and coliform counts observed in the present study.

Regarding personal hygiene practices, most vendors exhibited unsatisfactory fingernails status and inadequate hair covering, consistent with the findings of Ebrahim and Kibret (2025). These poor hygiene practices were further compounded by the high prevalence of bare-hand food handling (68.13%), which may increase the risk of food contamination. Although this proportion is lower than the 96.8% reported in Thika Town, Kenya (Kyalo, 2023), it remains alarmingly high from a food safety perspective. Bare-hand handling creates a direct route for transferring *Staphylococcus aureus* a primary finding in the present study from vendors' skin to ready-to-eat foods. The fact that fingernails appeared clean does not eliminate this risk, as pathogens are readily transferred from intact skin. Thus, the present findings suggest that visible cleanliness (e.g., hair covering) does not reliably predict hygienic food handling behaviors (e.g., use of gloves or utensils).

Critically, none of the vendors in the present study had received formal training on food handling practices. This finding aligns with Muendo *et al*. (2022) in Chuka Town, Kenya, where 91.1% of cooked food vendors lacked any food safety training. The complete absence of food safety training in the current study setting is particularly concerning, as it may limit vendors' knowledge of pathogen transmission, temperature control, cross-contamination prevention, and proper hand hygiene. However, inadequate access to food handling equipment, protective clothing, and sanitation facilities may also contribute to poor food safety practices. Collectively, these factors may explain the consistently elevated bacterial loads, including AMB, *Staphylococcus spp*., coliforms, *E. coli*, and *Salmonella spp*., observed across all study sites. The present findings diverge sharply from those of Aktar and Biswas (2022) in Kushtia City, Bangladesh, where 52.2% of vendors had received formal training, underscoring substantial regional disparities in food safety capacity among street food vendors. This contrast highlights that in some low- and middle-income countries, structured training programs for street food vendors exist and are implemented, whereas in the present study area, no such systems are in place. The absence of regulatory enforcement and health department oversight likely perpetuates this cycle of untrained vending and poor microbiological quality of foods.

In the present study, AMB (5.45–5.46 log $CFUg^{-1}$) and *Staphylococcus* spp. (6.40 log $CFUg^{-1}$) recorded the highest counts among all food samples across the study sites. According to the Health Protection Agency (HPA) guidelines, aerobic colony counts ≥5 log $CFUg^{-1}$ and *Staphylococcus* aureus counts ≥4 log $CFUg^{-1}$ in ready-to-eat foods are considered unsatisfactory, indicating poor microbiological quality and an increased risk to consumers (HPA, 2009). These findings were higher than those reported from Dessie Town, Ethiopia, and Thika Town, Kenya (Kyalo, 2023; Ebrahim & Kibret, 2025). Similarly, the counts of *Salmonella spp*., coliforms, and *E. coli* were higher than those reported in Dessie Town, Ethiopia (Ebrahim & Kibret, 2025), while *E. coli* counts also exceeded those reported from Thika Town, Kenya (Kyalo, 2023). The elevated AMB counts may reflect poor overall hygiene, inadequate sanitation, and prolonged storage at ambient temperature, whereas the high *Staphylococcus* spp. counts are likely attributable to contamination

from food handlers through improper hand hygiene, direct contact with food, or cross-contamination during preparation and vending.

In the present study, Aerobic Mesophilic Bacteria (AMB) and *Staphylococcus spp*. consistently recorded the highest bacterial counts across all samples and study sites. These values notably exceed those reported from Dessie Town, Ethiopia (Ebrahim & Kibret, 2025), and Thika Town, Kenya (Kyalo, 2023). This pronounced elevation in AMB and staphylococcal counts strongly suggests poor general handling practices and inadequate personal hygiene among food vendors, given that *Staphylococcus spp*. are primarily of human origin, commonly shed from skin and nasal passages (Touaitia *et al*., 2025). Furthermore, the present study found that *Salmonella spp*., coliforms, and *E. coli* levels were also higher than those reported from Dessie Town, Ethiopia (Ebrahim & Kibret, 2025). This consistent elevation across multiple bacterial indicators spanning both hygiene indicators (*Staphylococcus*, coliforms) and specific pathogens (*Salmonella*, *E. coli*) points to a multifaceted breakdown in food safety practices, including insufficient hand hygiene, use of contaminated water, and improper waste disposal, rather than a single point of failure.

In addition, the *E. coli* counts observed in the present study surpassed those reported from Thika Town, Kenya (Kyalo, 2023). This finding is particularly concerning, as *E. coli* is a direct indicator of fecal contamination, suggesting that vended foods in the current study setting may be exposed to fecal matter through contaminated water sources, unsanitary food contact surfaces, or improper hand washing after toilet use.

Taken together, the present findings reveal that vended foods examined in this study are microbiologically inferior to comparable foods from two other African settings (Ethiopia and Kenya). The persistently high levels of both AMB and *Staphylococcus spp*. (FSANZ, 2016) coupled with elevated fecal indicators (*E. coli* and coliforms) (Reed, 1994; FSANZ, 2016; Martin *et al*., 2016) and enteric pathogens (*Salmonella* spp.) (Abdul *et al.,* 2022) indicate a critical and generalized failure in food hygiene practices. Such conditions not only reduce the shelf life of vended foods (as reflected by high AMB counts) (CFS, 2022) but also pose a genuine public health risk for acute gastroenteritis and staphylococcal food poisoning among consumers. Immediate interventions, including mandatory food handler training, provision of clean water, and routine microbiological surveillance, are urgently needed in the study area.

In the present study, a total of 45 microbial isolates were recovered from ready-to-eat vended food samples, with the majority (86.67%) being Gram-positive. This predominance of Gram-positive bacteria is consistent with the nature of contamination typically introduced by food handlers, as skin-associated flora, particularly *Staphylococcus* spp. are frequently transferred through bare-hand contact. All isolates exhibited circular colony morphology, with yellow (46.67%) and dark red (24.44%) being the most prevalent colony colors, suggesting the presence of pigment-producing organisms such as *Staphylococcus aureus* (golden-yellow colonies) and possibly Serratia or other pigmented environmental bacteria.

Based on biochemical identification, *Staphylococcus* spp. emerged as the predominant genus, constituting 46.67% of all isolates, followed by *Escherichia coli* (24.44%), *Bacillus* spp. (15.56%), and *Salmonella spp.* (13.33%). The dominance of *Staphylococcus* spp. is a critical finding, as this genus particularly coagulase-positive strain such as *Staphylococcus aureus* serves as a direct indicator of poor personal hygiene among food vendors. This outcome is methodologically consistent with Siddiqua's (2016) findings that, of thirty food samples, six (60%) were suspected to contain Klebsiella spp., three (30%) to contain E. coli, and one (10%) to contain Vibrio spp. While Siddiqua (2016) identified a higher proportion of *Klebsiella* in their setting, the present study found a greater burden of *Staphylococcus* and *E. coli*, suggesting that the primary routes of contamination differ: bare-hand handling in the present study versus potentially environmental or waterborne contamination in their study context.

The present findings contrast with those of Ndunguru and Ndossi (2019), who reported E. coli (49.2%) as the predominant isolate, whereas the present study identified *Staphylococcus spp*. (46.67%) as the dominant genus, outnumbering *E. coli* nearly twofold. The predominance of *Staphylococcus spp*. suggests contamination mainly from food handlers through poor personal hygiene, direct hand contact, and cross-contamination during food preparation and vending, while the presence of *E. coli* indicates possible fecal contamination associated with contaminated water, inadequate sanitation, or improper food handling practices.

This discrepancy likely reflects different primary contamination sources: direct human handling (high staphylococcal counts) in the present study versus fecal contamination from water or soil (high *E. coli* prevalence) in the setting studied by Ndunguru and Ndossi (2019). Furthermore, the present study recovered *Salmonella* spp. at a notably higher proportion (13.33%) compared to the 1.6% reported by Ndunguru and Ndossi (2019). This is a serious public health concern, as *Salmonella* is a well-recognized enteric pathogen capable of causing severe gastroenteritis and systemic infections. The elevated prevalence of *Salmonella* in the present study, combined with the simultaneous presence of *E. coli* (24.44%) and *Staphylococcus spp*. (46.67%), indicates a multifactorial contamination pathway involving poor hand hygiene, fecal contamination, and potentially inadequate cooking or cross-contamination from raw ingredients.

The present study revealed marked variation in antimicrobial susceptibility among *Staphylococcus* spp. isolates. Notably, alarmingly high resistance rates were observed for amoxicillin (80–100%), ampicillin (80–100%), and carbenicillin (50–80%), indicating that these commonly used penicillins are largely ineffective against the circulating staphylococcal strains in the study area. This level of resistance likely reflects widespread and indiscriminate use of these antibiotics in both human and veterinary medicine, contributing to selective pressure. Conversely, complete or near-complete susceptibility (100%) to ciprofloxacin was recorded across all isolates, a finding consistent with Eromo *et al*. (2016), who also reported 100% sensitivity of *Staphylococcus* spp. to ciprofloxacin. This suggests that fluoroquinolones remain effective therapeutic options in the study setting. However, cautious use of ciprofloxacin is essential to preserve its efficacy and prevent the emergence of resistance.

Regarding chloramphenicol, susceptibility varied between 50–75% across isolate groups, which sharply contrasts with Eromo *et al*. (2016), who found 89% of *Salmonella* spp. to be resistant to chloramphenicol. For gentamicin, 50% of isolates in one group and 62.5% in another showed susceptibility, while resistance (37.5%) and intermediate susceptibility (50%) were also observed. This mixed profile suggests that gentamicin may not be reliably effective as empirical therapy without prior susceptibility testing. Should such resistance emerge in the study area, treatment options for severe staphylococcal infections would be severely compromised.

In contrast, Ebrahim and Kibret (2025) found *Salmonella spp*. to be susceptible to most tested antibiotics, including amoxicillin and cefradine, though resistant to oxacillin. This pattern differs from the high penicillin resistance observed in the present study, underscoring that

resistance profiles are pathogen-specific and context-dependent. The high rates of resistance to first-line antibiotics (ampicillin, amoxicillin) among *Staphylococcus spp.* isolates from vended foods are a serious public health problem when considered together. To direct empirical therapy and slow the spread of resistant bacteria throughout the food chain, regular susceptibility testing, careful antibiotic usage, and ongoing surveillance are desperately needed.

CONCLUSION

This study conclusively demonstrates that ready-to-consume street vended foods in Shambu Town, Horo Guduru Wollega Zone, represent a significant public health hazard. The bacteriological profile reveals widespread contamination with potentially pathogenic organisms, including *Staphylococcus spp*., *Escherichia coli*, *Bacillus spp*., and *Salmonella* spp., all of which exceeded acceptable safety limits. The presence of *E. coli* and *Salmonella spp*., in particular, indicates direct fecal contamination, likely arising from poor hand hygiene, unsafe water use, and unsanitary environmental conditions. Of even greater concern is the alarming antimicrobial resistance profile. Common foodborne infections in this community may become challenging or impossible to treat with first-line medications due to the near-complete resistance to widely accessible antibiotics like amoxicillin and ampicillin and the retention of susceptibility only to ciprofloxacin. This creates a dual burden: foodborne disease compounded by therapeutic failure. Critically, none of the vendors had received formal food safety training, and only 10.99% had basic knowledge of foodborne diseases. This knowledge-practice gap is the root cause of the observed failures, including bare-hand contact with food, lack of protective clothing, and inadequate utensil cleaning without detergents. In order to maintain the effectiveness of remaining susceptible medications like ciprofloxacin, the study concludes that immediate, multi-sectoral interventions are needed, including mandatory food safety training for all vendors on safe food handling, personal hygiene, temperature control, cross-contamination prevention, cleaning and sanitation practices, provision of clean water and waste management infrastructure, regular microbiological surveillance, and a strict policy to limit the use of over-the-counter antibiotics.

Acknowledgements

The author gratefully acknowledges Wollega University, Shambu Campus, for providing access to its laboratory facilities and technical resources, which enabled the successful completion of this research. The author also appreciates the support and assistance provided by the laboratory staff during the laboratory analysis and sample processing. Their cooperation and contribution are sincerely appreciated.

Funding

Not applicable.

Data availability

All data supporting the original article are included.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interest.

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