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ORIGINAL RESEARCH

Bacteriological Quality and Antimicrobial Resistant Patterns of Foodborne Pathogens Isolated from Commonly Vended Street Foods in Arba Minch Town, Southern Ethiopia

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Background: Ready-to-eat foods sold by street vendors act as potential sources for the spread of various foodborne infectious diseases. Thus, local determination of the level of foodborne bacterial pathogens and their antimicrobial resistance pattern is essential.

Methods: A community-based cross-sectional study was conducted from September 5th, 2022 to December 31th, 2022. The required data were collected by a structured questionnaire and observation checklist. Randomly selected street-vended foods were aseptically collected, and the bacteriological quality was assessed by using culture techniques. Different biochemical tests were used to identify and characterize bacterial isolates. The antimicrobial-resistant test for isolated foodborne bacterial pathogens was carried out by using the Kirby-Bauer disc diffusion method. The data were analyzed using SPSS version 22.

Results: A total of 34.2% (113/330) with a 95% CI of 29.1–39.4 of commonly consumed street-vended foods were identified as having unsatisfactory total mean aerobic bacterial counts (>10^5 CFU/g; 4.3×10^5 CFU/g). The mean total *Enterobacteriaceae*, coliform, and staphylococcal counts were found to be 1.4×10^5 CFU/g, 2.4×10^4 CFU/g, and 3.4×10^4 CFU/g, respectively. A total of 12.7% (42/330) of foodborne pathogens were recovered attributed to *Staphylococcus aureus* (31, 9.4%), *Salmonella* species (6, 1.8%), and *E. coli* O157:H7 (5, 1.5%). 6.5% and 16.1% of isolated *S. aureus* were found to be methicillin-resistant and multidrug-resistant (MDR), respectively. Additionally, 33.3% of *Salmonella* isolates and 40% of *E. coli* O157:H7 isolates were found to be MDR.

Conclusion: Street-vended foods in this setting have a considerable number of unsatisfactory bacterial qualities, along with drug-resistant foodborne pathogens. Thus, more effective health education and training for vendors, regular inspections of vending sites, and regular surveillance of drug resistance patterns of foodborne pathogens are all essential.

Keywords: bacteriological quality, street-vended foods, Arba Minch, Ethiopia

Introduction

Street food refers to a wide-ranging variety of readily available foods prepared and/or sold by vendors from a street side location in a public place for immediate consumption without further processing or preparation.[1–3] They are very popular among urban dwellers, particularly for middle- and low-income sectors of the population, because they are relatively inexpensive, convenient, and easily accessible on the sidewalk.[4–7] However, concerns have been raised about the safety and quality of street-vended foods, particularly from a food safety perspective, despite the fact that the importance of street-vended food cannot be overstated.[8–10]

Studies on street foods have highlighted them as a major public health risk.[11,12] Epidemiological evidence has estimated that foods unsafe for consumption, including street-vended foods, cause 7.69% (600 million) of the world's population (7.8 billion) to suffer from foodborne diseases every year, and 7.5% of all deaths (56 million) annually are due to foodborne illnesses.[13,14] A great proportion is attributed to countries where street food vending is prevalent and has been implicated in up to 70% of traced outbreaks, which has necessitated that street food safety remains a principal

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priority.[10,15] More than 60% of the burden of foodborne illnesses is associated with bacterial contamination and foodborne intoxications.[14,16] *Staphylococcus aureus*, enteropathogenic *Escherichia coli, Salmonella* species, *Shigella* species, *Bacillus cereus*, and *Clostridium perfringens* are some of the commonly detected foodborne pathogens in street-vended food items.[3,13,17]

The burden associated with street foodborne diseases like diarrhoea, cholera, typhoid fever, and food poisoning can occur in individuals of all ages, while 40% of the foodborne disease burden is accounted for by school-age children and persons living in low-income sub-regions of the world.[18–20] Moreover, travelers' diarrhea associated with consumption of street-vended food is a major inconvenience for visitors arriving in low-income countries and may be an important factor inhibiting tourism.[6,9,21] In Ethiopia, next to typhoid fever, foodborne-associated diarrheal disease represents the second leading cause of death.[6,9,22] These are frequently attributed to a lack of basic infrastructure and services, difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility, and temporary nature, unavailability of pure water, and insufficient reheating of cooked food.[22–24] Likewise, those who participate in the street food vendor sector are often poorly educated, unlicensed, and untrained in food hygiene, and they work under crude, unsanitary conditions with little or no knowledge about the causes of foodborne disease.[10,23]

Consequently, different studies[6,7,11] conducted on the microbial quality of different items of ready-to-eat foods vended on the street in low-income countries, including Ethiopia, revealed that different levels of contamination and the majority of isolated foodborne bacterial pathogens were resistant to commonly prescribed antibiotics and stated that street-vended foods were a common medium for the transmission of antimicrobial-resistant pathogens and had become a major threat in low-income countries due to the ease of infection resulting from poor living standards and a lack of access to adequate medical treatment.[25–29]

However, nothing has been done on the bacterial quality and antimicrobial resistance patterns of foodborne bacterial pathogens among street foods offered in the study area. While in Arba Minch town, it is common to see many street foods being sold in shops, in outdoor marketplaces, and more commonly at roadsides near waste drainage in an irregular way. It is also common to see people purchase those foods from vendors and consume them right away. Therefore, this study was designed to address the bacteriological quality and antimicrobial resistance pattern of foodborne pathogens in commonly consumed street-vended foods in Arba Minch town, southern Ethiopia.

Materials and Methods

Study Design, Study Area and Period

A community-based cross-sectional study was conducted in five vending sites (Sikela, Shecha, Yetnebersh, Limat, and Konso Sefer) of Arba Minch town, southern Ethiopia, from September 5th, 2022, to December 31st, 2022, where there are a high number of vendors and customers as well as an abundance of the types of street foods sold there. Arba Minch is the seat of administration for the Gamo Zone, which is located in southern Ethiopia, 454 kilometres away from Addis Ababa. In the town, there are many resorts, hotels, restaurants, and cafeterias, and alongside them are different ready-to-eat foods being vended in the streets of the town. The city of Arba Minch and its surroundings (the presence of 40 springs, proximity to Nech-Sar National Park, being a crocodile ranch, and being enriched with banana and mango) are endowed with diverse and impressive tourist attractions, and for the majority of tourists, street-vended fast foods are the first choice, unlike foods in hotels and resorts.

Sample Size Determination and Sampling Technique

The single population proportion formula was used with the assumptions that the proportion (p) of street-vended food samples showed total colony counts beyond the acceptable limits set for microbiological quality of ready-to-eat foods was taken from a previous study in Hawassa (31%),[7] a 95% confidence level ($Z\ \alpha/2 = 1.96$) and a 5% degree of precision ($d = 0.05$). As a result, 330 frequently vended and highly consumed street foods (Potato Chips (n = 75), Koker (n = 75), Sambusa (n = 75), Ambasha (n = 60), and Bombolino (n = 45)) were collected (Table 1) with a simple random sampling technique from seventy-five street food vendors at the selected five vending sites: from Sikela (n = 75), Shecha (n = 75), Yetnebersh (n = 45), Limat (n = 60) and Konso Sefer (n = 75).

Table 1 The Ingredients and Description of Commonly Vended Street Foods Microbiological Analysed from Arba Minch Town, Southern Ethiopia, 2022

Food Items	Ingredients	Description
"Sambusa"	Wheat dough, lentils or rice, chopped onions, cooking oil	Sambusa is a deep fried triangle of wheat dough stuffed with lentils or potato, chopped onions and green paper.
"Potato Chips"	Cylindrical tube shaped piece of potato	Sliced extremely thin and then boiled with oil or fired until they become crisp and ready to eat
"Bonbolino"	Wheat dough, cooking oil, baking powder, salt, Sugar	It is a fried piece of wheat dough commonly of a ring or circular shape without jam, custard or cream.
"Koker"	Wheat dough, cooking oil, baking powder, salt, Sugar	It is a deep fried piece of wheat dough commonly with a round or ball like shape without jam, custard or cream that is heated until golden brown
"Ambasha"	Made from wheat flour with baking powder, salt and cardamom	Sweet leavened bread, texture is similar to that of pizza dough, or bread sticks, but with many fragrant spices.

Data Collection Method and Tools

Data regarding the socio-demographic characteristics and personal hygiene practices of vendors as well as the area of sanitation in which the food was vended were collected through face-to-face interviews and observation by using structured questioners and observational checklists [Annex I].

Sample Collection and Transportation

Well-trained data collectors collected approximately 100 g of food samples aseptically using sterile aluminium foil from each item of street food and transported them using an icebox within 3–5 °C. The samples were processed in the Medical Microbiology and Parasitology Laboratory of Arba Minch University at the College of Medicine and Health Sciences within 1 hour after collection. The collected street-vended food samples were cut into smaller pieces with a sterile surgical blade, picked up with sterile forceps, and weighed at 10 g with an electronic digital scale for total aerobic bacterial, coliform, *Enterobacteriaceae*, and Staphylococcus counts and 25 g for *Salmonella* species detection. The measured 10 g and 25 g samples were homogenised in a measured volume of 90 mL and 225 mL of buffered peptone water (BPW) [Oxoid, Hampshire, UK], respectively, and shaken vigorously using a vortex to dislodge adhered bacteria.[30] The homogenate sample gave a 1:10 dilution, from which further dilution was made by adding 1 mL of homogenate into 9 mL of BPW. Serial dilutions of 10^{-2} and up to 10^{-6} were made using test tubes and then inoculated into the appropriate culture media (Figure 1).[6,7,30]

Bacterial Enumeration, Isolation and Identification

In the homogenized or mixed tube, 0.1 mL of aliquots were transferred using an automatic micropipette with sterile disposable tips and spread using an L-shaped sterile wire spreader onto nutrient agar plates [Oxoid, Hampshire, UK] for the total aerobic plate count and incubated for 24–48 h at 30–35 °C. The colonies were counted from plates containing more than 30 and less than 300 microbial colonies.[7,10] The average counted colonies were expressed in colony forming units per gram ($CFUg^{-1}$) after multiplying by the dilution factor.[2,17,31] Simultaneously, 0.1 mL aliquots of an appropriate dilution were spotted on MacConkey Agar plates and incubated at 30–35 °C for 24–48 h to count *Enterobacteriaceae* and coliform. Pink to reddish-purple colonies with or without haloes of precipitate were considered members of the *Enterobacteriaceae*, while pure pink colonies were considered coliforms. The microbiological qualities of street foods were classified by different labels; however, the classification varies among types of isolated pathogens: (a) Satisfactory: results are within expected microbiological levels and present no food safety concern. No action is required. (b) Acceptable: results are within expected microbiological levels but are at the upper range. Some action may be required to ensure food handling controls continue to be effective. (c) Unsatisfactory: results are outside expected microbiological

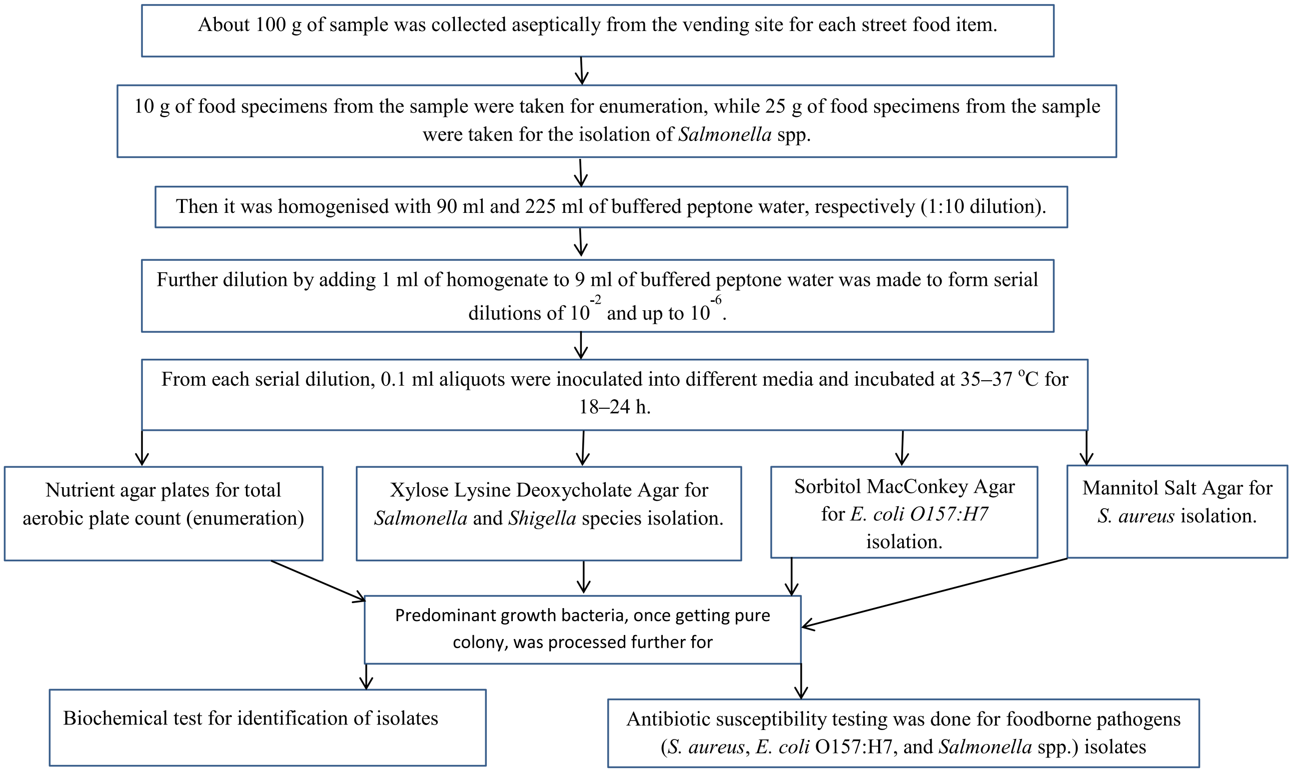

Figure 1 Laboratory procedures flow chart for microbiological analysis of selected street-vended foods from Arba Minch Town, Southern Ethiopia, 2022.

levels and indicate poor food handling practices. Further actions are required to re-establish effective food handling controls. (d) Potentially hazardous: indicates results exceed expected microbiological levels to a level that presents an immediate food safety concern.[2,17]

The predominant bacterial contaminants were identified by randomly picking 10–15 colonies with distinct morphological differences such as colour, size, and shape from countable plates. After purification by repeated plating, the isolated bacteria were characterised to the genus and species level by using cell morphology, Gram staining, and different biochemical tests [HiMedia Laboratory Pvt. Ltd., Mumbai, India], such as Triple Sugar Iron Agar (TSI), Simmon Citrate, Indole production, Gas, and H_2S production, Urease, Motility, Methyl Red-Voges Proskauer (MR-VP), and Oxidase.[7,32,33]

Isolation of *Staphylococcus aureus*

From the serial dilutions, 0.1 mL of the aliquot was spread onto Mannitol Salt Agar (MSA) [HiMedia Laboratory Pvt. Ltd., Mumbai, India] and incubated at 37 °C for 20–48 h. After incubation, golden yellow colonies on MSA, the catalase test (Remel Europe Ltd., Dartford, UK), coagulase activity (Remel Europe Ltd., Dartford, UK), and Gram staining were used to characterise *S. aureus* isolates.[6,10,33]

Isolation of *E. coli* O157:H7 Serogroup

From the serial dilutions, 0.1 mL of the aliquot was added into 5 mL of brain-heart infusion broth and incubated for 24 h at 37 °C for selective enrichment. Then, a 0.1-mL sample from the enrichments was subcultured onto Sorbitol MacConkey agar [HiMedia Laboratory Pvt. Ltd., Mumbai, India] plates recommended as the selective medium for isolation and detection of *E. coli* O157:H7. Unlike typical *E. coli*, the *E. coli* O157:H7 serogroup does not ferment Sorbitol and consequently grows colourless colonies following 24 h of incubation.[34,35] Thus, morphologically typical colonies producing a colourless (sorbitol non-fermenter) colony were then tested for lactose fermentation on MacConkey agar [HiMedia Laboratory Pvt. Ltd., Mumbai, India] along with different biochemical tests.[6,7,32,33]

Isolation of *Salmonella* and *Shigella* Species

The detection was performed by taking 25 g of street food samples into 225 mL of BPW [Oxoid, Hampshire, UK] and incubated at 37 °C for 24 h. Then, 1 mL of pre-enrichment broth culture was added to 10 mL of selenite faecal broth and again incubated at 37 °C for 24 h. Thereafter, a wire loopful of suspension from a tube was streaked onto Xylose Lysine Deoxycholate Agar (XLD) [HiMedia Laboratory Pvt. Ltd., Mumbai, India]. The presumptive colonies (a black colony surrounded by a red colour) were picked off and further characterised by a battery of biochemical tests and by Gram staining.[10,32,33]

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility test was performed on Mueller Hinton agar [HiMedia Laboratory Pvt. Ltd., Mumbai, India] by using Kirby-Bauer disk diffusion techniques.[36] The inoculation was incubated at 35–37 °C for 16–18 h according to the Clinical and Laboratory Standards Institute (CLSI).[37] Morphologically identical 3–5 pure colonies of foodborne pathogenic bacteria from the overnight incubated nutrient agar media were suspended in nutrient broth by using sterile wire loop with reference to 0.5 McFarland standards and incubated at 37 °C for up to 4 h. Then by using sterile cotton swab, the broth was uniformly inoculated into Mueller Hinton agar media. After 3–5 minutes of inoculation, selected antibiotic discs were applied to the surface of the medium by considered the size of the plate.

Antibiotic discs [Abtek Biologicals Ltd., UK] were selected for isolated foodborne pathogens as per the CLSI 2020 guideline[37] and by considering the commonly prescribed antibiotics for the treatment of foodborne diarrhoea in the area. Penicillin (10 µg), cefoxitin (30 µg), gentamicin (10 µg), erythromycin (15µg), tetracycline (30 µg), doxycycline (30 µg), ciprofloxacin (5 µg), clindamycin (10 µg), cotrimoxazole (25 µg), and chloramphenicol (30 µg) were utilised for testing isolated *S. aureus*, while *Salmonella* spp. and *E. coli* O157: H7 isolates were tested with antibiotics including ampicillin (10 µg), amoxicillin-clavulanic acid (30 µg), cefepime (30µg), ceftriaxone (5 µg), meropenem (10 µg), gentamicin (10 µg), azithromycin (15 µg), tetracycline (30 µg), doxycycline (30 µg), ciprofloxacin (5 µg), cotrimoxazole (1.25 µg), and chloramphenicol (30 µg). Then, after overnight incubation at 37 °C, the diameter of the zone of inhibition was measured by millimetre and interpreted as susceptible, intermediate, or resistant.[37]

Data Quality Management

The quality and reliability of data was ensured from data collection up to final microbiological identification by strictly following the standard operating procedures (SOPs) and by giving adequate training and follow-up for data and sample collectors. All required equipment and reagents were autoclaved, and icebox was used for sample transportation and samples were analyzed without delay. Reagent expiration date, appropriate storage conditions, and standard control strains like *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 25923 were used to check the quality of solid and liquid culture media, biochemical tests, and performance of antibiotic disk before use as per the manufacturer's instruction.[37] Significant foodborne pathogens were identified from pure culture following standard microbiological procedures.[32,33]

Data Analysis and Interpretation

Data was coded and entered by using Epi-data version 4.6 and exported to SPSS version 22 for further cleaning and analysis. Descriptive statistics like frequency, mean and percentage were calculated. A binary logistic regression model was used to assess associations between dependent and independent variables. Odds ratio (OR) with its corresponding 95% confidence interval (CI) was estimated. A variable with a p-value < 0.25 in the bivariate analysis was considered as candidates for further multivariate analysis. Adjusted odds ratio (AOR) with a corresponding 95% confidence interval and variables with a p-value < 0.05 were considered as statistically significant. Microbiological quality of street foods with $>10^5$ CFU/g of aerobic bacteria or mesophiles, $>10^4$ CFU/g of *Enterobacteriaceae*, $>10^3$ CFU/g of coliform, >10 CFU/g of enteropathogenic *E. coli* and 10^2 to 10^4 CFU/g of Staphylococcus species were considered unsatisfactory for consumption with this level of contamination, which results in foodborne illness. Detection of *Salmonella* species within 25 gram of street-vended ready-to-eat foods and *Shigella* species was considered as potentially hazardous.[2,17]

Ethical Considerations and Consent to Participate

The project protocol was approved by the Arba Minch University College of Medicine and Health Sciences' Institutional Research Ethics Review Board (Ref. No. IRB/1158/2021). In accordance with the Helsinki Declaration, the written consent was taken from all street food vendors and, moreover, vendors aged below 18 years old were approved by the ethics review committee to provide informed consent on their own behalf after explaining the objective of the study.

Operational Definition

Foodborne Pathogens

In this study, only *Staphylococcus aureus, Salmonella* species, and *Escherichia coli* O157:H7 isolates were considered foodborne pathogens.

Escherichia coli O157:H7

Escherichia coli O157:H7 was determined as an *E. coli* serogroup, which does not ferment Sorbitol and consequently grows colourless colonies on Sorbitol MacConkey agar medium following 24 h of incubation.[34,35]

Multidrug Resistance (MDR)

Multidrug resistance (MDR) was defined as isolated foodborne bacterial pathogens that resist at least one antimicrobial drug in three or more antimicrobial categories.[37]

Results

Socio-Demographic Characteristics of Street Food Vendors

Of the 75 street food vendors recruited for this study, the majority (48, 64%) were female. Thirty-three (44%) of the vendors were between the ages of 15 and 25; 23 (30.7%) were between the ages of 26 and 35; and 19 (25.3%) were over the age of 36. In relation to educational status, sixteen (21.3%) were illiterate, 28 (37.3%) and 26 (34.7%) had completed their primary and secondary school, respectively, and five (6.7%) were in college or above. About 26 (34.7%), 38 (50.7%), and 11 (14.5%) vendors had vending experience of less than five years, six to ten years, and more than eleven years, respectively, and about 51 (68%) vendors were unmarried.

Food-Handling and Hygienic Practices of Vendors

Among the overall food vendors, 28 (37.3%) vendors were ambulant, and 22 (29.3%) vendors had the practice of handling food for customers with their bare hands. While serving food, only 16 (21.3%) vendors were covered their hair. About 55 (73.3%) vendors reported having no training in managing and ensuring the safety of food. Despite the fact that 45 (60%) vendors were aware of foodborne illnesses from various sources, 8 (10.6%) vendors had a history of a foodborne illness, especially diarrhea and abdominal cramps. Closed bins and toilets were inaccessible for 24 (32%) and 38 (50.7%) vendors, respectively, at nearby vending sites (Table 2).

Hygiene of Commonly Vended Street Foods

A total of 330 samples of street food—Potato Chips (75, 22.7%), Sambusa (75, 22.7%), Koker (75, 22.7%), Ambasha (60, 18.2%), and Bombolino (45, 13.6%)—were gathered in the Sikela, Shecha, Yetnebersh, Limat, and Konso Sefer vending sites. Of which, 77 (23.3%) of the collected street foods were vended on tables without cover, and 52.1% of foods were vended near waste drainage (within 1–2 meters). In the display case, we observed that 56.1% of foods were directly exposed to dust and sunlight. Likewise, 56.1% of foods were transported from place to place in an unsafe way, mainly from the market and bus station vending areas (Table 3).

Bacteriological Quality of Street-Vended Foods

A total of 330 samples of street food were tested for bacterial contamination, and the study found that 99 (30%), 123 (37.3%) and 113 (34.2%) of the food samples had satisfactory ($<10^3$ CFU/g), acceptable ($\geq 10^3$, $<10^5$ CFU/g) and unsatisfactory ($\geq 10^5$ CFU/g) total mean aerobic bacterial contamination, respectively. Of which, about 25.7% (29/113)

Table 2 Food-Handling Practices, Vendors Personal Hygiene and Awareness on Foodborne Disease in Arba Minch Town, Southern Ethiopia, 2022

Variables	Categories	Number of Respondents (n = 75)
		Frequency (%)
Status of vendors	Ambulant	28 (37.3)
	Stationary	47 (62.7)
Place of preparation of food	Home	32 (42.7)
	Vending site	43 (57.3)
Hand washing practice	Yes	39 (52)
	No	36 (48)
Handled food with their bare hands	Yes	22 (29.3)
	No	53 (70.7)
Use of hair cover	Yes	16 (21.3)
	No	59 (78.7)
Practice of nail cutting	Yes	59 (78.7)
	No	16 (21.3)
Vendors handle money while serving food	Yes	61 (81.3)
	No	14 (18.7)
Use of clean water for cleaning utensils	Yes	63 (84)
	No	12 (16)
Training on food safety	Yes	20 (26.7)
	No	55 (73.3)
Information on food borne diseases	Yes	45 (60)
	No	30 (40)
History of food borne diseases	Yes	8 (10.6)
	No	67 (89.3)
Hand washing facilities accessible	Yes	36 (48)
	No	39 (52)
Availability of closed bins for waste disposal	Yes	51 (68)
	No	24 (32)
Availability of toilet nearby vending sites	Yes	37 (49.3)
	No	38 (50.7)

and 21.2% (24/113) of "Ambasha" and "Sambusa" street food items were found to have unsatisfactory total aerobic bacterial load, respectively, while only 5.5% (18/113) of "Potato Chips" samples had unsatisfactory bacterial contamination (Figure 2).

Among commonly vended street food samples with unsatisfactory bacterial contamination, the overall mean total aerobic bacterial count was recorded to be 4.3×10^5 CFU/g, ranging from 3.1×10^5 to 6.2×10^5 CFU/g. The highest

Table 3 Hygienic Safety of Commonly Vended Street Foods from Selected Vending Sites in Arba Minch Town, Southern Ethiopia, 2022

Variables	Categories	Frequency (%)
Means of vending	On the floor with basket	101 (30.6)
	On shelf in shop	91 (27.6)
	On tables with plastic cover	61 (18.5)
	On tables without cover	77 (23.3)
Proximity of the vending areas to drainage or sewerage	Yes	172 (52.1)
	No	158 (47.9)
Safety of food from dust, sun and winds	Yes	185 (56.1)
	No	145 (43.9)
Sheltered vending place	Yes	168 (50.9)
	No	162 (49.1)
Safety of food transportation	Appropriate	185 (56.1)
	Not appropriate	145 (43.9)

average aerobic bacterial counts were registered from Ambasha (6.2×10^5 CFU/g), followed by Koker (4.1×10^5 CFU/g), and Sambusa (3.8×10^5 CFU/g), while the smallest average aerobic bacterial count was obtained from potato chips with 3.1×10^5 CFU/g. In addition, the total mean *Enterobacteriaceae* count was 1.4×10^5 CFU/g, and the value ranged from 2.1×10^4 to 3.4×10^5 CFU/g. Likewise, the mean coliform count was 2.4×10^4 CFU/g, in which the value ranged from 1.6×10^3 to 4.8×10^4 CFU/g, and the total mean staphylococcal count was 3.4×10^4 CFU/g, which varied from 4.3×10^3 to 5.2×10^4 CFU/g (Table 4).

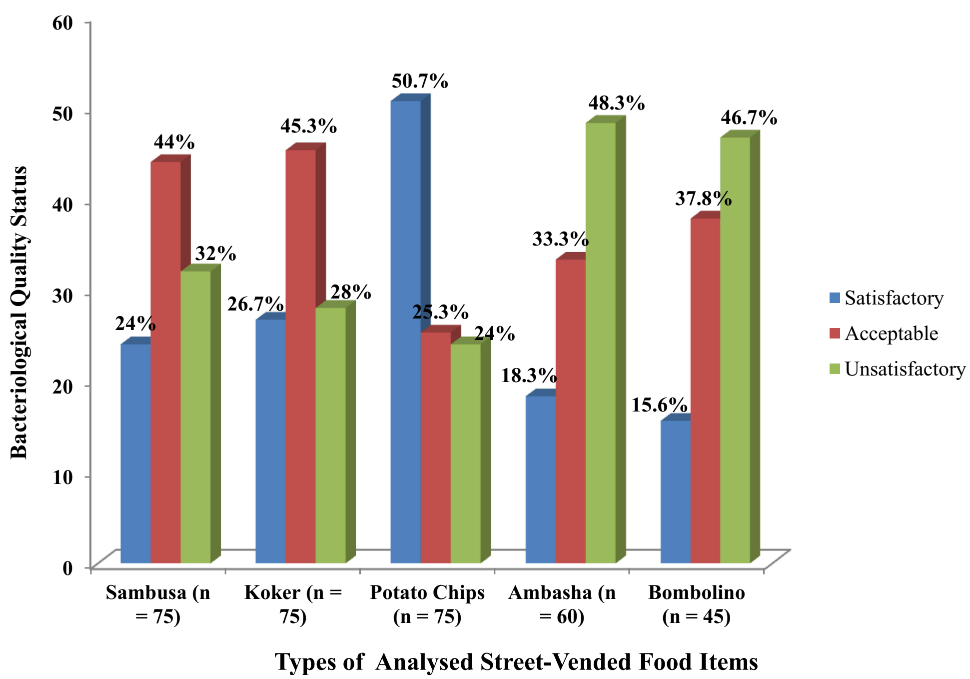

Figure 2 Bacteriological quality classification of street-vended foods (n = 330) by total aerobic bacterial count from selected vending sites in Arba Minch Town, Southern Ethiopia, 2022.

Table 4 Mean Total Aerobic Bacterial, *Enterobacteriaceae*, Coliform, and Staphylococcal Counts Among Commonly Vended Street Foods at Selected Vending Sites in Arba Minch Town, Southern Ethiopia, 2022

Variables	Mean Bacterial Quality of Street Foods (CFU/g)			
	Aerobic Bacterial Count	*Enterobacteriaceae* Count	Coliform Count	Staphylococcal Count
Street-Vended Food Items				
Sambusa (n = 75)	3.8×10^5	1.3×10^5	3.2×10^3	3.6×10^4
Koker (n = 75)	4.1×10^5	1.6×10^5	2.3×10^4	4.4×10^4
Potato Chips (n = 75)	3.1×10^5	2.1×10^4	1.6×10^3	4.3×10^3
Ambasha (n = 60)	6.2×10^5	3.4×10^5	4.8×10^4	5.2×10^4
Bombolino (n = 45)	3.4×10^5	6.1×10^4	1.8×10^4	3.4×10^4
Total (n = 330)	MABC = 4.3×10^5	MEBC = 1.4×10^5	MCFC = 2.4×10^4	MSC = 3.4×10^4
Selected Street Food Vending Sites				
Sikela (n = 75)	2.5×10^6	4.4×10^5	2.1×10^4	2.3×10^4
Shecha (n = 75)	2.3×10^6	4.1×10^5	2.3×10^4	2.2×10^4
Yetnebersh (n = 45)	2.7×10^5	3.1×10^4	2.1×10^3	1.3×10^4
Konso Sefer (n = 75)	1.9×10^6	1.7×10^5	1.8×10^4	2.4×10^4
Limat (n = 60)	1.8×10^5	2.8×10^5	1.3×10^4	2.3×10^4

Abbreviations: CFU/g, Colony Forming Unit/Gram; MABC, Mean Aerobic Bacterial Count; MEBC, Mean *Enterobacteriaceae* Count; MCFC, Mean Coliform Count; MSC, Mean Staphylococcal Count.

Regarding the vending sites, the highest mean of aerobic bacterial count (2.5×10^6 CFU/g) and Enterobacteriaceae count (4.4×10^5 CFU/g) from street vending food was recorded from samples collected from "Sikela" followed by food samples from "Shecha" with 2.3×10^6 CFU/g, and "Konso Sefer" with 2.3×10^6 CFU/g. The mean coliform count was high among street food samples from "Shecha" with 2.3×10^4 CFU/g, while the highest staphylococcal count was identified from street foods collected from 'Konso Sefer' (Table 4).

Factors Associated with Unsatisfactory Bacteriological Quality

Bivariate and multivariate logistic regression analyses were conducted to determine factors associated with the unsatisfactory bacteriological quality of commonly vending street foods. Thus, by using a p-value less than or equal to 0.25 in bivariate analysis as a cutoff point, multivariate logistic regression analysis using conditional backward methods revealed that vending style [AOR = 1.82, 95% CI: (1.12–2.94)], proximity of vending areas to waste drainage [AOR = 2.04, 95% CI: (1.25–3.29)], exposure of street foods to dust, sunlight, and winds [AOR = 4.99, 95% CI: (3.05–8.16)], and inappropriate way of street food transportation [AOR = 2.35, 95% CI: (1.38–3.98)] were found to be statistically significant to the unsatisfactory bacteriological quality of street-vended foods (Table 5).

Distribution of Predominant Bacterial Isolates from Street-Vended Foods

Among the 113 street food samples with an unsatisfactory bacterial contamination limit ($>10^5$ CFU/g), 137 bacteria were predominantly isolated and grouped under eight distinct genera. Twenty-four double bacterial contamination were registered in samples from 7, 6, 5, 4, and 2 of "Ambasha", "Sambusa", "Koker", "Bombolino", and "Potato Chips", respectively. Gram-negative bacteria were the dominant contaminants, constituting 77.4% of predominant isolates. *E. coli* was the most common isolate, accounting for 42 (30.7%), followed by *S. aureus* 31 (22.6%), and *Citrobacter* spp. 21 (15.3%). 4.4% (6/137) of *Salmonella* spp. were isolated, while *Shigella* spp. was not detected (Table 6).

Table 5 Factors Associated with Unsatisfactory Bacteriological Quality of Commonly Vended Street Foods from Selected Vending Sites in Arba Minch Town, Southern Ethiopia, 2022

Variables	Bacteriological Quality of Street-Vended Foods				
	Satisfactory (< 10^5 CFU/g)*	Unsatisfactory (≥ 10^5 CFU/g)	COR (95% CI)	AOR (95% CI)	*P*-value
Means of vending					
On shelf in shop	69 (31.8%)	32 (28.3%)	1	1	
On floor with basket	63 (29.0%)	28 (24.8%)	0.96 (0.52–1.76)	0.84 (0.45–1.56)	0.576
On table with cover	44 (20.3%)	19 (16.8%)	0.93 (0.47–1.84)	0.64 (0.32–1.34)	0.241
On table without cover	41 (18.9%)	34 (30.1%)	1.79 (0.96–3.32)	1.54 (0.82–2.91)	0.181
Vending Styles					
Ambulant	75 (34.6%)	51 (45.1%)	1.56 (0.98–2.48)	1.81 (1.12–2.94)	0.016
Stationary	142 (65.4%)	62 (54.9%)	1	1	
Proximity of Vending Areas to Waste Drainage					
Yes	103 (47.5%)	70 (61.9%)	1.80 (1.13–2.86)	2.04 (1.25–3.29)	0.004
No	114 (52.5%)	43 (38.1%)	1	1	
Safety of Food from Dust, Sunlight and Winds					
Yes	156 (71.9%)	29 (25.7%)	1	1	
No	61 (28.1%)	84 (74.3%)	7.41 (4.42–12.40)	4.99 (3.05–8.16)	0.001
Safety of Food Transportation					
Appropriate	134 (61.8%)	51 (45.1%)	1	1	
Not appropriate	83 (38.2%)	62 (54.9%)	1.96 (1.24–3.11)	2.35 (1.38–3.98)	0.002

Notes: *Street-vended foods under both Satisfactory (< 10^3 CFU/g), and Acceptable (< 10^5 CFU/g) range of bacteriological quality.
Abbreviations: AOR, Adjusted Odds Ratio; CFU/g, Colony Forming Unit/Gram; CI, Confidence Interval; COR, Crude Odds Ratio.

Prevalence of Foodborne Pathogenic Bacterial Isolates

From a total of 330 common street food samples tested, 42 (12.7%) foodborne pathogens were recovered. The isolated foodborne pathogens were 31 (9.4%) *S. aureus*, 6 (1.8%) *Salmonella* spp., and 5 (1.5%) *E. coli* O157:H7 (Sorbitol MacConkey non-fermenter among a total of 42 *E. coli* isolates). *E. coli* O157:H7 was isolated from "Sambusa" (n = 2), "Ambasha" (n = 2), and "Potato Chips" (n = 1). The maximum number of *S. aureus* was isolated from street foods from "Sikela" and "Konso Sefer" vending sites. Likewise, *Salmonella* spp. were isolated from street foods from 'Sikela,' 'Shecha,' and 'Konso Sefer' vending sites with equal distribution (n = 2) (Table 6).

Antimicrobial Susceptibility Profiles of the Isolated *S. aureus*

Out of the 31 isolates of *S. aureus* tested, relatively higher resistance was observed to penicillin 17 (54.8%) and tetracycline 16 (51.6%). Moreover, 6.5% (n = 2) of *S. aureus* isolates were found to be methicillin-resistant *S. aureus* (MRSA). On the other hand, isolated *S. aureus* exhibited 80.6%, 70.9%, and 61.3% susceptibility to gentamicin, clindamycin, and ciprofloxacin, respectively. Five *S. aureus* isolates (16.1%) were found to be multidrug-resistant (MDR) (Table 7).

Table 6 Distribution of Predominant Bacterial Isolates (n = 137) from Commonly Vended Street Foods at Selected Vending Sites in Arba Minch Town, Southern Ethiopia, 2022

Variables	Categories	Types of Predominant Bacterial Isolates								
		E. coli	*S. aureus*	*Citrobacter* Species	*Enterobacter* Species	*Klebsiella* Species	*Proteus* Species	*Salmonella* Species	*P. aeruginosa*	Total (%)
Food items	Sambusa (n = 75)	10	6	4	3	3	2	2	0	30 (40)
	Koker (n = 75)	6	5	5	4	2	2	1	1	26 (24.7)
	Potato chips (n = 75)	8	6	3	2	0	1	0	0	20 (26.7)
	Ambasha (n = 60)	11	8	5	3	3	2	2	2	36 (60)
	Bombolino (n = 45)	7	6	4	2	2	2	1	1	25 (55.5)
	Total number (330)	42 (30.7)	31 (22.6)	21 (15.3)	14 (10.2)	10 (7.3)	9 (6.6)	6 (4.4)	4 (2.9)	137 (100)
Vending Sites	Sikela (n = 75)	14	8	4	4	4	3	2	2	41 (54.7)
	Shecha (n = 75)	10	7	4	4	3	2	2	1	33 (44)
	Yetnebersh (n = 45)	4	5	3	1	0	1	0	0	14 (31)
	Konso Sefer (n = 75)	8	8	3	3	3	2	2	1	30 (40)
	Limat (n = 60)	6	3	7	2	0	1	0	0	19 (31.7)
	Total number (330)	42 (30.7)	31 (22.6)	21 (15.3)	14 (10.2)	10 (7.3)	9 (6.6)	6 (4.4)	4 (2.9)	137 (100)

Table 7 Antimicrobial Susceptibility Patterns of *S. aureus* Isolated from Commonly Vended Street Foods at Selected Vending Sites in Arba Minch Town, Southern Ethiopia, 2022

List of Antibiotics	Isolated *S. aureus* (n = 31)		
	Susceptible (%)	Intermediate (%)	Resistant (%)
Penicillin	14 (45.2)	Not applicable	17 (54.8)
Cefoxitin	29 (93.5)	Not applicable	2 (6.5)
Gentamicin	25 (80.6)	3 (9.7)	3 (9.7)
Erythromycin	16 (51.6)	6 (19.4)	11 (35.5)
Tetracycline	8 (25.8)	7 (22.6)	16 (51.6)
Doxycycline	11 (35.5)	6 (19.6)	14 (45.2)
Ciprofloxacin	19 (61.3)	7 (22.6)	5 (16.1)
Clindamycin	22 (70.9)	6 (19.6)	3 (9.7)
Cotrimoxazole	15 (48.4)	9 (29)	7 (22.6)
Chloramphenicol	12 (38.7)	7 (22.6)	12 (38.7)

Antimicrobial Susceptibility Profiles of Isolated *Salmonella* Spp. and *E. coli* O157:H7

Four of the six identified *Salmonella* spp. were ampicillin and tetracycline-resistant. Furthermore, three *Salmonella* spp. isolates were azithromycin resistant. Amoxicillin-clavulanate and meropenem were relatively efficient against five isolated *Salmonella* spp. Similarly, four identified sorbitol non-fermenter *E. coli* (*E. coli* O157:H7) strains were found to be ampicillin-resistant. Meropenem, on the other hand, was effective against four isolates of *E. coli* O157:H7. MDR was determined among two of each *Salmonella* spp. and *E. coli* O157:H7 isolate (Table 8).

Table 8 Antimicrobial Resistance Profiles of *Salmonella* Spp. and *E. coli* O157:H7 Isolates from Commonly Vended Street Foods at Selected Vending Sites in Arba Minch Town, 2022

List of Tested Antibiotics	*Salmonella* spp. (n = 6)			*E. coli* O157:H7 (n = 5)		
	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)
Ampicillin	2 (33.3)	0 (0)	4 (66.7)	0 (0)	1 (20)	4 (80)
Amoxicillin-clavulanate	5 (83.3)	1 (16.6)	0 (0)	3 (60)	0 (0)	2 (40)
Cefepime	4 (66.7)	NA	2 (33.3)	2 (40)	NA	3 (60)
Ceftriaxone	3 (50)	1 (16.6)	2 (33.3)	1 (20)	1 (20)	3 (60)
Meropenem	5 (83.3)	0 (0)	1 (16.6)	4 (80)	0 (0)	1 (20)
Gentamicin	4 (66.7)	1 (16.6)	1 (16.6)	3 (60)	1 (20)	1 (20)
Azithromycin	3 (50)	NA	3 (50)	2 (40)	NA	3 (60)
Tetracycline	2 (33.3)	0 (0)	4 (66.7)	1 (20)	2 (40)	2 (40)
Doxycycline	2 (33.3)	1 (16.6)	3 (50)	2 (40)	1 (20)	2 (40)
Ciprofloxacin	3 (50)	1 (16.6)	2 (33.3)	1 (20)	1 (20)	3 (60)
Cotrimoxazole	3 (50)	1 (16.6)	2 (33.3)	2 (40)	1 (20)	2 (40)
Chloramphenicol	4 (66.7)	1 (16.6)	1 (16.6)	2 (40)	0 (0)	3 (60)

Abbreviations: S, Susceptible, I, Intermediate, R, Resistant, NA, Not Applicable, spp: Species.

Discussion

In this study, 34.2% (113/330) with a 95% CI of 29.1–39.4 of frequently vended and highly consumed street food samples were found to be unsatisfactory due to being contaminated with indicator organisms and/or foodborne pathogens, which were comparable with a previous study done in Hawassa, Ethiopia (31%).[7] However, the result of this study was lower than studies conducted in different parts of Ethiopia: Gonder (ranges from 61.1% to 82.8%),[6,21] Addis Ababa (70%),[38] and Jigjiga (72%).[9] In contrast, the finding of this study was higher than the report from the study in Bangladesh (12%).[24] The kinds of street food involved, their compositions, bacteriological quality label interpretation difference and vendor personal hygiene and serving practices as well as the diversity of the environments and climatic circumstances could all contribute to the disparities in the setting.

The overall mean total aerobic bacterial count was recorded to be 4.3 × 10^5 CFU/g, ranging from 3.1 × 10^5 to 6.2 × 10^5 CFU/g, which was in line with the reports obtained from Gonder, 1.10 × 10^5 to 3.61 × 10^5 CFU/g,[21] and Kumasi, Ghana (5.9 × 10^5 CFU/g).[39] On the other hand, the findings of this study were lower than the studies conducted in Hawassa (1.7 × 10^5 to 6.7 × 10^6 CFU/g),[7] Jigjiga (1.9–4.6 × 10^6 CFU/g),[9] and Tirumala, India (12.16–25.81 × 10^5 CFU/g).[40] In contrast, this finding was higher than reports from Gondar (6.64 × 10^4 CFU/g)[6] and Lagos, Nigeria, which ranged from 2.98 × 10^3 CFU/g to 4.09 × 10^4 CFU/g.[28] These differences are primarily brought on by variations in food type and ingredients, preparation techniques, personal hygiene, vendor management, and serving practices, as well as a variety of environments and climatic conditions, which are favorable for bacterial proliferation.

"Ambasha" (6.2 × 10^5 CFU/g), "Koker" (4.1 × 10^5 CFU/g), and "Sambusa" (3.8 × 10^5 CFU/g) account for the maximum range of unsatisfactory high mean aerobic bacterial counts. This might be because "Ambasha" has a higher water activity, which may favor bacterial proliferation, and "Sambusa" has some internal ingredients that serve as excellent media for bacterial multiplication after being contaminated at room temperature, whereas "Koker" was mostly vended by ambulant vendors and handled excessively during transport, storage, and sale. In contrast, "Potato Chips" were the least contaminated among the foods tested. This could be due to the low moisture content and the manner in which these foods are handled and displayed. Unlike other street food items, we noticed that these "Potato Chips" were displayed by being covered with paper sheets.[7,9,21,38]

In this study, the mean total coliform count was 2.4 × 10^4 CFU/g, which ranged from 1.6 × 10^3 to 4.8 × 10^4 CFU/g, which is to some extent comparable with 2.6 × 10^3 to 1.9 × 10^5 CFU/g documented in Addis Ababa,[38] 8.3 × 10^4 CFU/g documented in Jigjiga,[9] and 2.6 × 10^3 to 5.2 × 10^4 CFU/g reported in Hawassa.[7] In contrast, our finding is much higher than the 3 × 10^2 to 6.4 × 10^3 CFU/g and 0.3–6.4 × 10^3 CFU/g reported in Gondar[6,21] and the 2.8 × 10^2 to 3.99 × 10^3 CFU/g in Tirumala, India.[40] Whereas the mean total *Enterobacteriaceae* count of 1.4 × 10^5 CFU/g recovered in this study, ranging from 2.1 × 10^4 to 3.4 × 10^5 CFU/g, which was higher than the 5.55 × 10^4 reports from Gonder, Ethiopia,[6] from Hawassa, Ethiopia, 8.2 × 10^3 to 6.8 × 10^4 CFU/g,[7] the 10^4–10^5 CFU/g reports from Sikkim, India,[41] the 1.0 to 4.7 × 10^4 CFU/g reports made in Ghana,[39] and the 6 × 10 to 8 × 10^2 CFU/g reports made in Egypt.[42] Similarly, the mean staphylococcal count was 3.4 × 10^4 CFU/g, which was consistent with results ranging from 1.4 to 2.9 × 10^4 CFU/g documented in Jigjiga.[9] The high coliform, *Enterobacteriaceae*, and staphylococcal counts observed in this study could be attributed to post-processing contamination as well as poor hygienic conditions among vendors and their vending environments.

In contrast to findings from studies in Jimma and Jigjiga, Ethiopia,[9,10] in this study, *E. coli* was the most predominant isolate, constituting 42 (30.7%), followed by *S. aureus* 31 (22.6%), and *Citrobacter* spp. 21 (15.3%), which suggests that the hands of people who handle food serve as the primary means of transferring bacteria from feces, noses, and skin to food. Additionally, some foods are kept in their original cooking pans until they are sold or reheated, which can lead to a prolonged holding period and favor the development of *E. coli* and *S. aureus*.[6,7,21]

In this study, 42 (12.7%) with a 95% CI of 9.4–16.4 of foodborne pathogens (*S. aureus*, 31 (9.4%), *Salmonella* spp., 6 (1.8%), and *E. coli* O157:H7, 5 (1.5%)) were recovered, which was in line with reports from the study in Bangladesh (12%).[24] On the other hand, the overall number of isolated foodborne pathogens in this study was lower than previous studies conducted in different parts of Ethiopia.[6,9,21] Unlike a study done in Addis Ababa, Ethiopia,[38] but consistent with previous studies, no *Shigella* spp. were encountered.[6,9,21] These foodborne pathogens could have been contaminated by vendors while being prepared or handled, or they could have come from contaminated water used to cleanse hands and utensils. The contamination of street foods with *S. aureus* stored at ambient temperature, could lead to food poisoning. Similarly, the presence of *E. coli* O157:H7 in ready-to-eat street foods could attribute to severe gastroenteritis and further complications; however, the prevalence discovered in this study (1.5%) was much lower than previous studies.[6,7,43] On the other hand, the prevalence of *Salmonella* spp. (1.8%) in this study was higher than the zero report in the study conducted in Gonder.[6,21] In contrast, the finding is much lower than reports from studies in Jigjiga (19.7%),[9] Hawassa (12.7%),[7] Jimma town (13.13%),[10] and Bahir Dar (57.5%).[29] The isolation of this organism from ready-to-eat street food is suggestive of poor hand hygiene and handling practices. Therefore, proper sanitary measures need to be taken when serving ready-to-eat street foods.

Additionally, the ongoing emergence and re-emergence of antibiotic-resistant foodborne bacterial pathogens necessitates concerted efforts.[6,7,10,38] This study revealed that among the 31 isolates of *S. aureus* tested, relatively higher resistance was observed to penicillin 17 (54.8%) and tetracycline 16 (51.6%). On the other hand, isolated *S. aureus* exhibited 80.6%, 70.9%, and 61.3% susceptibility to gentamicin, clindamycin, and ciprofloxacin, respectively. The finding is comparable with previous studies done in different parts of Ethiopia.[6,7,10] 6.5% of *S. aureus* isolates were found to be MRSA, which is lower than the studies conducted in Benin (15.18%)[44] and Hawassa (28.6%).[7] Likewise, 16.1% of isolated *S. aureus* were found to be MDR; this finding is below the reports from the study done in Jimma Town, south-western Ethiopia (38.3%).[10] 66.7% (4/6) of isolated *Salmonella* spp. were resistant to ampicillin and tetracycline; however, amoxicillin-clavulanate and meropenem were effective for 83.3% (5/6) of isolated *Salmonella* spp. MDR *Salmonella* spp. was discovered in 33.3% (2/6) of isolates, which is greater than the values reported in Jimma, Ethiopia (14.29%).[10] Eighty percent (4/5) of isolated *E. coli* O157:H7 strains were found to be ampicillin-resistant; however, more than 60% (3/5) responded better to amoxicillin-clavulanate, gentamicin, and meropenem. The proportion of MDR *E. coli* O157:H7 isolates was found to be 40% (2/5). The finding is in agreement with study findings in different parts of Ethiopia,[6,7,10] and Dhaka, Bangladesh.[45] The possible justification for the difference and increased prevalence of antibiotic-resistant foodborne pathogens could be the extensive spread of antimicrobial-resistant bacterial strains in the community, the source of contamination, vendor health status, community awareness towards the use of antimicrobials, and the easy availability of drugs without a prescription.

In terms of vendor profiles, the majority (64%) of vendors were female. The finding is in line with other studies carried out in Ethiopia and elsewhere, including Gondar, Addis Ababa, Jigjiga, and Jimma.[6,9,10,38] The majority (40%) of the food vendors had no information on foodborne diseases, in line with a previous study conducted in Gondar, where 42.5% to 58.3% of the food vendors had knowledge of foodborne diseases.[6,21] From the present study, it has been found that 29.3% of the food vendors served foods with bare hands, which is actually lower than reported in studies conducted in Gonder (45.8%) and Jigjiga (47.62%).[6,9] The majority (73.3%) of the food vendors had no training in food safety, which is similar to a study in Gonder, Ethiopia (79.2%).[6]

In the current study, street-vended foods with unsatisfactory ($>10^5$ CFU/g) bacterial quality were statistically associated with ambulant vending styles, which were found to be 1.82 times more likely to be contaminated than foods sold among stationary vendors [AOR = 1.82, 95% CI: 1.12–2.94], whereas street foods sold near waste drainage were 2.04 times more likely to be contaminated with indicator and/or foodborne pathogens [AOR = 2.04, 95% CI: 1.25–3.29]. Likewise, street foods exposed to direct dust particles and sunlight due to the absence of shelter from vending areas are found to be 4.99 times more likely to be contaminated with unsatisfactory loads of bacteria [AOR = 4.99, 95% CI: 3.05–8.16]. Similarly, street foods transported by vendors in an inappropriate way (without cover, leaving them exposed to different insects and dust particles) were more than twice as likely to be contaminated by bacteria in unsatisfactory loads [AOR = 2.35, 95% CI: 1.38–3.98]. Overall, these findings were consistent with reports from different studies conducted in Ethiopia.[6,9,22,46] Unsanitary surroundings, as well as poor personal hygiene of vendors due to a lack of training on proper handling and processing, are potential sources of post-processing contamination of ready-to-eat foods.[7,21,22]

Limitation of the Study

The range of foodborne bacterial pathogens investigated was constrained because the current research did not address pathogens like *Campylobacter* spp. and *Bacillus cereus* that have particular isolation requirements. Due to financial and material constraints, only Sorbitol MacConkey agar medium was utilised for the isolation of *E. coli* O157:H7 strain isolates and the antimicrobial susceptibility pattern was done only for *S. aureus*, *Salmonella* spp., and *E. coli* O157:H7 isolates. Similarly, the minimum inhibitory concentration (MIC) required for vancomycin susceptibility testing for S. aureus was carried out.

Conclusion and Recommendation

In this study, a significant number (113, 34.2%) of the street-vended foods were found to have a total mean aerobic bacteriological quality that was unsatisfactory (>10^5 CFU/g; 4.3×10^5 CFU/g). The total mean of *Enterobacteriaceae*, coliform, and staphylococcal counts were 1.4×10^5 CFU/g, 2.4×10^4 CFU/g, and 3.4×10^4 CFU/g, respectively. *S. aureus* (31, 9.4%), *Salmonella* spp. (6, 1.8%), and *E. coli* O157:H7 (5, 1.5%) were identified and made up 12.7% of foodborne bacterial pathogen prevalence. Higher resistance was observed to penicillin (54.8%) and tetracycline (51.6%) among isolated *S. aureus*. 6.5% and 16.1% of *S. aureus* isolates were found to be MRSA and MDR, respectively. Likewise, MDR *Salmonella* spp. and *E. coli* O157:H7 isolates were determined to be 33.3% (n = 2) and 40% (n = 2), respectively. Ambulant vending style, proximity of vending areas to waste drainage, exposure of street foods to dust, sunlight, and winds, and an inappropriate way of street food transportation were found to be statistically significant for the unsatisfactory bacteriological quality of street-vended foods. As a result, comprehensive health education and training for street food vendors, regular inspections of vending area environmental sanitation, and regular antibiotic resistance testing for foodborne bacteria are required. The study, on the other hand, provides helpful baseline data for public health specialists in the management of human infections caused by foodborne disease in the surveyed area. However, more research into the molecular characterization of foodborne bacterial pathogens is required.

Abbreviation

ATCC, American Type Culture Collection; BPW, Buffered Peptone Water; CLSI, Clinical and Laboratory Standards Institute; CFU, Colony Forming Unit.

Data Sharing Statement

The datasets generated during the current study are available from the corresponding author on reasonable request under the Ethics Committee's approval.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no conflicts of interest in this work.

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