Bacteriological Profile Antimicrobial Resistance Pattern and Handling Practice of Street Vended Foods, in Harar City, Eastern Ethiopia

Kasahun Bogale[1*], Wondwossen Abebe[2], Aklilu Ambachew[2], Tewodros Tesfa[1], Fitsum Weldegebreal[1, 3], Shambel Mekonnen[1], Firayad Ayele[1], and Aschalew Gelaw[2]

[1]School of Medical Laboratory Sciences, College of Health and Medical Science Haramaya University, Harar, Ethiopia
[2]School of Biomedical and Laboratory Sciences, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia
[3]Laboratory Bacteriology Research, Faculty of Medicine and Health Sciences, Ghent University, Corneel Heymanslaan 10, Ghent, Belgium

Abstract
Background: Street foods are prepared and sold by vendors, especially in the streets around trading centers and other public places, for immediate or later consumption without further processing or preparation. However, the extent of the bacterial profiles of street foods and the handling practices of food handlers are poorly understood. Therefore, this study aimed to assess the bacteriological profiles of street foods, handling practices, and antimicrobial resistance patterns of the bacterial isolates in Harar city between March and June 2021.
Methods: A cross-sectional study design was conducted among 137 food samples from 137 street food vendors. A questionnaire and observational checklist were used to collect the data. The samples were analyzed for bacterial pathogens and counted for bacteria load by the standard aerobic plate count method. Ten grams of solid and 10 ml of liquid samples were collected then each food samples were transferred and homogenized into 90 ml of sterile buffered peptone water. The homogenates solution was serially diluted, and a volume of 0.1 ml dilution was spread on plate count agar, Violet red bile agar, MacConkey agar, Xylose Lysine Deoxycholate agar, and Mannitol salt agar to identify and enumerate bacteria. An antibiotic susceptibility test of the isolates was done on Muller Hinton agar using the Kirby Bauer disk diffusion method. Data were entered into Epi info 7.2 and analyzed using Statistical Package for the Social Sciences version 20.
Results: All the food items tested were contaminated with one or more bacteria. The predominant isolates were *E. coli* (46.7%), and *S. aureus* (27.7%). Accordingly, the aerobic plate count, *Enterobacteriaceae* count, and *Staphylococcal* count for all the samples tested varied from 5.2 x 105 CFU/g to 4 x 107 CFU/g, 1.2 x 103 CFU/g to 8.4 × 106 CFU/g, and 1.6 x 103 CFU/g to 3.4 x 105CFU/g, respectively. Among all the antibiotics tested, ampicillin (71.2%), ceftriaxone (39.6%), and sulphamethoxazole-trimethoprim (38.5%) showed higher resistance against all the isolates. In this study, 69 (50.4%) of vendors were observed to handle fast food with bare hands and 11% of them allowed their customers to touch the fast food with their bare hands.
Conclusions: All of the food samples tested were found contaminated with different pathogenic bacteria that could be associated with food-borne illnesses. Training street food handlers to raise their awareness about proper food handling practices and personal hygiene is necessary.
***Keywords*:** Bacteriological assessment, street vended foods, antimicrobial resistance pattern, Harar, eastern Ethiopia.

How to cite: Bogale, K., Abebe, W., Ambachew, A., Tesfa, T., Weldegebreal, F., Mekonnen,S., Ayele, F.,.and, Gelaw, A. 2023 Bacteriological Profile Antimicrobial Resistance Pattern and Handling Practice of Street Vended Foods, in Harar City, Eastern Ethiopia. *East Africa Journal of Health and Biomedical Sciences,* Volume 7 (2): 41-56.

Introduction
Street vended foods are types of foods prepared and sold by vendors, especially bus stations, industrial areas, schools, marketplaces, streets sides, and other public places, for immediate or later consumption without further processing (WHO, 1996). The growing informal sector maintains the food supply chain and provides affordable food to all groups of people (Alimi and Workneh, 2016). The ingredients, forms, frequency of consumption, and regularity of street-vended foods are diverse and are influenced by national and/or regional food cultures. In addition, the preparation methods are also different, which could be fried, roasted, boiled, baked, steamed, or eaten raw (ImathIu, 2017;Modarressi and Thong, 2010).

The street vendor food did not fulfill the food safety requirements (Rane, 2011, Teferi, 2020) and is not

Corresponding Author; Email kasahun.bogale16@gmail.com
Haramaya University, 2023
ISSN 2519-917X, ISSN: 2959-2097

subject to formal inspection by regulatory authorities in many developing countries (Temesgen and Abdisa, 2015). Most street food vendors also operate without a license and in undesignated locations with limited infrastructure. The street-vended foods are also vulnerable to contamination by pathogens as they are sold openly without any proper coverings. Environmental dust in the hands of vendors, and customers increases the risk of food contamination (Rane, 2011, WHO, 1996). In addition, street food is often subjected to cross-contamination organisms from diverse sources such as utensils, knives, raw foods, and flies (Muyanja *et al*., 2011). According to the National Hygiene and Sanitation Strategy program, about 60% of the burden of the disease in Ethiopia is due to poor hygiene and sanitation, contaminated raw foods, improper food storage, poor personal hygiene during food preparation, and insufficient cooling (Ayana *et al*., 2015).A wide range of foodborne infections are becoming an increasing public health concern worldwide, the problem is excessively affecting low and middle-income countries (Skovgaard, 2001). According to the World Health Organization (WHO) 2015 survey, 600 million individuals were affected with food-borne diseases (WHO, 2015). It has been estimated that about 700,000 deaths due to food and water-borne diseases occur in Africa annually (Mengist *et al*., 2018).

Many pathogenic microorganisms are isolated from street vended foods. Most common isolates are: *Escherichia coli*, *Klebsiella* species, *Proteus* species, *Salmonella* species, *Pseudomonas* species, *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus* and *Enterobacter* species (Rane, 2011).Antimicrobials are used for growth promotion, treatment, and prevention of bacterial infectious diseases in food animals. This can be responsible development of antimicrobial-resistant zoonotic foodborne bacterial pathogens and possible transmission to humans (Hoelzer *et al.,* 2017). The prevalence of antimicrobial resistance among foodborne pathogens has risen significantly in recent decades (Threlfall *et al*., 2000). A study conducted in Hawassa; Ethiopia found that around 89% of *Salmonella* species and 14.3% of *staphylococcus aureus i*solated from street foods were resistant to chloramphenicol and vancomycin, respectively (Eromo *et al*., 2016b). In another study, high rates of resistance to ampicillin and ceftazidime were observed among *Enterobacteriaceae* isolates from street vendor food (Amare *et al*., 2019). These findings emphasize the growing challenge of antimicrobial resistance in the food supply, particularly in developing regions. Thus, these high levels of resistance, including critically important antimicrobials, underline the need for improved food safety practices, surveillance, and antimicrobial stewardship to mitigate the spread of resistant pathogens (Okaiyeto *et al.,* 2024).

Food regulation in Ethiopia is a joint duty of the Ministry of Health, the Ministry of Agriculture and Rural Development, the Ministry of Trade and Industry, and the Ethiopian Quality and Standards Authority. However, there is little coordination and cooperation between various government regulatory units. Furthermore, present laws, and regulations are out of date and cannot address modern food quality and safety concerns (Temesgen and Abdisa, 2015). In Harar city, street food vending practices are common, however, the bacterial profile of food is not known. Therefore, this study aimed to determine the bacteriological profiles of street food, the handling practices, and the antimicrobial susceptibility pattern of the bacterial isolates in Harar city eastern Ethiopia.

Materials and Methods

Study Setting, Design, and Period

The community-based cross-sectional study was conducted from March to June 2021 on a street food vendor in Harar city, Ethiopia. Harar city is the capital city of Harari People Regional State. Harar city was found 525km east of Addis Ababa. It is one of the major urban areas of the region, about 133,673 of the population resides in the town (Assefa and Semahegn, 2016). A total of 405 street food vendors were registered in the town of which 274 street food vendors were found in five selected study areas Harar city namely, Arategna, Bira, Jugol, Bus station, and Shewaber. Street food vending is common in Harar city, during breakfast and snack time. Among fast foods, “Foul”, “Bonbolino”, Potato chips, “Sambussa”, Juices, and Bread were the commonly street-vended foods often sold on the street of Harar city.

Population, Inclusion/ Exclusion Criteria

Street food vended places in Harar city were the study population. Ready-to-eat street foods and vendors that have direct contact with food and food contact surfaces were included. While vendors who were not involved in the preparation of food, fruits, and leftover foods from selected samples were not included.

Sample Size and Sampling Technique

The sample size of the study was determined by using a single population proportion formula by considering the prevalence (p) of bacterial contamination (83%) from a study conducted in Gondar town, Ethiopia (Adimasu *et al*., 2016), with a 95% confidence interval (CI), and a 5% margin of error. In this study, five street food vended places in Harar city like Arategna, Bira, Jugol, Bus station, and Shewaber, were randomly selected. One hundred thirty-seven street food vendors and ready-to-eat foods were included in this study. Study participants were selected by simple random sampling method from a selected area of the town. Samples of potato chips, bread, "foul", fruit juice, "bonbolino" and "sambussa" were selected street food items because those foods were commonly street vended foods in the study area and were collected from the five different highly street food vending sites in Harar city, namely, Arategna, Bira, Jugol, Bus station, and Shewaber. A total of 137 samples of a street (food samples were collected from 137 street food vendors) from foods were collected. The food items included in this study were 24 potato chips, 23 bread, 23 "foul", 24 fruit juice, 21 "bonbolino", and 22 "sambussa". (Figure 1).

Data Collection Techniques

Data were collected by the following method;

Face-to-face interview and observation: were conducted by three bachelor's degree nurses using a pretested questionnaire and observation checklist adapted from the literature (Amare *et al*., 2019, Eliku, 2016, Derbew *et al*., 2013, Khairuzzaman *et al*., 2014). The questionnaire contains socio-demographic characteristics such as age, sex, marital status educational status; vending site hygiene such as vending area neatness, presence of a toilet in the working area, presence of waste bin in the working area, presence of flies in the working area and food handling practices such as handing of food with a bare hand, contact of the customer to food, cleanness of fingernail, and wearing of jewelry.

Food sample collection and transportation: Food samples were purchased from vendors between 8 to 10 am and 3 to 6 pm by using vendors' serving utensils and placing them into sterilized aluminum plates. The samples were collected by buying whole food as a consumer and the required amount, 10 grams for solid food items and 10 milliliters for liquid food items, was taken for laboratory analysis. Each of the fruit juice samples (100ml) was collected in a sterile Erlenmeyer flask. All the samples were aseptically collected in sterile containers and then transported to the Haramaya University, School of Medical Laboratory Sciences, and Medical Microbiology Laboratory in an icebox and processed within 2 hours of collection (Kiiyukia, 2003).

Bacterial isolation and identification: A 10grams (10ml, if fruit juice) food sample was homogenized in 90ml of buffered peptone water and shaken vigorously using a vortex (Kiiyukia, 2003). A 10-fold serial dilution was performed on the homogenized samples and diluted serially to obtain dilutions up to 10-5. Then 0.1ml suspension of the dilutions was spread onto duplicate sterile plates of plate count agar, Violet red bile agar, MacConkey agar, Xylose Lysine Deoxycholate agar, and Mannitol salt agar, for the total aerobic plate count, Coliform count, *Enterobacteriaceae* count, isolation of *Salmonella* and *Shigella,* and for enumeration of *Staphylococcus aureus,* respectively. Plates for bacterial enumeration were inoculated on appropriate media using the spread plate method and then incubated under an aerobic atmosphere at 37^{o}C for 24-48 hrs. Thereafter, colonies between 30-300 were counted, then multiplied by dilution factors, and expressed as colony-forming units per gram (CFU/ml) (Acco *et al*., 2003). The plate count was then compared to the microbiological quality of ready-to-eat food's standard plate count threshold based on the table below (Authority, 2009). Different colonies grown on mannitol salt agar and MacConkey agar were further sub-cultured on the nutrient agar to get pure isolates and finally, each isolate was identified and confirmed through gram staining and using different biochemical tests, such as Catalase test, Oxidase test, DNase, Triple sugar iron agar, Lysine iron agar, Urea agar, Simmons Citrate agar, Phenylalanine deaminase, Motility indole ornithine, and Methyl Red and Voges-Proskauer (Cheesbrough, 2005).

Table 1; Guideline levels for determining the microbiological quality of ready-to-eat foods (Authority, 2009).

Test	Microbiological result (cfu/g)		
	Good	Acceptable	Unsatisfactory
Aerobic plate count			
Category A	$<10^4$	$<10^5$	$\geq10^5$
Category B	$<10^6$	$<10^7$	$\geq10^7$
Category C	NP	NP	NP
Enterobacteriaceae count	$<10^2$	10^2 to $<10^4$	$\geq10^4$
Staphylococcal count	$<10^2$	10^2 to $<10^3$	10^3 to $<10^4$

NP: not applicable

Antimicrobial susceptibility testing: Antimicrobial susceptibility testing was carried out for isolates using the Modified Kirby Bauer Disk Diffusion method on Mueller-Hinton agar (MHA), according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (CLSI. 2020). In brief, three to five bacterial colonies were taken from selected street food and transferred to a tube containing 5 ml of normal saline and mixed gently until it formed a homogeneous suspension equivalent to 0.5 McFarland standards. Sterile cotton swabs were dipped into the bacterial suspension and then swabbed using a sterile cotton swab over the whole surface of MHA. Within five to ten minutes, antibiotic discs were applied using a sterile forceps on the medium surface and were gently pressed to ensure that the disk was attached to the agar surface of the plate. The antibiotic discs tested were ciprofloxacin (5µg), ampicillin (10µg), erythromycin (15µg), sulfa- methoxazole-trimethoprim (1.25/23.75µg), gentamicin (10µg), cefoxitin (30µg), ceftriaxone (30µg), amikacin (30µg), and Augmentin (20/10□g). These antibiotics were chosen based on their availability and prescription frequency in Ethiopia for the treatment of bacterial infections. The growth inhibition zone size around each disc was measured using a digital caliper after incubation at 37 °C for 18-24 hrs and interpreted as sensitive, intermediate, and resistant according to the breakpoints of the Clinical and Laboratory Standards Institute guidelines (CLSI. 2020). Bacterial isolates that were resistant to at least one agent in three or more antimicrobial categories were classified as multidrug-resistant (Kang *et al*., 2017).

Definition of Terms

Sambusa: A deep-fried triangle of wheat dough stuffed with lentils, chopped onions, salt, cooking oil, and chill paper.

Foul: The boiled bean and then mixed with onion, tomato, potato, and chilled paper.

Bonbolino**:** It is a fried piece of wheat dough with salt and baking powder cooked with cooking oil, commonly of a ring or circular shape without cream.

Data Quality Control

The questionnaire was first prepared in English and translated into Amharic and Afan Oromo which are two local language use frequently in area and then translated back to English by different bilingual experts to check the consistency. The questionnaire was reviewed and pretested on 5% of the food handlers in Aweday town. Standard operating procedures were employed in every step of sample collection and processing. To ensure sterility, materials, and media were autoclaved at 121ºC for 15 minutes. All culture media were prepared following the manufacturer's instructions and their sterility was checked by incubating 5% of the batch at 37°C overnight and observing for growth. Culture media, which showed any growth, was rejected, and replaced by preparing a new sterile batch. The aseptic technique was used throughout all sampling and handling procedures by using sterile materials, flaming, and refrigeration. The performance of the media was checked using *S. aureus* (ATCC, 25923) for mannitol salt agar and *E. coli* (ATCC, 25922) for MacConkey agar and was incubated aerobically at 37°C and observed for the degree of growth, size of colonies, and other morphological identification characteristics.

Data Processing and Analysis

All the data were checked for completeness and internal consistency by cross-checking and then were coded and double-entered into EPI Info 7.2 and exported to the SPSS version 20.0 software package for analysis. Descriptive statistics such as median, interquartile range, standard deviation, frequencies, and percentages were computed.

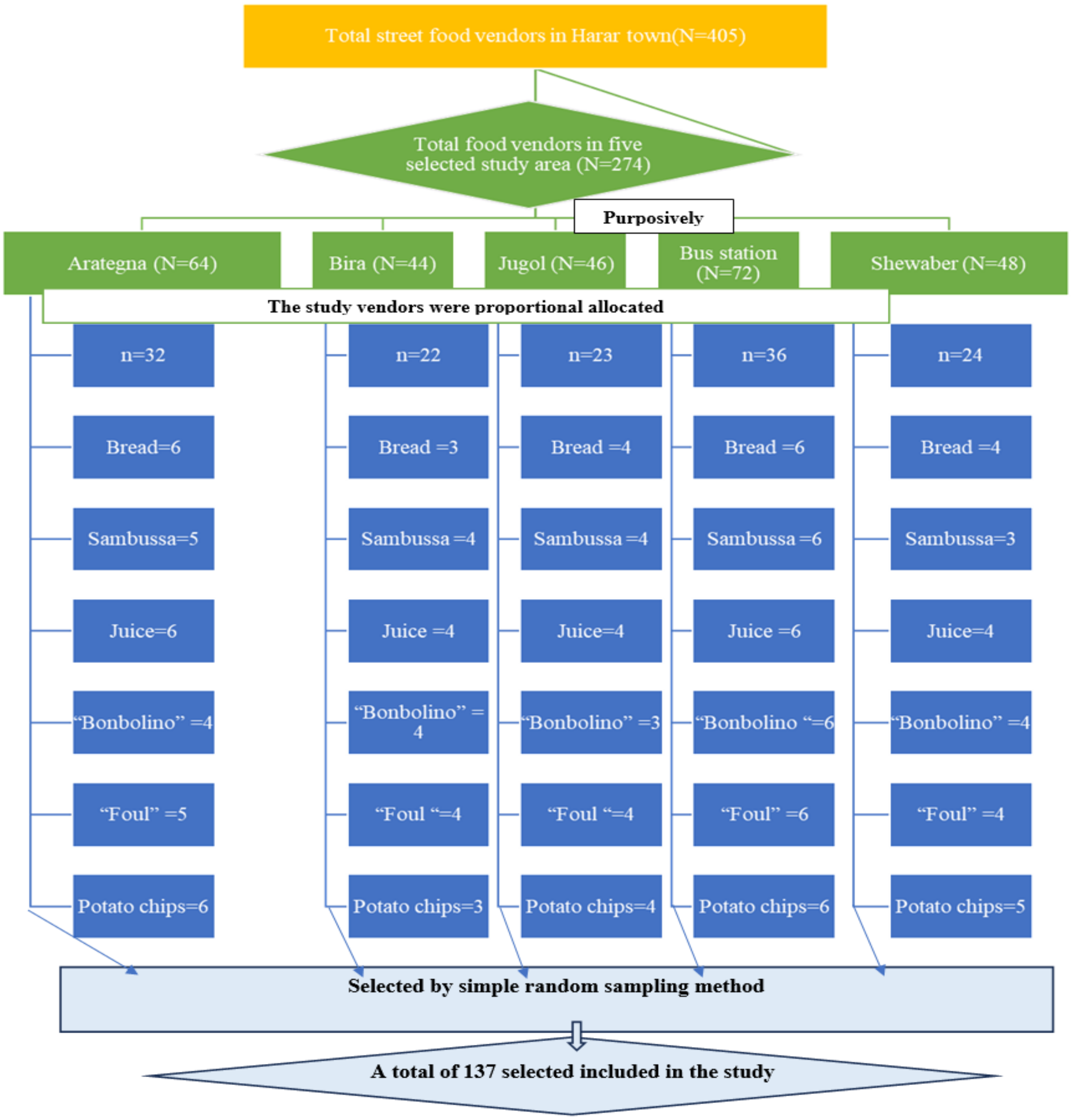

Figure1: Diagrammatic presentation of sampling techniques of street food vendors and food in Harar city from March 2021 to June 2021 (n=137)

Ethical Consideration

Ethical clearance was obtained by the Research and Ethical Review Committee of the School of Biomedical and Laboratory Sciences, College of Medicine and Health Sciences, University of Gondar. An official letter of cooperation was obtained from the Harari Region Health Bureau and Municipality office. The purpose and objective of the study were described to the vendors, and their informed consent was obtained.

Results

Socio-demographic characteristics of participants

A total of 137 street food vendors with one of their selected foods were included in this study. Most of the study participants (69.3%) were female. The ages of participants ranged from 11 to 70 years with a median age of 27 and an interquartile range of 18. About 37 (27%) were below 20 years and 42 (30.7%) were between 21 and 30 years old. More than half (57%) of the vendors were married. Regarding educational status, 19.7% were unable to read or write and 41% had completed primary education (Table 2).

Table 2: Socio-demographic characteristics of street food vendors, in Harar city, Harari region, eastern Ethiopia, 2021(n=137).

Socio-demographic characteristics		Number	Percentage
Age (in years)	≤20	37	27.0
	21-30	42	30.7
	31-40	30	21.9
	41-50	19	13.9
	≥51	9	6.6
Gender	Female	95	69.3
	Male	42	30.7
Marital status	Single	49	35.8
	Married	78	56.9
	Divorced	5	3.6
	Widowed	5	3.6
Educational status	Unable to read or write	27	19.7
	Primary school	56	40.9
	Secondary school	40	29.2
	Diploma and above	14	10.2
Street food Venders' location	Arategna	32	23.4
	Bira	22	16.1
	Jugol	23	16.8
	Bus station	36	26.3
	Shewa Ber	24	17.5
Experience of vendor (in years)	0-4	96	70.1
	5-9	32	23.4
	10-14	8	5.8
	>15	1	0.7

Street food preparation and vending environment

Ninety-five (69.3%) of vendors were non-mobile vendors, 86 (62.8%) of vendors worked in the presence of some garbage, and 30 (21.9%) of vendors worked in dusty environments. Among non-mobile vendors, half percent of them had waste bins and 73.7% of them hadn't a waste pit. Thirty-nine percent of non-mobile vendors had not a hand-washing facility with soap and among them, only 12.6% were using a towel to clean their hands. Among non-mobile vendors, 87(91.6%) of were having latrines and 8 (8.4%) didn't have a latrine nearby to the working area (Table 3).

Street food handling practices

In this study, 69 (50.4%) of vendors were observed to handle fast food with bare hands and 11% of them allowed their customers to touch the fast food with their bare hands. As observed during their vending practices, 89% of the vendors handle food and collect money with the same hand. In addition, 60% of vendors wore finger jewelry, 22% of vendors had a long and uncleaned nail and 5(3.6%) of the total study vendors were observed having sores and cuts on their hands. Ninety-eight (71.5%) of respondents were observed to vend food from containers with cover while 39 (28.5%) of them sold food to customers from containers without cover. About 86.1% of vendors were not having a refrigerator. Among the vendors, 85.4% didn't have washing dishes to wash their utensils washing dishes. Most (95.6%) of the vendors didn't have formal training in vending and the preparation of food (Table 4).

Table 3: Characteristic of street food preparation, vending environment and food handling practices of handlers, eastern Ethiopia, 2021 (n=137).

Street food working environment	Category	Number	Percentage
Vending area	Mobile vendor	42	30.7
	Non-mobile vendor	95	69.3
Vending area neatness	No visible garbage	18	13.1
	Some	86	62.8
	Much	33	24.1
Dusty vending area [a]	No	107	78.1
	Yes	30	21.9
Waste bin present*	No	47	49.5
	Yes	48	50.5
Waste pit present*	No	70	73.7
	Yes	25	26.3
Presence of a hand-cleaning towel	No	83	87.4
	Yes	12	12.6
Hand washing soap present*	No	37	39.0
	Yes	58	61.0
Presence of toilet nearby area*	No	8	8.4
	Yes	87	91.6
the presence of houseflies around the food waiting area	No	80	58.4
	Yes	57	41.6

[a]*: the presence of dusty air conditioning around food preparation, and selling area, *: non-mobile vendors*

Table 4: Food handling practices of handlers, eastern Ethiopia, 2021 (n=137)

Food handling practices	Catagory	Number	Percentage
Handle food with bare hand	No	68	49.6
	Yes	69	50.4
Customers contact food	No	122	89.1
	Yes	15	10.9
Uses the same hand to handle food and collect money	No	16	11.7
	Yes	121	88.3
Vend food from the container with a cover	No	98	71.5
	Yes	37	28.5
Vender wear finger jewelry	No	55	40.1
	Yes	82	59.9
The Vender had long and unclean nail	No	107	78.1
	Yes	30	21.9
Vendor had refrigerator	No	118	86.1
	Yes	19	13.9
Vender had a cut/lesion on their hand	No	132	96.4
	Yes	5	3.6
Utensil washing dishes present	No	117	85.4
	Yes	20	14.6
Training in food preparation	No	131	95.6
	Yes	6	4.4
Awareness of food-borne disease	No	30	21.9
	Yes	107	78.1
History of illness in relation with food borne disease	No	123	89.8
	Yes	14	10.2

Prevalence of bacterial isolates

The detection rate of bacteria from 137 street food items was 100%. The majority, 93 (68%) foods were contaminated with two different bacterial species. Thirty-eight (27.7%) of food items were contaminated with a single bacterial species, and the remaining 6 (4.3%) of the food items were contaminated with three different bacterial species. Overall, 245 bacterial isolates were detected, 139 (56.7%) of the isolates were gram-negative and 106 (43.3%) isolates were gram-positive bacteria. Among the gram-negative bacteria isolates, *E. coli* 64 (46.7%) was the predominant followed by *Enterobacter* spp. 20 (14.6%), *Proetus* species 19 (13.86%) and *Klebsiella* species 18 (13.1%). Other gram-negative bacterial isolates detected at relatively lower proportions include *Citrobacter* species 7 (5.1%), *P. aeruginosa* 5 (2%), *Salmonella* species 4 (2.9%), and *Providencia* species 2 (0.8%).Among the gram-positive bacteria, *S. aureus* 38 (27.7%) was the predominant followed by Bacillus species 31 (22.6%), Coagulase-negative staphylococci 27 (19.7%), and Enterococcus species 10 (7.3%). The distribution and detection rate of bacterial isolates across the food items tested were different. A high number of isolates were found from "foul" 47 (19.1%), followed by bread, "sambussa" and Juice 42(17.1% each), and potato chips 35 (14.2%). *Escherichia coli* and *S. aureus* were the most frequently detected isolates across the various food items (Table 5)

Table 5: Prevalence of bacterial isolates from street food, eastern Ethiopia, 2021(n=24).

Types of food items	Types of bacterial isolates												Total (%)
	E. coli	*S. aureus*	*Klebsiella spp.*	*Coagulase-negative staphylococci*	*Enterobacter* spp.	*Bacillus* spp.	*Citrobacter* spp.	*P. aeruginosa*	*Salmonella* spp.	*Proetus* spp.	*Providencia* spp.	*Enterococcus* spp.	
Bread(n=23)	10	10	5	4	1	7	1	1	1	2	0	0	42
"Sambusa" (n=22)	12	7	1	5	2	5	3	3	1	2	0	1	42
Juice(n=24)	14	2	2	6	8	5	3	0	1	1	0	0	42
"Bombolino" (n=21)	7	8	4	7	0	1	1	1	1	5	0	3	38
"Foul" (n=23)	9	6	3	3	4	11	0	0	0	5	1	5	47
Potato chips(n=24)	12	5	3	2	5	2	1	0	0	4	1	1	36
Total (%) (n=137)	64	38	18	27	20	31	9	5	4	19	2	10	247
Vendor's location													
Arategna(n=32)	17	10	6	6	4	6	2	2	0	5	0	1	59
Bira(n=22)	13	5	3	4	3	5	2	1	0	3	0	2	41
Jugol(n=23)	11	4	3	4	4	3	2	1	1	3	0	3	39
Bus station(n=36)	12	11	3	8	6	12	2	1	2	7	1	3	68
Shewa ber(n=24)	11	8	3	5	3	5	1	0	1	1	1	1	40
Total (n=137)	64	38	18	27	20	31	9	5	4	19	2	10	247

The microbial load of street food

Ten (7.3%) of street vended foods showed an unsatisfactory result which ACC was ≥107 CFU/g. One hundred twenty-seven (92.7%) of food items were detected to have a high *Enterobacteriaceae* count greater than 104 CFU/g, which is beyond the acceptable limit of ready-to-eat foods (Kiiyukia, 2003). Similarly, the coliform counts of all tested food items were beyond the acceptable range (Authority, 2009). Out of 38 *S. aureus*, positive samples 26 (68.4%) were also beyond the acceptable range (>104CFU/g). The total mean aerobic plate count (MAPC) of bacteria was 9.9x106CFU/g, with high MAPC detected in "sambussa" (4x107 CFU/g) and low MAPC detected in fruit juices (5.2x105 CFU/ml). The total mean *Enterobacteriaceae* count was 6.4x105 CFU/g in which the value ranged from 1.2x103 CFU/g in fruit juices to 8.4 × 106 CFU/ml in bread samples. Similarly mean coliform count for all samples tested was 2.5x105 CFU/g, which ranged from 8x102 CFU/g in "foul" to 7.4x106

CFU/g detected in "sambussa". The total mean Staphylococcal count (MSC) was 4.1x104CFU/g which varied from 1.6x103 CFU/g in "sambussa" to 3.4x105CFU/g which was detected in "bonbolino" (Table 6).

Table 6: Mean Bacterial Count of food and distribution of bacterial load, eastern Ethiopia, 2021(n=137).

Food items	Aerobic plate count (cfu/g)			*Enterobacteriaceae* count (cfu/g)			Coliform count (cfu/g)			*Staphylococcal* count (cfu/g)		
	Min.	Max	Mean	Min.	Max	Mean	Min.	Max	Mean	Min.	Max	Mean
Bread	1.7×10^3	4.5×10^7	$4.2x10^6$	$2.1x10^3$	8.4×10^6	$9x10^5$	Nd	$3.1x10^6$	$2.8x10^5$	$4.2x10^3$	$19x10^4$	$9.5x10^3$
"Sambussa"	$2.6x10^4$	$6.5x10^8$	$4x10^7$	$1x10^4$	$6.4x10^6$	$8.8x10^5$	$1x10^2$	$7.4x10^6$	$4.9x10^5$	$1.6x10^3$	$5.2x10^4$	$1.8x10^4$
Juices*	$1.7x10^4$	$3.5x10^6$	$5.2x10^5$	Nd	$4.5x10^6$	$4.9x10^5$	Nd	$4.2x10^5$	$8.9x10^4$	$1.3x10^4$	$1.8x10^4$	$1.55x10^4$
"Bonbolino"	$1.3x10^4$	$5.4x10^7$	$6.6x10^6$	Nd	$3.7x10^6$	$5x10^5$	Nd	$5.8x10^5$	$1.2x10^5$	$2.7x10^3$	$3.4x10^5$	$1.1x10^5$
"Foul"	$2.2x10^4$	$5.1x10^7$	$8.5x10^6$	$7x10^3$	$3.1x10^6$	$4.3x10^5$	$8x10^2$	$3.1x10^6$	$2.6x10^5$	$8x10^3$	$9x10^4$	$3.3x10^4$
Potato chips	$1.1x10^3$	$7.8x10^6$	$1.1x10^6$	Nd	$3.4x10^6$	$6.5x10^5$	Nd	$3.7x10^6$	$2.4x10^5$	$2.5x10^3$	$1.7x10^5$	$6.8x10^4$
Total mean	$9.9x10^6$			$6.4x10^5$			$2.5x10^5$			$4.1x10^4$		

Bacterial count (cfu/g) range: No. (%)						
Count types	$<10^3$	10^3-$<10^4$	10^4-$<10^5$	10^5-$<10^6$	10^6-$<10^7$	$\geq 10^7$
Aerobic Plate Count (n=137)		4(2.9)	23(16.8)	51(37.2)	49(35.8)	10(7.3)
Enterobacteriaceae Count (n=137)	3(2.2)	7(5.1)	42(30.7)	66(48.2)	19(13.9)	
Coliform Count (n=137)	7(5.1)	36(26.3)	52(38)	36(26.3)	6(4.4)	
Staphylococcal Count (n=38)		12(31.6)	23(60.5)	3(7.9)		

*= *cfu/ml*

Antimicrobial resistance pattern of the isolates

Out of the 245 isolates, antimicrobial susceptibility tests were done for 187 of them. Overall, most of the bacterial isolates were resistant to ampicillin 133 (71.2%), followed by ceftriaxone 74 (39.6%), and sulfamethoxazole-trimethoprim 72 (38.5%). On the other hand, higher sensitivity was observed for amikacin 159 (85%), ciprofloxacin 145 (77.5%), and cefoxitin 120 (64.2%). The *S. aureus* isolates showed 55.2% and 56.8% resistance to ampicillin and ceftriaxone, respectively. The *Salmonella* isolates showed 3(75%) resistant to ampicillin and sulfamethoxazole-trimethoprim. All *Salmonella* isolates were sensitive to ciprofloxacin, and amikacin. Forty-six (71.9%) and 27 (42.2%) of E. coli isolates showed resistance to ampicillin and sulfamethoxazole-trimethoprim, respectively. All *P. aeruginosa* isolates were resistant to ampicillin, sulfamethoxazole-trimethoprim, and augmentin (Table 7).

Table 7: Antimicrobial resistance pattern of bacterial isolates from street food vendors, eastern Ethiopia, 2021 (n=187).

Isolate (No.)	Antimicrobial resistance pattern									
	Pattern	CRO	E	CIP	AMP	CN	SXT	AUG	AK	FOX
Citrobacter spp. (n=9)	S	6	7	7	-	5	3	7	8	3
	I	3	1	-	2	3	2	1	1	3
	R	0	1	2	7	1	4	1	0	3
E. coli (n=64)	S	44(68.8)	40(62.5)	50(78.1)	10(15.6)	43(67)	30(46.9)	37(58.7)	59(92.2)	49(76.6)
	I	3(4.7)	13(20.3)	2(3.1)	8(12.5)	7(11.1)	7(10.9)	21(32.8)	3(4.7)	13(20.3)
	R	17(26.5)	11(17.2)	12(18.8)	46(71.9)	14(21.9)	27(42.2)	6(9.5)	2(3.1)	2(3.1)
Enterobacter spp. (n=20)	S	6(30)	10(50)	15(75)	3(15)	8(40)	5(25)	11(55)	15(75)	11(55)
	I	3(15)	7(35)	2(10)	3(15)	5(25)	5(25)	4(20)	5(25)	5(25)
	R	11(55)	3(15)	3(15)	14(70)	7(35)	10(50)	5(25)	0	4(20)
Enterococcus spp. (n=10)	S	4(40)	4(40)	4(40)	5(50)	4(40)	6(60)	8(80)	2(20)	6(60)
	I	1(10)	3(30)	1(10)	1(10)	2(20)	2(20)	1(10)	2(20)	3(30)
	R	5(50)	3(30)	5(50)	4(40)	3(30)	2(20)	1(10)	6(60)	1(10)
Klebsiella spp. (n=18)	S	7(38.9)	12(66.8)	15(83.3)	1(5.5	7(38.9)	12(66.7)	11(61.1)	17(94.5)	14(77.8)
	I	1(5.55)	5(27.7)	1(5.5)	1(5.5)	0	2(11.7)	5(27.8)	0	4(22.2)
	R	10(55.5)	1(5.5)	2(11.1)	16(88.9)	11(61.1)	4(22.2)	2(11.1)	1(5.5)	0
Proteus spp. (n=19)	S	12(63.2)	8(42.1)	17(89.5)	2(10.5)	10(52.6)	8(42.1)	14(73.7)	15(79)	9(47.3)
	I	2(10.5)	8(42.1)	2(10.5)	4(21)	5(26.3)	4(21)	4(21)	3(15.8)	6(31.6)
	R	5(26.3)	3(15.8)	0	13(68.4)	4(21.1)	7(36.9)	1(5.2)	1(5.2)	4(21.1)
P. aeruginosa (n=5)	S	1	3	4	0	1	0	0	4	1
	I	1	1	0	0	1	1	1	0	2
	R	3	1	1	5	3	4	4	1	2
Salmonella spp. (n=4)	S	1	4	4	1	2	0	1	4	2
	I	1	0	0	0	0	1	2	0	2
	R	2	0	0	3	2	3	1	0	0
S.aurus (n=38)	S	16(42.1)	14(36.8)	29(76.3)	5(13.3)	23(60.5)	24(63.1)	29(76.3)	35(92)	25(65.7)
	I	1(2.7)	9(23.7)	2(5.3)	8(21)	4(10.5)	4(10.5)	7(18.4)	1(2.6)	2(5.3)
	R	21(55.2)	15(39.5)	7(18.4)	25(65.7)	11(29)	10(26.4)	2(5.3)	2(5.4)	11(29)
Total(n=187) No. (%)	S	97(51.9)	102(54.6)	145(77.5)	27(14.4)	104(55.6)	88(47.1)	118(63.1)	159(85)	120(64.2)
	I	16(8.5)	47(25.1)	10(5.3)	27(12.4)	27(14.4)	27(14.4)	46(24.6)	15(8)	40(21.4)
	R	74(39.6)	38(20.3)	32(17.2)	133(71.2)	56(30)	72(38.5)	23(12.3)	13(7)	27(14.4)

CRO; ceftriaxone, E ;Erythromycin, CIP; Cipro floxacillin, AMP; ampicillin, CN; gentamicin, SXT; Sulfamethoxazole-trimethoprim, AUG; Augmentin, AK; amikacin, FOX, Cefoxitin, S;sensitive, I;intermediate, R; Resistant

Multiple antimicrobial resistance of bacterial isolates

In this study, the overall prevalence of multidrug resistance (MDR) among all bacterial isolates was 55.1%%. A high frequency of MDR rate was observed in some bacterial isolates like *P. aeruginosa* 4(80%) followed by *S. aureus* 25(65.8%), and *Klebsiella* species 10(55.5%) (Table 8).

Table 8: Multiple antimicrobial resistance of bacterial isolates, eastern Ethiopia, 2021 (n=187).

Isolates		Level of resistance									
	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	MDR
E. coli (n=64)	12	9	13	15	8	4	1	0	1	1	30(46.8%)
S. aureus (n=38)	4	2	7	12	9	1	3	0	0	0	25(65.8%)
Citrobacter spp.(n=9)	0	1	1	3	2	1	0	0	1	0	7(77.8%)
Enterobacter spp. (n=20)	1	4	5	5	1	3	1	0	0	0	10(50%)
Enterococcus spp. (n=10)	1	0	2	4	2	1	0	0	0	0	7(70%)
Klebsiella spp. (n=18)	3	1	4	4	6	0	0	0	0	0	10(55.5%)
Proteus spp. (n=19)	3	7	2	2	3	1	1	0	0	0	7(37%)
P .aeruginosa (n=5)	0	0	1	0	1	3	0	0	0	0	4(80%)
Salmonella spp. (n=4)	0	0	1	1	1	1	0	0	0	0	3(75%)
Total (187)	24	24	35	46	33	15	6	0	2	1	103(55.1%)

R0; Sensitive to all tested antimicrobials, R1, R2, R3, R4, R5, R6, R7, R8, R9;Resistant to one, two, three, four, five, six, seven, eight, nine antimicrobials, respectively

Discussion

The present study was carried out to assess the bacteriological quality, handling practice, and antimicrobial resistance pattern of street-vended foods sold in five locations in Harar city. The study revealed that 100% of the foods sampled showed the presence of bacterial pathogens with a high bacterial count. The predominant isolates were *E. coli* (46.7%), and *S. aureus* (27.7%). In this study, 69 (50.4%) of vendors were observed to handle fast food with bare hands and 11% of them allowed their customers to touch the fast food with their bare hands. As observed during their vending practices, 89% of the vendors handle food and collect money with the same hand.

In this study, half (50.4%) of the vendors handle food with a bare hand, which is comparable with a study done in Gondar, Ethiopia (45.8%) (28). However, this finding is lower than the study done in Nigeria (66.7%) (Aniekpeno and Elijah1, 2020), Kenya (96.8%) (Mwove *et al*., 2020), Jimma Ethiopia (81%) (Nemo *et al*., 2017)(Aniekpeno I. Elijah1, 2020, Mwove *et al*., 2020, Nemo *et al*., 2017). In this study, 89% of street food vendors handle food and exchange money with the same hand, which is comparable with a study done in Nigeria (93.3%) (Aniekpeno, Elijah, 2020). A study done in Bahir Dar and Addis Ababa revealed that all the food vendors collect money and handle food with the same hand (Tesfaye, 2019, Eliku, 2016). Because the hands play an important role in the contamination and transmission of fecal-oral transmitted germs, this risk increases significantly when food is handled with bare hands (FAO, 2009).

In this study, 60% of vendors wear finger jewelry, which is comparable with a study done in Gondar (67.5%), of the vendors wear jewelry (Adimasu *et al.,* 2016). Among vendors in this study, 22% of vendors had a long and uncleaned nail. This is in line with a study done in Kenya (20.9%%) of the vendors who have long nails (Mwove *et al*., 2020). The current finding is higher than the report from Gondar (12.3%) of food vendors who have long nails (Adimasu *et al.,* 2016), however, lower than the study done in Bahir Dar (63.9%) (Tesfaye, 2019) and Gondar (54.2%) (Amare *et al*., 2019). Long fingernails and finger jewelry can harbor pathogenic microorganisms, which can contaminate food (FAO, 2009). This study also found that 95.6% of vendors didn't have formal training in the preparation of food and vending practices. This is in line with a study done in Kenya (Mwove *et al*., 2020), which found that 93% of vendors have no training. Training of street food vendors on food hygiene and safety is expected to give them the right knowledge that will increase the quality and safety of the foods sold on the street (Mwove *et al.,* 2020).

In this study, *E. coli* (46.7%) is the predominant isolate. This finding is comparable with the study done in Jigjiga (51.5%) (Bereda *et al.,* 2016), Yirgalem (43.8%) (Tsegaye Shamebo and Asefa Hamato, 2019), Gondar (46.3) (Derbew *et al.,* 2013), and Woldia (57%) (Alem, 2020). In contrast, this finding is higher than studies conducted in India (21%) (Tambekar *et al.,* 2008), Bangladesh (33.3%) (Sabuj *et al.,* 2018), Nigeria (18%) (Oluwapelumi *et al*., 2020), Gondar (23.8%) (Amare *et al.,* 2019), and Hawassa (29.6%) (Eromo *et al.,* 2016a). While the study conducted in Bahir Dar reveals a higher prevalence of *E. coli* (72.5%) (Kibret and Tadesse, 2013). The high detection rate of *E. coli* in this study could be due to heat processing failure or postprocessing cross-contamination, fecal contamination, or poor food handler hygiene (Authority, 2009).

In this study, the prevalence of *S. aureus* is 27.7%. This finding is in line with a study done in Jimma (29.4%) (Nemo *et al*., 2017), and it is higher than the study done in India (16%). But the current study is lower than the study conducted in Yirgalem (54.4%) (Tsegaye and Asefa, 2019), Jigjiga (64.4%) (Bereda *et al*., 2016), and Metemma (100%) (Seid, 2016). The presence of *S. aureus* could be an indicator of contamination through food workers' skin, mouth, or nose during coughing and sneezing. In addition; in food handling, preparation, or vending, contamination can be introduced into street foods (Eromo *et al*., 2016a). The current study shows that the prevalence of Bacillus species is 22.6%. This finding is lower than the study done in Jimma, Ethiopia (41.96%) (Nemo *et al.,* 2017). However, this finding is higher than the study done in Nigeria (7.2%) (Oluwapelumi *et al.,* 2020). In this study, the prevalence of *Salmonella* is 2.9%. This finding is in agreement with a study in Yirgalem (0.6%) (Tsegaye Shamebo and Asefa Hamato, 2019). This finding however lower than the study done in, Bangladesh (26.7%) (Sabuj *et al.,* 2018), Jimma

(13.3%) (Nemo *et al.,* 2017), Addis Abeba (20%) (Muleta and Ashenafi, 2001), Hawassa (12.7%) (Eromo *et al.,* 2016a), Jigjiga (19.7%) (Bereda et al., 2016), and Bahir Dar (57.5%) (Kibret and Tadesse, 2013). A study was done in Gondar (Derbew *et al.,* 2013) and Metema (Seid, 2016) reported that there was no *Salmonella* detected. However, the low frequency of *Salmonella* might be attributed to the fact that enrichment mediums were not used for isolation (Amare *et al*., 2019).

The current study revealed that all of the food items tested were contaminated with bacteria and a high bacterial count was also observed. Ten (7.3%) of street vended foods showed an unsatisfactory result with ACC $\geq$107 CFU/g. According to the guideline level for the microbiological quality of ready-to-eat street foods, results are outside the expected microbiological levels for this type of food (Authority, 2009). The aerobic plate count in all the samples tested varied from 5.2x105 CFU/g to 4x107 CFU/g. This finding is lower in contrast to a study in Woldia (1.3x103 – 2.8 x 1010cfu/g) (Alem, 2020). However, a study done in Cameroon (Nicholas *et al.,* 2020), and Jigjiga (Bereda *et al*., 2016), reported lower range aerobic plate count was observed than in the current study. The high standard plate count may be due to the food product being produced unhygienically and/or variations in the ingredients included in the food (Authority, 2009).

This study also revealed a high *Enterobacteriaceae* count, which ranged from 1.2x103 CFU/g to 8.4 × 106 CFU/g. This finding is higher than the study reported from Metema (Seid, 2016), and Hawassa (Eromo *et al.,* 2016a). The high *Enterobacteriaceae* count of food in this study might be due to heat processing failure or post-processing contamination, fecal contamination, or inadequate food handler hygiene (Authority, 2009). In this study, the *Staphylococcal* count was varied from 1.6x103 CFU/g to 3.4x105CFU/g. This finding is comparable with a study done in Gondar which reported that *staphylococcal* count ranged from 1.25 × 104 - 2 × 105 CFU/g (Amare *et al*., 2019), and the lower count was reported from the study done in Bangladesh (Sabuj *et al.,* 2018), Gondar (Derbew *et al*., 2013), Metema (Seid, 2016), and Jigjiga (Bereda *et al*., 2016). The high overall aerobic plate counts suggested that the food sold on the streets was of poor quality (Bereda *et al.,* 2016). The bacterial load might vary from place to place due to a variety of factors, including ambient conditions that encourage bacteria growth and, most importantly, sanitary measurements to avoid food post-contamination (Amare *et al*., 2019).

In this study, among nine *Citrobacter* isolates, 77.8% of them were resistant to ampicillin followed by trimethoprim-sulphamethoxazole (44.4%). This is comparable to a study done at Gondar (Amare *et al*., 2019), which revealed that 75% of the isolates were resistant to ampicillin. This might be due to the *Citrobacter* species being intrinsically resistant to ampicillin. Amikacin (88.9%) was the most effective antibiotic against *Citrobacter* species followed by ciprofloxacin and erythromycin (77.8% each). However, ceftriaxone and gentamicin were effective antibiotics in a study done in Gondar (Amare *et al*., 2019). *E. coli* showed resistance to ampicillin (71.9%) followed by trimethoprim sulphamethoxazole (42.2%).This finding agrees with Bangladesh (Sabuj *et al*., 2018), in which more than 70% of *E. coli* were resistant to ampicillin. In this study, *E. coli* was susceptible to amikacin (92.2%), and ciprofloxacin (77.8%). This is in line with a study done in Gondar (Amare *et al*., 2019), in which *E. coli* isolates were sensitive to gentamicin (93%).

High resistance was detected in *S. aureus* for ampicillin (65.7%) and ceftriaxone (55.2%). However, this finding was lower than the study from Gondar (Amare *et al*., 2019), in which 73.5% of isolates were resistant to ampicillin. *S. aureus* however showed sensitivity to amikacin (92%) and augmentin (76.3%). Cefoxitin resistance was found in 29% of *S. aureus* isolates. According to the CSLI guidelines, cefoxitin-resistant *S.aureus* isolates should also be methicillin-resistant (CLSI. 2020). In medical practice, the rise of methicillin-resistant *S. aureus* strains has become a major concern (Eromo *et al.,* 2016a). In this study, the total rate of multi-drug resistance was 41.2%. This finding is lower than the study done in Bahir Dar (Kibret and Tadesse, 2013), which revealed that 75.2% of MDR was detected. The cause of the variation in MDR prevalence is unknown, however, it could be attributed to ineffective empirical antimicrobial treatment, easy availability, and in discriminate use of common antimicrobials (Marami *et al*., 2018).

Limitations of the study

While this study addresses a lot of issues, it is not without limitations. We did not associate risk factors because the identification of the isolate and susceptibility tests were our primary concerns. Additionally, an enrichment medium was not used for isolation that better recovered when using enrichment media.

Conclusion

This study revealed that most of the food tested was contaminated with different pathogenic bacteria, which poses health risks to consumers of these foods. The high contamination is indicated by high bacteria counts which are unacceptable microbiologically and quality levels. All food items were contaminated with at least one bacterium. *E. coli, S. aureus*, and *Bacillus* species were the most frequently isolated bacteria. Amikacin and ciprofloxacin were more effective antibiotics against all the isolates. However, ampicillin, ceftriaxone, and trimethoprim-sulphamethoxazole showed higher resistance against all the isolates. This study assesses food handling practices handlers and vending environment hygiene of the vendors which was poor. Therefore, training and raising awareness about food handling practices and personal hygiene among street food vendors, and regular sanitary inspection subsequently strict implementation to improve sanitary conditions. To limit the spread of foodborne bacterial pathogens in the population, regular testing of these foods for microbiological quality and safety is also recommended.

Acknowledgments

We acknowledged the University of Gondar, , Colleges of Medicine and Health Sciences Institutional Health Research Ethical Review Committee for giving the ethical clearance. We also thank the study participants and all individuals who have contributed to the completion of this research.

Competing Interests

The authors declare that they have no competing interests.

Funding Statement

No funding.

Authors' Contributions

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

List of Abbreviations

CFU: Colony Forming Unit, CSLI Clinical Laboratory Standard Institute, ACC; Aerobic Colony Count; MDR Multi-Drug Resistance; MAPC; Mean Aerobic Plate Count

References

Adimasu, A., Mekonnen, B., Guadu, T., Gizaw, Z. & Adane, T. 2016. Bacteriological quality assessment of selected street foods and their public health importance in Gondar town, North West Ethiopia. Global veterinaria, 17, 255-264.

Alem, K. 2020. Bacterial Load Assessment of some Food Items Sold in Street in Woldia Town, North-East Ethiopia. *J Pure Appl Microbiol*, 14, 1845-1854.

Alimi, B. A. & Workneh, T. S. 2016. Consumer awareness and willingness to pay for safety of street foods in developing countries: a review. *International Journal of Consumer Studies,* 40, 242-248.

Amare, A., Worku, T., Ashagirie, B., Adugna, M., Getaneh, A. & Dagnew, M. 2019. Bacteriological profile, antimicrobial susceptibility patterns of the isolates among street vended foods and hygienic practice of vendors in Gondar town, Northwest Ethiopia: a cross sectional study. *BMC microbiology*, 19, 120.

Aniekpeno I. Elijah1, A. B. a. V. E. E. 2020. Investigation of microbiological quality of selected street vended foods sold in Uyo Metropolis, Akwa Ibom state, Nigeria. Bacterial Empire, 3, 32-40.

Assefa, N. & Semahegn, A. 2016. Fertility is below replacement in Harar health and demographic surveillance system (Harar HDSS), Harar town, Eastern Ethiopia. Fertility research and practice, 2, 1-7.

Authority, N. F. 2009. Microbiological quality guide for ready-to-eat foods: A guide to interpreting microbiological results. NSW/FA/CP028/0906, 1-9.

Ayana, Z., Yohannis, M. & Abera, Z. 2015. Food-borne bacterial diseases in Ethiopia. *Acad J Nutr,* 4, 62-76.

Bereda, T. W., Emerie, Y. M., Reta, M. A. & Asfaw, H. S. 2016. Microbiological safety of street vended foods in Jigjiga City, Eastern Ethiopia. *Ethiopian journal of health sciences,* 26, 163-172.

Cheesbrough, M. 2005. District laboratory practice in tropical countries, part 2, Cambridge University Press.

CLSI Performance Standards for Antimicrobial Susceptibility Testing. M100, 30th ed. 2020; 40(1).

Derbew, G., Sahle, S. & Endris, M. 2013. Bacteriological assessment of some street vended foods in Gondar, Ethiopia. *Internet Journal of Food Safety*, 15, 33-38.

Eliku, T. 2016. Hygienic and sanitary practices of street food vendors in the city of Addis Ababa, Ethiopia. Food Science and Quality Management, 50, 32-38.

Eromo, T., Tassew, H., Daka, D. & Kibru, G. 2016a. Bacteriological quality of street foods and antimicrobial resistance of isolates in Hawassa, Ethiopia. *Ethiopian journal of health sciences*, 26, 533-542.

Eromo, T., Tassew, H., Daka, D. & Kibru, G. J. E. J. O. H. S. 2016b. Bacteriological quality of street foods and antimicrobial resistance of isolates in Hawassa, Ethiopia. 26, 533-542.

FAO. 2009. Good hygienic practices in the preparation and sale of street food in Africa, tools for training. Rome, Italy, FAO, ISBN 978-92-5-105583-0.

Hoelzer, K., Wong, N., Thomas, J., Talkington, K., Jungman, E. & Coukell, A. 2017. Antimicrobial drug use in food-producing animals and associated human health risks: what, and how strong, is the evidence? *BMC veterinary research,* 13, 1-38.

Imathiu, S. 2017. Street vended foods: potential for improving food and nutrition security or a risk factor for foodborne diseases in developing countries? *Current Research in Nutrition and Food Science Journal*, 5, 55-65.

Kang, A. D., Smith, K. P., Eliopoulos, G. M., Berg, A. H., Mccoy, C. & Kirby, J. E. 2017. In vitro apramycin activity against multidrug-resistant Acinetobacter baumannii and Pseudomonas aeruginosa. Diagnostic microbiology and infectious disease, 88, 188-191.

Khairuzzaman, M., Chowdhury, F. M., Zaman, S., Al Mamun, A. & Bari, M. 2014. Food safety challenges towards safe, healthy, and nutritious street foods in Bangladesh. International journal of food science, 2, 1-9.

Kibret, M. & Tadesse, M. 2013. The bacteriological safety and antimicrobial susceptibility of bacteria isolated from street-vended white lupin (Lupinus albus) in Bahir Dar, Ethiopia. *Ethiopian Journal of Health Sciences*, 23, 19-26.

Kiiyukia, C. 2003. Laboratory manual of food microbiology for Ethiopian Health and nutrition research institute. UNIDO project (YA/ETH/03/436/11-52), 1-197.

Marami, D., Hailu, K. & Tolera, M. 2018. Prevalence and antimicrobial susceptibility pattern of Salmonella and Shigella species among asymptomatic food handlers working in Haramaya University cafeterias, Eastern Ethiopia. *BMC research notes*, 11, 1-6.

Mengist, A., Mengistu, G. & Reta, A. 2018. Prevalence and antimicrobial susceptibility pattern of Salmonella and Shigella among food handlers in catering establishments at Debre Markos University, Northwest Ethiopia. *International Journal of Infectious Diseases*, 75, 74-79.

Modarressi, S. & Thong, K. L. 2010. Isolation and molecular sub-typing of Salmonella enterica from chicken, beef, and street foods in Malaysia. Scientific Research and Essays, 5, 2713-2720.

Muleta, D. & Ashenafi, M. 2001. Salmonella, Shigella and growth potential of other food-borne pathogens in Ethiopian street vended foods. *East African Medical Journal*, 78, 576-580.

Muyanja, C., Nayiga, L., Brenda, N. & Nasinyama, G. 2011. Practices, knowledge and risk factors of street food vendors in Uganda. Food control, 22, 1551-1558.

Mwove, J., Imathiu, S., Orina, I. & Karanja, P. 2020. Food safety knowledge and practices of street food vendors in selected locations within Kiambu County, Kenya. *African Journal of Food Science,* 14, 174-185.

Nemo, R., Bacha, K. & Ketema, T. 2017. Microbiological quality and safety of some street-vended foods in Jimma Town, southwestern Ethiopia. *African Journal of Microbiology Research*, 11, 574-585.

Nicholas, T., Emlah, N. V., Babila, N. R., Meriki, H. D., Mbino, T. L. & Pamela, Y. K. 2020. Microbial analysis and factors associated with contamination of ready-to-eat chili pepper sauce in Buea municipality, Cameroon. *African Journal of Food Science*, 14, 366-372.

Okaiyeto, S. A., Sutar, P. P., Chen, C., Ni, J.-B., Wang, J., Mujumdar, A. S., et al. 2024. Antibiotic-resistant bacteria in food systems: Current status, resistance mechanisms, and mitigation strategies. 100027.

Oluwapelumi, O. B., Oluwasegun, S. A., Funmilayo, A. J. & Yomi, A. R. 2020. Evaluation of Bacterial Contamination of Ready-To-Eat Foods Sold in Ado-Ekiti, Ekiti State, Nigeria. *American Journal of Biomedical Sciences*, 12, 164-172.

Rane, S. 2011. Street vended food in developing world: hazard analyses. Indian journal of microbiology, 51, 100-106.

Sabuj, A. a. M., Haque, Z. F., Barua, N., Islam, M. A. & Saha, S. 2018. Assessment of bacteriological quality of street vended fast foods and their antimicrobial resistance. *International Journal of Current Microbiology and Applied Sciences*, 7, 3049-3059.

Seid, M. 2016. Assessment of Different Food Contaminant Bacterial Species and Their Antimicrobial Susceptibility Pattern among Some Street Vended Foods in Metema Yohannes Town, Amhara Region, North Gondar Zone, Ethiopia. Semantic Scholar.

Skovgaard, N. 2001. Foodborne disease: a focus for health education-World Health Organization, Geneva, 2000, xiii+ 198 pages: paperback (available in English; French and Spanish editions in preparation); ISBN 92 4 156196 3. Sw. fr. 62.-/US $55.80; in developing countries: Sw. fr. 43.40. Order no. 1150475. International Journal of Food Microbiology, 1, 163-164.

Tambekar, D., Jaiswal, V., Dhanorkar, D., Gulhane, P. & Dudhane, M. 2008. Identification of microbiological hazards and safety of ready-to-eat food vended in streets of Amravati City, India. *Journal of Applied Biosciences*, 7, 195-201.

Teferi, S. C. 2020. Street Food Safety, Types and Microbiological Quality in Ethiopia: A Critical Review. *American Journal of Applied Scientific Research*, 6, 67-71.

Temesgen, M. & Abdisa, M. 2015. Food standards, food law, and regulation system in Ethiopia: a review. Public Policy and Administration Research, 5, 58-73.

Tesfaye, M. 2019. Bacteriological Quality of street vended ready to eat legume and vegetable-based foods in Bahir Dar Town, Amhara regional state, North Western Ethiopia. Asian *Journal of Science and Technology*, 10, 9959-9968.

Threlfall, E. J., Ward, L. R., Frost, J. A. & Willshaw, G. a. J. I. J. O. F. M. 2000. The emergence and spread of antibiotic resistance in food-borne bacteria. 62, 1-5.

Tsegaye Shamebo, A. & Asefa Hamato, K. 2019. Microbiological quality and safety of ready-to-eat foods from restaurants and food establishments in Yirgalem town Southern, Ethiopia. Research Square, 2, 1-10.

WHO. 1996. Essential safety requirements for street-vended foods. World Health Organization.

WHO. 2015. World Health Organization estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015, World Health Organization.