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Microbiological quality and safety of some-street-vended foods in Jimma Town, Southwestern Ethiopia

Reda Nemo*, Ketema Bacha and Tsige Ketema

Jimma University, College of Natural Science, Ethiopia.

Street food vending has been benefiting both consumers, who are the in low socio economic status, as well as vendors, by creating job opportunities. However, street foods are perceived to be a major public health risk due to contamination. The objective of this study was to evaluate the microbiological quality and safety of street-vended foods in Jimma town in Ethiopia. The study involved collection of socio-economic data using structured questionnaire and laboratory analysis for microbial quality and safety. A total of 160 ready-to-eat street foods (40 each of firfir (mixture of majority of cabbage, watt, macaroni and injera), bread, injera (Ethiopian traditional food) and sambussa) samples were collected from Merkato, Kochi and Agip vending sites in Jimma. Result of the study shows that 85.5% of vendors were women, 54.5% had primary education, 90.9% did not use special apparel for their job as street food vendors, 80.9% handled food with bare hands, 49.1% used well water for cleaning of utensils, and 40% wore no hair covering. The mean microbial counts (CFUg^{-1}) of food samples were dominated by aerobic mesophilic bacteria (5.0 ± 0.5), aerobic bacterial spore (4.0 ±0.4), lactic acid bacteria (4.0 ±0.4), Enterobacteriaceae (3.9 ± 0.6), staphylococci (3.7 ± 0.6), coliform (2.6 ± 0.4), yeasts (3.8 ± 0.5) and moulds (2.6 ± 0.4). Of the total 1697 isolates characterized, the most predominant were Bacillus spp. (41.96%) followed by *Staphylococcus* spp*. (*24.28%). Out of the food samples, 29.38% were positive for *S. aureus* and 13.13% samples were positive for Salmonella*. Staphylococcus aureus isolates* were resistant to maximum of six antibiotics (8.51%) but Salmonella had showed resistance to four antibiotics (14.29%). Generally, the microbial quality of street-vended food in Jimma town was poor and calls for special attention.

Key words: Foodborne Pathogens, Street-vended Foods, Vendors.

INTRODUCTION

Street-vended foods are cooked ready-to-eat solid foods and beverages prepared and sold by vendors, especially, on streets and other public places (FAO, 1990). According to WHO (1996), street-vended foods enable urban and rural poor consumers obtain a source of readily available, inexpensive, convenient and often nutritious food. In the developing countries, street-vended food is a source of income for a vast number of vendors (Muzaffar et al., 2009).

Moy et al. (1997) reported that in contrast to the potential benefits of street-vended foods, concerns over their safety and quality have been raised. Vendors lack

*Corresponding author. E-mail: redanemo@gmail.com.

appreciation of basic food safety issues. Unhygienic conditions and practices of vendors and environment are likely to lead to cross-contamination of cooked foods (Yasin et al., 2012).

Microbiological studies on street-vended foods in different countries have suggested the presence of high bacteria counts and a high incidence of food-borne bacterial pathogens (Rane, 2011). For instance, in the Malaysian state, 14 people died because of eating rice noodles bought from street vendors (Dawson and Canet, 1991). In Cuba, 14 people died because of eating foods sold by a private vendor (Barro et al., 2006). In Senegal, over 200 cases of food poisoning were traced to street foods (Bryan et al., 1992). In Egypt, pathogenic microorganisms were reported from street-vended foods (El-Sherbeeny et al., 1985). In Ethiopia, particularly Addis Ababa, Muleta and Ashenafi (2001a) reported, the presence of *Salmonella* and *Shigella* from street- vended foods.

In Nigeria, pathogens isolated from street-vended food showed high resistance to different antibiotics (Oladipo and Adejumobi, 2010). *S. aureus* strains isolated from street-vended food in Cotonou, Benin, were resistant to a wide range of antibiotics. According to Crump and Mintz (2010) the multiple drug resistant (MDR) strains of *Salmonella* are encountered frequently and their rates of occurrence have increased considerably in the recent years.

The present study evaluate the microbial safety and quality of street-vended foods like *injera*, *sambussa*, *firfir* (mixture of majority of cabbage, *watt*, macaroni and injera) and bread (prepared locally at home) from Markato, Agip and Kochi vending sites of Jimma town.

Injera and *wot* are two very important traditional foods in Ethiopia. While *injera is* thin, pancake-like, sour, leavened bread, which can be made of either teff, corn, sorghum, barley or a mixture of two or three of these. W*ot* is a traditional Ethiopian stew. Sambussa is a thin dough shell stuffed with lentils and spice. Homemade bread is mainly made of wheat and corn. Injera, firfir and bread are largely produced and consumed by millions urban and rural areas Ethiopians. In Jimma town, these food items are sold in hotels, markets and streets.

MATERIALS AND METHODS

Description of the study site

The study was conducted in Jimma town, located at 353 km southwest of Addis Ababa, the capital city of Ethiopia. The town's geographical coordinates are $7^o41'$N latitude and $36^o50'$E longitude. The study area has an average altitude of 1780 m above sea level (Alemu et al., 2011).

Study design and population

A cross sectional study design was used. The sample size was calculated by using Cochran (1977) formula. The total population of

the street venders at three sites of this study was 274 irrespective of vendors' age and sex. There were 102 street food vendors from Merkato, 96 from Kochi, and 76 from Agip, all of them locations in Jimma.

Sampling technique

A systematic random sampling technique was used to select representative street food vendors in the study area. Systematic sampling is a statistical method involving the selection of elements from an ordered sampling frame.

Socio-demographic data collection

Data about general sanitation were collected from the street vendors using a structured questionnaire.

Sample collection

A total of 160 ready-to -eat food samples comprising 40 samples each of firfir, bread, injera and sambussa were collected from the three different vending sites of Jimma town, namely, Merkato, Kochi and Agip between the months of November 2011 to March 2012. Food samples were purchased from vendors between 5 to 6 pm during the period. Food samples were collected from vendors using vendors' own serving utensils and placing into sterilized aluminum plates. All food samples were transported to Postgraduate Research Laboratory, Department of Biology, College of Natural Sciences, Jimma University The food samples were kept in the refrigerator at 4□C until microbial analysis was conducted. Microbial analysis was conducted with in one to three hours after sample collection.

Microbiological methods

Sample preparation

Approximately 250 g of each food sample was collected from street vendors to be analyzed for microbiological quality and safety. Accordingly, 25 g of each well-mixed food sample was taken and mixed with 225 ml buffered peptone water (BPW) (oxiod), homogenized in a flask for five minutes using A shaker at 160 rpm. After homogenization, 1 ml of each food sample was aseptically transferred into 9 ml of BPW, and mixed thoroughly by using vortex mixer. The homogenates were serially diluted from 10^{-1} to 10^{-6} and a volume of 0.1 ml aliquot of appropriate dilution was spread-plated on pre-solidified plates and incubated at appropriate temperature and time for enumeration. The colonies were counted from plate containing microbial colonies between 30 and 300. The counted colonies were expressed in colony forming units per gram ($CFUg^{-1}$) and later converted to log $CFUg^{-1}$.

Microbial enumeration

Enterobacteriaceae count: From the serial dilutions, 0.1 ml of the aliquot was spread-plated on MacConkey agar (Oxoid) and incubated at 32°C for 18 - 24 h after which, pink to red purple colonies were counted as member of the family Enterobacteriaceae (Spencer et al., 2007).

Coliform count: From the serial dilutions, 0.1 ml of the aliquot was spread plated on pre-solidified surfaces of Violet Red Bile Agar (VRBA) (Oxoid) plates. Then the plates were incubated at 32°C

for 18 - 24 h. After this, purplish red colonies surrounded by reddish zone of precipitated bile were counted as coliforms (Weil et al., 2006).

Aerobic Bacterial Spore Count: For aerobic bacterial spore counts, 10 ml of the serial dilutions were heated in a water bath kept 80°C for 10 min and then cooled rapidly in tap water. From appropriate dilution, 0.1 ml aliquot was spread-plated on pre-dried surface of plate count agar and incubated at 32°C for 72 h (Acco et al., 2003).

Staphylococci count

From the serial dilutions, 0.1 ml of the aliquot was spread plated onto Mannitol Salt Agar (MSA) (Oxoid) and incubated at 32 °C for 48 h (Acco et al., 2003).

Lactic acid bacteria count

From the serial dilutions, 0.1 ml of the aliquot was spread plated on de Mann Rogosa Sharpe (MRS) agar media (Oxoid) and incubated at 37°C for 48 h under anaerobic condition using anaerobic Jar (Patra et al., 2011).

Yeasts and moulds counts: From the serial dilutions, 0.1 ml aliquot was spread-plated on pre-solidified surfaces of Potato Dextrose Agar (Oxoid) supplemented with 0.1 g chloramphenicol and incubated at 25°C for 5-7 days (Spencer et al., 2007). Smooth (non-hairy) colonies without extension at periphery were counted as yeasts whereas hairy colonies with extension at periphery were counted as moulds.

Microbial characterization

After enumeration of aerobic mesophilic bacteria, 10 to 15 colonies with distinct morphological differences such as color, size and shape were randomly picked from countable plates and aseptically transferred in to a tube containing 5 ml nutrient broth (Oxoid). The inoculated cultures were incubated at 32°C for 24 h. Cultures were purified by repeated plating and preserved on slants at 4°C for a month. Finally, the obtained organisms were characterized to genus and family levels. The characterizations of isolates were done based on John (2012) bacterial classification manual.

To determine the morphology and biochemical characteristics of the bacterial isolates, bacterial cells were Gram-stained (Gram, 1884). Motility test was conducted according to Shields and Cathcart (2012). Endospore test was done according to Schaeffer and Fulton (1933) method. Presence of lipopolysaccharide that is Gram positivity or negativity was determined according to Gregerson (1978). Oxidation-reduction properties were determined according to Hugh and Leifson (1953). Catalase test was conducted according to MacFaddin (1980). Cytochrome test was conducted using the method outlined by Kovacs (1956).

Isolation of *Salmonella* spp.

For the detection of *Salmonella* spp., 25 g of food samples were mixed with 225 ml of BPW and incubated at 37°C for 24 h. Then 1 ml pre-enrichment broth culture was added to 10 ml of selenite cysteine broth (Oxoid) and again incubated at 37°C for 24 h. Thereafter, a loopful of suspension from a tube was streaked onto Xylose Lysine Deoxycholate Agar (XLD) (Oxoid). The presumptive

Salmonella colonies (black colony surrounded by red color) were picked off, transferred to 5 ml nutrient broth (Oxoid), incubated at 37°C for 24 h, then streaked onto Nutrient Agar (Oxoid) for purity, and incubated at 37°C for 24 h (Arvanitidou et al., 1998). The presumptive *Salmonella* spp. were characterized by standard biochemical tests. The biochemical testes were done according to the procedure of Johnson and Case (2007).

Isolation of *Staphylococcus aureus*

After counting staphylococci, golden yellow colonies on MSA plates were aseptically picked and transferred into 5 ml nutrient broth and incubated at 37°C for 24 h for further purification. Then, a loopful of culture from the nutrient broth was streaked on nutrient agar supplemented with 0.75% NaCl and again incubated at 37°C for 24 h. Finally, the distinct colonies were characterized using the established microbiological methods (Acco et al., 2003). Gram-positive cocci with clustered arrangement under the microscope were subjected to preliminary biochemical tests: oxidase, catalase and coagulase tests (Cheesbrough, 2006).

Antimicrobial Susceptibility testing for some pathogens

Antimicrobial susceptibility testing was investigated on Mueller Hinton Agar (Oxoid) plates following the standard disk diffusion techniques. The antibiotic discs were placed on the medium by using forceps and incubated at 35°C for 18 h and the zone of inhibition was measured manually with a transparent ruler. The results of the antimicrobial susceptibility were interpreted based on the guidance of National Committee for Clinical Laboratory Standards (NCCLS, 2007).

The following standard discs (Oxoid) and their potency ($\mu g ml^{-1}$) were used depending up on the antibacterial spectrum, toxicity, effectiveness and availability (Vlkova et al., 2006): ampicillin (10), chloramphenicol (30), ciprofloxacin (5), gentamycin (10), kanamycin (30), naldixic acid (30), norflaxacin (10), streptomycin (10) and tetracycline (30) were used for *Salmonella* spp. Chloramphenicol (30), ciprofloxacin (5), clindamycin (2), erythromycin (15), gentamycin (10), kanamycin (30), penicillin G (10), streptomycin (10) and tetracycline (30) were used for *Staphylococcus aureus.* The reference strains were *Salmonella typhimurium* (ATCC13311*)* and *S. aureus* (ATCC25923).

Data analysis

The Percentage of Coefficient of variation (% CV) was calculated to verify if there was significant variation in microbial counts within the food samples analyzed. The data obtained from the respondents were analyzed using SPSS software version 16.0. Mean values of food samples from different sites were compared using one way ANOVA and the significance of differences were considered at 95% confidence interval ($P < 0.05$).

RESULTS

Socio-demographic characteristics of the street vendors

Table 1, which presents the socio-demographic characteristics of street vendors shows that 39.1% of street vendors' belonged to the age group between 31-40 years and the majority (85.5%) of the vendors were

Table 1. Socio-demographic characteristics of street vendors in Jimma town, southwestern Ethiopia 2011/2012.

Parameter	Number of respondents (N=110)	Percentage
Age		
< 20	10	9.1
21-30	26	23.6
31-40	43	39.1
41-50	19	17.3
> 51	12	10.9
Sex		
Male	16	14.5
Female	94	85.5
Academic Status		
Illiterate	34	30.9
Primary education	60	54.5
Secondary education	8	7.3
Experience in vending food (years)		
< 5	29	26.4
6-10	15	13.6
11-15	22	20.0
16-20	40	36.4
>20	4	3.6

females. Educationally, 54.5% had primary education. Among the vendors 36.4% had an experience of 16-20 years, 26.4% < 5 years and 20% had 11-15 years' experience in street food vending.

General hygiene of street vendors and the vended foods

In Table 2, majority (64.5%) of the street vendors used tap water for preparation of food while 27.3% used well water. On the other hand, 49.1% of street vendors used well water for cleaning utensils. In addition, 43.6% of the vendors cleaned the utensils using hand and water only.

Table 3 shows that, 80.9% of street food vendors handled food with their bare hands. Again, 80.91% of the vendors worked in dusty environment and 70.9% in the vicinity of litter. Training- wise, 92.7% of the vendors did not get training on food hygiene, although 7.3% had exposure on personal hygiene. A significant number (66.4%) of the vendors had no information about food and water-borne diseases whereas 33.6% had information about foodborne and waterborne diseases such as diarrhea and giardia.

Microbial counts

From Table 4, the mean count of aerobic mesophilic bacteria (AMB) was the highest (6.6 log $CFUg^{-1}$) in firfir followed by bread (5.1 log $CFUg^{-1}$) whereas the lowest

was in sambussa (4.0 log $CFUg^{-1}$). The mean count of Enterobacteriaceae was the highest in firfir (4.9 log $CFUg^{-1}$) whereas it was lower in bread (4.1 log $CFUg^{-1}$) and injera (4.0 log $CFUg^{-1}$). Likewise, the mean counts (log $CFUg^{-1}$) of yeast, coliform and mould were the highest in firfir (5.5, 4.0 and 3.7, respectively) and the mean count of lactic acid bacteria (LAB) was low in sambussa (3.2 log $CFUg^{-1}$). Furthermore, the mean counts (log $CFUg^{-1}$) of staphylococci were the highest (4.8) in firfir followed by bread (4.1). However, it was relatively lower in injera (3.1) and sambussa (2.7). Generally, the mean counts of all bacteria and fungi (yeast and moulds) in all food samples were above detectable level whereas the mean counts of mould and coliform in sambussa were below detectable level.

The percentage coefficient of variation (% CV) ranged from 6.8 to 22.7%. Accordingly, the highest (22.7%) was observed for yeasts count in sambussa and the lowest (6.8%) for AMB count in injera sample. The highest mean counts of AMB were recorded in firfir from Merkato site (6.8 log $CFUg^{-1}$) and bread from Kochi site (5.1 log $CFUg^{-1}$). Accordingly, the maximum mean counts (log $CFUg^{-1}$) of AMB, yeasts, staphylococci, Enterobacteriaceae, coliform, and moulds were observed in firfir, which accounted 7.3, 6.2, 5.6, 5.5, 4.8 and 4.6, respectively.

There was statistically significant difference (p < 0.05) among the mean counts of AMB, Enterobacteriaceae, coliform, ABS, staphylococci, LAB, yeasts and moulds in all food samples between the groups. However, there was no significant difference (p > 0.05) of the mean counts in all microbes among the three sites.

Table 2. Source of water and utensils handling of street vendors in Jimma town, southwestern Ethiopia 2011/2012.

Parameter	Number of respondents (N=110)	Percentage
Source of water for preparation of food		
Tap	71	64.5
Well	30	27.3
Spring	7	6.4
Source of water for cleaning utensils		
Tap	49	44.5
Well	54	49.1
River	7	6.4
Clean the utensils		
By hand using water only	48	43.6
With warm water and soap	14	12.7
With cold water and soap	28	25.5
Frequency of changing the vending utensils		
Daily	16	14.6
Weekly	25	22.7
Monthly	11	10.0
Yearly	4	3.6
Not changed	54	49.1

Table 3. Food-handling practices, vendors personal hygiene and awareness on food and water-borne disease in Jimma town, southwestern Ethiopia 2011/2012.

Parameter	Number of respondents (N=110)	Percentage
Apparel for vending		
Yes	10	9.1
No	100	90.9
Handling food with bare hands		
Yes	89	80.9
No	21	19.1
Vendors covered their hair		
Yes	66	60.0
No	44	40.0
Vending site neatness		
No litter	7	6.4
Some litter	25	22.7
Much litter	78	70.9
Dusty vending site		
Yes	89	80.91
No	21	19.09
Undergone training about of vending food		
Yes	8	7.3
No	102	92.7
Informed about food and water-borne disease		
Yes	37	33.6
No	73	66.4

Microbial analysis of street-vended foods

From Table 5 out of total 160 food samples analyzed, 457 bacterial strains were isolated from firfir, 440 from bread and 400 from each of injera and sambussa. Totaling 1697 bacterial isolates. Generally, among the

Table 4. Mean microbial counts (log CFUg^{-1}) in Jimma town, southwestern Ethiopia 2011/2012.

Food type		Microbial mean counts (log CFUg^{-1} ± SD)															
	Number	AMB	% CV	Entero	% CV	Coli	% CV	ABS	% CV	Staph	% CV	LAB	% CV	Yeast	% CV	Mould	% CV
Firfir	40	6.6 ± 0.6	9.1	4.9±0.5	10.2	4.0±0.5	12.5	4.3±0.4	9.3	4.8±0.7	14.6	4.3±0.5	11.6	5.5±0.5	9.1	3.7±0.6	16.2
Bread	40	5.1 ± 0.5	9.8	4.1±0.6	14.6	2.5±0.5	20.0	4.0±0.4	10.0	4.1±0.6	14.6	4.2±0.3	7.1	4.0±0.5	12.5	2.6±0.3	11.5
Injera	40	4.4 ± 0.3	6.8	4.0±0.6	15.0	2.2±0.3	13.6	3.8±0.5	13.2	3.1±0.6	19.4	4.1±0.5	12.2	3.4±0.4	11.8	2.4±0.2	8.3
Sambussa	40	4.0 ± 0.4	10.0	2.7±0.5	18.5	1.7±0.3	17.6	3.8±0.3	7.9	2.7±0.4	14.8	3.2±0.4	12.5	2.2±0.5	22.7	1.8±0.4	22.2
Total		5.0 ±0.5	10.0	3.9 ±0.6	15.4	2.6±0.4	15.4	4.0±0.4	10.0	3.7±0.6	16.2	4.0±0.4	10.0	3.8±0.5	13.2	2.6 ±0.4	15.4

AMB = Aerobic Mesophilic Bacteria; Entero = Enterobacteriaceae; ABS = Aerobic Bacterial Spore; Staph =Staphylococci; LAB =Lactic Acid Bacteria, Coli = Coliform.

Table 5. Frequency distribution of dominant bacteria in some street-vendedfood, Jimma town, southwestern Ethiopia 2011/2012.

Food Type	Number of isolates	*Bacillus* spp.	*Staphylococcus* spp.	*Micrococcus* spp.	Enterobacteri aceae	*Pseudomonas* spp.	*Acinetobacter* spp.	*Alcaligens* spp.	*Aeromonas* spp.
	Number	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Firfir	457	157 (34.35)	143 (31.29)	85 (18.6)	42 (9.19)	12 (2.63)	9 (1.97)	6 (1.31)	3 (0.66)
Bread	440	227(51.59)	67 (15.23)	80 (18.18)	27 (6.14)	18 (4.09)	11 (2.5)	10 (2.27)	-
Injera	400	148 (37)	104 (26)	59 (14.75)	65 (16.25)	15 (3.75)	-	6 (1.5)	3 (0.75)
Sambussa	400	180 (45)	98 (24.5)	76 (19)	17 (4.25)	13 (3.25)	4 (1)	5 (1.25)	7 (1.75)
Total	1697	712 (41.96)	412 (24.28)	300 (17.68)	151 (8.90)	53 (3.12)	26 (1.53)	30 (1.77)	13 (0.77)

total isolates, the predominant bacterial group was *Bacillus* spp. (41.96%) followed by *Staphylococcus* spp. (24.28%), *Micrococcus* spp. (17.68%) and Enterobacteriaceae (8.9%).

Prevalence of *S. aureus* and *Salmonella* spp.

In Table 6, the overall 29.38% samples were positive for *S. aureus*. However, the frequency distribution varied among the food samples. the highest (57.5%) being found in firfir and the lowest being found in sambussa (12.5%) . With regard to sites, the prevalence of *S.aureus* was comparably higher in firfir from Merkato, Agip and Kochi sites. No *S.aureus* was detected in sambussa sample. from Agip site.

For overall, 13.13% samples were positive for *Salmonella* isolates. As a result, the prevalence of *Salmonella* spp. was higher (27.5%) in firfir and bread (12.5%) and low in injera (7.5%) and sambussa (5.0%). In terms of site, the prevalence of *Salmonella* spp. was highest in firfir from Merkato (33.3%) and Agip (27.27%). However, *Salmonella* spp. were not isolated from injera at Merkato site and sambussa from Agip and Merkato sites.

Antimicrobial Susceptibility patterns of *S. aureus* and *Salmonella* spp.

From Table 7, out of a total 47 isolates of S. *aureus,* the majority were susceptible to

chloramphenicol and gentamycin (95.74% each) followed by ciprofloxacin (93.62%), streptomycin (85.11%) and kanamycin (76.59%). However, the isolates were highly resistant to penicillin G (100%) followed by clindamycin (80.85%) and tetracycline (63.83%).

From Table 8, all the 21 isolates of *Salmonella* spp. were susceptible (100%) to ciprofloxacin, gentamycin and norflaxacin followed by chloramphenicol (95.24%), and kanamycin (85.71%) (Table 10). However, the highest frequency of resistance to ampicillin (95.24%) was observed followed by naldixic acid (76.19%) and streptomycin (47.62%).

From Table 9, the multi-drug resistance (MDR) patterns of *S.aureus* showed that, 38.30% of the

Table 6. Prevalence of *S. aureus* and *Salmonella* spp. from street-vended food in Jimma town, southwestern Ethiopia 2011/2012.

Sample	Sample size (160)	Number *S. aureus* positive samples (%)	Number *Salmonella* spp. positive samples (%)
		Frequency (%)	
Firfir	40	23 (57.5)	11 (27.5)
Bread	40	13 (32.5)	5 (12.5)
Injera	40	6 (15.0)	3 (7.5)
Sambussa	40	5 (12.5)	2 (5.0)
Total	160	47 (29.38)	21 (13.13)

Table 7. Antimicrobial susceptibility patterns of *S. aureus* isolated from street-vended food in Jimma town, southwestern Ethiopia 2011/2012.

Antimicrobial Agents	Disc concentration (µg/ml)	Resistance Frequency (%)	Intermediate Frequency (%)	Sensitive Frequency (%)
Chloramphenicol (C)	30	1(2.13)	1 (2.13)	45 (95.74)
Ciprofloxacin (CIP)	5	-	3 (6.38)	44 (93.62)
Clindamycin (DA)	2	35 (74.47)	3 (6.38)	9 (19.15)
Erythromycin (E)	15	5 (10.64)	21 (44.68)	21 (44.68)
Gentamycin (CN)	10	1(2.13)	1 (2.13)	45 (95.74)
Kanamycin (K)	30	2 (4.26)	9 (19.15)	36 (76.59)
Penicillin G (P)	10	47 (100)	-	-
Streptomycin (S)	10	-	7 (14.89)	40 (85.11)
Tetracycline (TE)	30	6 (12.77)	24 (51.06)	17 (36.17)

Table 8. Antimicrobial susceptibility patterns of *Salmonella* spp. Jimma town, southwestern Ethiopia 2011/2012.

Antimicrobial Agents	Disc concentration (µg/ml)	Resistance Frequency (%)	Intermediate Frequency (%)	Sensitive Frequency (%)
Ampicillin (AMP)	10	20 (95.24)	-	1 (4.76)
Chloramphenicol (C)	30	-	1 (4.76)	20 (95.24)
Ciprofloxacin (CIP)	5	-	-	21 (100)
Gentamycin (CN)	10	-	-	21 (100)
Kanamycin (K)	30	-	3 (14.29)	18 (85.71)
Naldixic Acid (NA)	30	12 (57.14)	4 (19.05)	5 (23.81)
Norflaxacin (NOR)	10	-	-	21(100)
Streptomycin (S)	10	5 (23.81)	5 (23.81)	11 (52.38)
Tetracycline (TE)	30	8 (38.10)	-	13 (61.90)

isolates were resistant to 3 antibiotics (mainly DA/ P/ E and DA/ P/TE combinations) followed by 23.40% to 4 antibiotics and 14.89% to 5 antibiotics (Table 11). The highest MDR in *S.aureus* (17.02%) was for four antibiotics (mainly DA/P /E/TE). The maximum number of antibiotics resisted by *S.aureus* was six antibiotics with total proportion of 8.51%. Generally, MDR to three and four antibiotics dominated the resistance pattern (Table 9).

In Table 10, the MDR profile of *Salmonella* spp. showed the highest resistance (33.33%) of the isolates towards three antibiotics followed by two and four antibiotics (14.29% each). In case of *Salmonella* spp., the maximum number of antibiotics resisted was four antibiotics. However, the highest MDR (14.29%) was observed for NA/AMP/S (resistance to naldixic acid, ampicillin and streptomycin). Generally, MDR to three antibiotics dominated the resistance pattern

Table 9. MDR patterns of *S. aureus* isolated from street-vended food in Jimma town, southwestern Ethiopia 2011/2012.

Number of antimicrobial resistance	Antimicrobial resistance patterns	Number of isolates (%)	Total (%)
Two	DA/ P	3(6.38)	4(8.51)
	P/TE	1(2.13)	
Three	P/E/S	2(4.26)	18(38.30)
	P/E/CIP	1(2.13)	
	P/K/TE	1(2.13)	
	DA/ P/K	2(4.26)	
	DA/ P/ E	6(12.77)	
	DA/ P/TE	6(12.77)	
Four	DA/P/K/S	1(2.13)	11(23.40)
	DA/P/K/TE	2(4.26)	
	DA/P /E/TE	8(17.02)	
Five	DA/P/E/S/TE	1(2.13)	7(14.89)
	DA/P/E/K/TE	4(8.51)	
	DA/P/E/C/TE	1(2.13)	
	DA/P/E/CN/TE	1(2.13)	
Six	DA/P/E/S/TE/C	1(2.13)	4(8.51)
	DA/P/E/K/S/TE	1(2.13)	
	DA/P/E/CIP/S/TE	1(2.13)	
	DA/P/E/K/CIP/TE	1(2.13)	

DA=Clindamycin; P=Penicillin, TE=Tetracycline; E=Erythromycin; C=Chloramphenicol; CN= Gentamycin; K=kanamycin, NA= Naldixic Acid; S= Streptomycin; CIP= Ciprofloxacin.

Table 10. MDR of *Salmonella* spp. isolated from street-vended food in Jimma town, southwestern Ethiopia 2011/2012.

Number of antimicrobial resistance	Antimicrobial resistance patterns	Number of isolates	(%)	Total (%)
Two	AMP /S	1(4.76)		3 (14.29)
	TE/AMP	1(4.76)		
	NA /AMP	1(4.76)		
Three	TE/AMP/S	2 (9.52)		7 (33.33)
	TE/AMP/K	2 (9.52)		
	NA/AMP/S	3 (14.29)		
Four	NA/AMP/S/K	1(4.76)		3 (14.29)
	NA/TE/AMP/S	1(4.76)		
	NA/TE/AMP/C	1(4.76)		

AMP, Ampicillin; TE, Tetracycline; C, Chloramphenicol; K, kanamycin; NA, Naldixic Acid; S, Streptomycin.

(33.33%)

DISCUSSION

The socio-demographic characteristics of street vendors in the present study showed that the majority of street vendors were females. Similarly, Mensah et al. (2002) in their study in Accra, Ghana, found that 100% of vendors were females. In addition, Chukuezi (2010) in Nigeria also reported that majority (66.67%) of the street vendors were females. In the current study, 49.1% of vendors

used well water for cleaning utensils and 27.3% of them used well water for cooking. Ali et al. (2011) reported that well waters used for drinking and washing in Jimma town were not of acceptable range both in physico - chemical property and bacteriological safety. Water is a critical raw material in many street vending food operations. One of the most critical problems in street food vending is the supply of water of acceptable quality and insufficient quantities for drinking, washing, cleaning and other operations.

The food handling practices of the street vendors in the present study showed that, 90.9% served their customers without having a special apparel and 80.9% handled food with their bare hands. These numbers were higher than what was reported by Chukuezi (2010) from Owerri, Nigeria, where 42.86% had not used special apparel for vending food and 47.62% handled food with bare hands. Insanitary handlings of street foods by some of the vendors lead cross contamination (Dawson and Canet, 1991). The vendors can be carriers of pathogens like *E.coli*, *Salmonella* and *S. aureus* and eventually can transfer these foodborne pathogens to the consumers. The hands of the food handlers are the most important vehicle for the transfer of organisms from faeces, nose, and skin to the food (WHO, 1989).

In the present study, the majority of vendors had no education or training about the hygiene of vending food and many had no information about food and waterborne diseases. Education or training is critical for street vendors at all ages to prevent cross contamination and mishandling of foods at home and vending site. Hence, training and sharing of information to the vendors are critical at all levels of preparation (Collins, 1997). FAO (1998) also suggested that the food handlers should have the necessary knowledge and skills to handle food hygienically

The mean total counts of AMB (5.0 $CFUg^{-1}$) observed in the present study is in agreement with the findings of Bryan et al. (1997), who reported between 3 to 9 log $CFUg^{-1}$ from meatballs of street-vended foods from Zambia. In general, there is no standard set for the permissible level of microbes for street-vended food being served in Ethiopia. However, Gilbert et al. (2000) set the recommended guideline of street-vended food in London. According to this guideline, all food samples in the present study belonged to Level 1, which mean all food samples were fully cooked. Specifically the mean counts of AMB in all food samples (firfir, bread, injera and sambussa) in the present study were 4 log $CFUg^{-1}$ and above. Hence, they belonged to unsatisfactory level (≥ 4 log $CFUg^{-1}$). This could be as a result of from vendors' personal hygiene and dust, and litter at the vending sites. Most processed foods are regarded as harmful when they have large populations of aerobic mesophilic microorganisms, even if the organisms are not known to be pathogens (Sudershan et al., 2009).

The mean count of Enterobacteriaceae in the present study was 3.9 log $CFUg^{-1}$. This agrees with the findings of Mustafa and Abdulla (2011), who reported the counts between 2.3 to 4.4 log $CFUg^{-1}$ in Sudanese street-vended traditional foods. According to the guideline, the mean counts ($CFUg^{-1}$) of Enterobacteriaceae in firfir (4.9), injera (4.1) and bread (4.0) showed unsatisfactory level (≥ 4 log $CFUg^{-1}$), whereas sambussa (2.7) belonged to the group with acceptable level (2 to < 4 log $CFUg^{-1}$). Enterobacteriaceae and the high number AMB clearly suggest that the poor hygiene could be a source of foodborne disease (Motarjemi et al., 1993).

The mean count of coliform in the present study is between 1.7 to 4.0 $CFUg^{-1}$. The presence of coliforms in the present study could be due to fecal contamination of food or water after preparation. Heat-processed foods usually have no vegetative microbial contaminants immediately after cooking. However, food could be contaminated later. Most probably, the source of contamination for food was the water used in washing utensils or directly from hands or bodies of vendors. Of course, once introduced into the food samples and the foods left at ambient temperature for a while, the contaminating coliform would multiply to higher counts (Tomkins, 1981). The fecal coliforms have been used as an indicator of the sanitary conditions. Since the indicator is a typical component of the fecal microbiota, its detection indicate the potential occurrence of other microorganisms which could be even more pathogenic to human and both domestic and wild animals (Souza et al., 2005).

The mean aerobic bacterial spore (ABS) count (4.0 log $CFUg^{-1}$) of the present study is higher compared to report by Mosupye and Van Holy (1999) where the counts ranged between 1.2 to 2.0 log $CFUg^{-1}$ in ready to eat food samples from Johannesburg, South Africa. According to the guideline, mean counts of ABS in firfir (4.3 log $CFUg^{-1}$) and bread (4.0 log $CFUg^{-1}$) were of unsatisfactory level (>4 log $CFUg^{-1}$) whereas injera and sambussa (3.8 log $CFUg^{-1}$each) were in acceptable level (3 to < 4 log $CFUg^{-1}$). The higher counts in the present study could be due to the contamination of food by the heat resistant spores, which had survived cooking temperature because of temperature / time inadequacy during preparation of food.

The mean counts of staphylococci in the present study were 3.7 log $CFUg^{-1}$. This is in agreement with the microbiological studies made on street-vendedfoods in India (Mohapatra et al., 2002), where counts were greater than 3 log $CFUg^{-1}$. The higher levels of staphylococci in the present study could be due to unhygienic handling of food items by the vendors and vendors' personal hygiene. The interview results showed 80.9% of the vendors handled food with their bare hands and 90.9% did not use special cloth while processing and vending the food samples. According to Mensah et al. (2002), the uses of a fork or spoon to serve food reduced the level of contamination, while the use of bare hands resulted in an increase of contamination. Staphylococci exist in air,

dust, sewage, water and food or on food equipment and environmental surfaces. *S.aureus* can be found in the nose (50%), on hands (5-30%), in hair, eyes and throat of healthy persons (Hammad, 2004).

In the present study, the mean count of LAB was 4.0 log CFUg^{-1}. Incontrast to the present study, Omemu and Omeike (2010) reported the higher count ranging between 4.5 to 9.2 log CFUg^{-1} in cooked ogi used as weaning food from Nigeria. The high count of LAB in food has significant impact in lowering the counts of pathogens. The growth of many bacteria is inhibited or decreased in the presence of lactic acid bacteria (Shirazinejad et al., 2010).

The mean counts (log CFUg^{-1}) of moulds and yeasts in the present study were 2.6 and 3.8, respectively. The presence of high count of yeasts and moulds in the present study could be due to litters in the environment. Yeasts do not produce adverse toxins to humans. However, some moulds produce toxic substances that can cause disease or illness when eaten by humans. It is difficult to prevent moulds from growing on foods but their levels can be decreased by maintaining hygienic conditions during food processing and storage. Spores of mould can be carried by wind, and hence can easily enter into food sample (Stratford, 2006).

The predominant microfloral of street-vended foods in the present study was generally *Bacillus* spp. (41.96%) followed by *Staphylococcus* spp. (24.28%), and *Micrococcus* spp. (17.68%). The current study showed higher percentage of isolates than Muleta and Ashenafi (2001b) report where the isolates from street-vended food were dominated by *Bacillus* spp. (29.1%), followed by *Staphylococcus* spp. (22.8%) and *Micrococcus* spp. (15.4%) in Addis Ababa, Ethiopia. The predominance of *Bacillus* spp. among isolates on aerobic plate count plates was possibly due to the presence of spores in the raw materials. The heat-resistant spores may have survived cooking while vegetative bacteria were eliminated (Mosupye and von Holy, 1999). High number of *Bacillus* spp. could cause food poisoning result foodborne disease. *Micrococcus* spp. and *Staphylococcus* spp. were among the dominant isolates possibly due to much litter and dust in vending sites, handling of food with bare hands and the vendors serving utensils stayed for a long period before replacement. They are common environmental bacteria that could be introduced into the food after cooking through cross-contamination (Cardinale et al., 2005).

The prevalence of *S. aureus* and *Salmonella* spp. in the present study were 29.38 and 13.13% respectively. The higher prevalence of *Salmonella* spp. and *S. aureus* in the present study could be due to handling of food with bare hand, washing of the utensils using well water, litter and dust at vending site. The presence of a large number of *S. aureus* in a food may indicate poor handling or sanitation and lead to cross contamination from vendors to food (Sina et al., 2011). Ready-to-eat foods should be free of *Salmonella* as consumption of food containing this pathogen may result in foodborne illness. The presence of this organism indicates poor food preparation and handling practices such as inadequate cooking (Tunung et al., 2007).

The antibiotic resistance patterns of the isolates revealed low number of resistance (4.26%) of *S.aureus* to each of chloramphenicol and gentamycin. Similarly, Alina et al. (2011) reported lower number of S. *aureus* isolates resistant to chloramphenicol (0.5%) and gentamycin (1.5%). In the current study, all S. *aureus* isolates were resistant to Penicillin G. This was in agreement with Sina et al. (2011) who reported that, 100% of the isolates were resistant to Penicillin G. The resistance of *S. aureus* to penicillin G could be due to the production of penicillinase enzyme (a type of ß-lactamase) that hydrolyzed the beta-lactam ring of penicillin (Lowy, 2003).

The prevalence of antimicrobial resistance among foodborne pathogens has increased during recent decades (Chui et al., 2002), possibly as a result of selection pressure created by the use of antimicrobials in food-producing animals (Bywater, 2004). The coexistence of resistance genes with mobile elements such as plasmids and transposons facilitate the rapid spread of antibiotic resistant genes among bacteria (Sunde, 2005).

The study in Sarab, Iran by Akbarmehr (2012), showed that *Salmonella* spp. were highly susceptible to chloramphenicol (100%) followed by ciprofloxacin and gentamycin (91.89% each). However, isolates of *Salmonella* spp. exhibited resistance to streptomycin and tetracycline (29.72% each) and ampicillin (13.51%). In the present study, high number of *Salmonella* spp. was susceptible to ciprofloxacin and gentamycin (100% each) and lower number to chloramphenicol (95.24%). In this study we found, lower resistance to streptomycin (23.81%) while higher resistance was observed in tetracycline (38.1%) and ampicillin (95.24%). Antibiotics such as ampicillin and sulphamethoxazole are the first line antibiotics used for the treatment of salmonellosis. However, *Salmonella* strains which are resistant to these first-line antibiotics have recently emerged worldwide, and is causing great concern. With that increase, the risk to public health has also increased. It is particularly serious in low-resource countries where bacterial infections remain among the major causes of death (Bartoloni et al., 2005).

Conclusions

The overall microbial quality of street-vended foods assessed in the current study was poor as compared to the guidelines set by other regulatory bodies. This could be due to the poor personal hygienic practice of street vendors such as handling food with bare hand, washing the utensils using well water, availability of dust and litters

at vending site and lack of training for vendors lead to the higher level of microbial load though cross contamination. The most predominant microbial groups were *Bacillus* spp., *Staphylococci* spp., *Micrococcus* spp. and Enterobacteriaceae. Thus, the presence these microorganisms could be a possible prediction for the presence of pathogens. The presence of high number of pathogenic bacteria such as *Salmonella* spp. and *S.aureus* could cause foodborne diseases like diarrhea, typhoid fever and food poisoning. *S.aureus* isolates were susceptible to chloramphenicol, gentamycin and ciprofloxacin but resistant to penicillin G. On the other hand, *Salmonella* spp. was susceptible to ciprofloxacin, gentamycin, norflaxacin and chloramphenicol. However, it was resistant to ampicillin and naldixic acid. The consumption of un hygienically prepared and contaminated street-vended foods could lead to the dissemination of drug resistant bacteria such as *Salmonella* and *S. aureus.*

RECOMMENDATIONS

Vendors should wash hands before and after preparation of food, cleaning the vending site with the collaboration of the municipal of Jimma town, washing the utensils with soap and warm water and serve the consumers using fork or spoon. The concerned bodies like the municipal of Jimma town, health official of Jimma town and other voluntary NGO's should give attention to improve the quality of street vending food by providing training to the vendors to keep their personal hygiene and clean the vending sites. Moreover, vendors should adequately heat vended food. The guideline for Ethiopia street vending food should be set. The unusually high microbial load of firfir and bread samples calls for regular inspection for safety of street-vended foods. As significant numbers of population in Jimma town is earning income from street vending business, government should give attention and provide the necessary infrastructure to the vendors in order to improve the safety of street-vended foods. Currently, different antibiotics are available in a market among these and it is better to use chloramphenicol, gentamycin and ciprofloxacin for foodborne disease caused by *S. aureus* and ciprofloxacin, gentamycin, norflaxacin and chloramphenicol for foodborne disease caused by *Salmonella* spp. It is necessary to enhance food hygiene practices to reduce or eliminate the risk from resistance to antibiotic and pathogenic bacteria originating from food. Identification of the isolates could not show the exact identity. Thus, molecular approach can overcome this drawback.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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