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Bacteriological Quality of Street Vended Ready to Eat Legume and Vegetable Based Foods in Bahir Dar Town, Amhara Regionalstate, North Western Ethiopia

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Abstract

Street vending foods are readily available sources of meals for many people, but the microbiological quality of such foods has been always in doubt. The aim of this study was to determine the microbial quality of legume and vegetable based foods and the hygienic practices of street vendors in Bahir Dar town. Sixty (60) food samples were collected from different locations. Aerobic mesophilic, total coliforms, fecal coliforms and *Staphylococcus aureus* counts was based on standard methods from December 2013 to June 2014. Out of the total samples, 28.3%, 33.3%, 18.3% and 51.7% of the foods were above acceptable limit for aerobic mesophilic count, *S. aureus*, total coliforms and thermotolerant, respectively. While *S. aureus* and thermotolerant coliforms were not detected in 1(21.7%) and 29(48.3%) of the food samples, respectively. Only 7(11.7%) out of the total sample was hazardous due to high mean count of *S. aureus*. There were no statistically significance differences (i.e., p>0.05) in bacterial counts between the two food items. On the other hands, most of the water samples used to wash ready to eat foods and utensils in food preparation were contaminated and above WHO drinking water standards. In addition, an observational checklist showed as majority of the food handlers did not practice hand washing during food preparation and serve prepared foods without reheating. Most of the ready-to-eat foods were contaminated and they can pose potential risks to consumers and therefore the local authority should emphasize on educating the ready-to-eat food handlers on food and personal hygiene to ensure the hygienic standards and food safety.

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Keywords

Bacterial count, Coliform, Contamination, Food hygiene, Street food

Introduction

Street-vended foods are foods and beverages prepared and sold by vendors in the streets and other public places for immediate consumption or consumption at a later time without further processing or preparation (Thomas, 2010; Ackah *et al.*, 2011; Garode and Waghode, 2011). These foods may be consumed at the same place or can be taken away and consumed elsewhere. Street vended foods are not only appreciated for their unique flavors, convenience and the role they play in the cultural and social heritage of societies, but also become important and essential for maintaining the nutritional status of the population (Garode and Waghode, 2011). At present, street food offers a chance for self-employment and to develop business skills with low capital investment (Draper, 1996; Thomas, 2010; WHO, 2010). In addition, the street food industry feeds millions of people daily with a wide variety of foods that are cheap and easily accessible (Garode and Waghode, 2011).

On the other hands, street foods show great variation in terms of ingredients, processing, and methods of marketing and consumption. They often reflect traditional local cultures and exist in an endless variety encompassing meal, drinks and snacks. These categories reflect a growing difficulty to provide adequate infrastructure and environmental hygiene to ensure the safe production of food (Leonard *et al.,* 2003). There is much diversity in the raw materials as well as in the method of preparation of street foods and there are also differences in the places where street foods are prepared; however, the majority of the vendors, prepared their food at home and brought to the streets for marketing (Leonard *et al.,* 2003; WHO, 2010).

Epidemiological studies suggest that street foods contribute to a significant number of food poisonings are inadequate, due to paucity of data in knowledge about important parameters in the food chain and host pathogen interactions; however, there have been several documented cases of food poisoning outbreaks due to street foods (Umoh and Odoba, 1999). The people who depend on such foods are often more interested in its convenience than its safety or quality and hygienic aspects of the consumed food. Besides, the traditional processing methods that are used in the preparation, inappropriate holding temperature and poor personal hygiene of food handlers are some of the main causes of food borne illness of microbial origin and a major health problem associated with street foods (Feglo and Sakyi, 2012).

Food borne bacterial pathogens commonly detected in street vended foods are *B. cereus*, *C. perfringens*, *S. aureus* and *Salmonella* spp. (Umoh and Odoba, 1999; Deribaand Mogessie, 2001). People who patronize street foods have been reported to suffer from food borne diseases like diarrhea, cholera, typhoid fever and food poisoning (Kauland Agarwal, 1998).

Heavily contaminated water which used for food preparation and drinking is also a primary source of diarrheal diseases to the street food consumers. Pathogens like *Salmonella* and *Shigella* have been detected in the water used by vendors for dishwashing (Barro *et al.,* 2006). Similarly, studies done to find out the bacteriological quality of the water used by some street vendors have revealed frequent contamination with coliforms and fecal coliforms (Agard *et al.,* 2002).

Among the traditional foods throughout Ethiopia, vegetables and legumes based foods are the most popular dishes and the vendors sold foods throughout the day along with local pancake like bread called *engera*. Different researchers in the country revealed that pathogens and indicators are enumerated above the acceptable limit from different categories of street vended foods. Study done in Jemma town, *Staphylococcus* count in street foods was much higher(5.39 log cfu/ml) than the standard and dominated by almost the same load of aerobic mesophilic bacteria (6.13 log cfu/ml) and Enterobacteriacae (5.96 log cfu/ml) (Tekletsadikand Tsige, 2011).

Additionally, according to Deriba and Mogessie (2001), from a total of 150 samples were collected from different outlets in Addis Ababa, most of the street food samples had aerobic mesophilic counts $>10^7$cfu/g. On the other hand, a study done in Bahir Dar town, the total coliform counts on the surface and the core of street vended white lupin ranged from 15 to 1100MPN/g and 11 to 1100MPN/g, respectively; and out of 40 samples, 92.5% of the surface and the core was contaminated with fecal coliforms (Mulugeta and Million, 2013).

In Bahir Dar town, different types of ready to eat foods are commonly sold near the streets, taxi ranks and bus station, market centers and other public areas. Researches were done on microbiological quality and safety of some ready to eat foods in the city (Alemayehu, 2011; Mesfin, 2011; Mastewal, 2011). However, there is no information on microbiological quality and safety of cooked legume and vegetable based foods sold in the streets of Bahir Dar town. Therefore, the present study was conducted to determine bacterial detection and count in relation to food quality as well as water quality which used for food preparation and washing equipment's along with the hygiene and handling practices of food handlers.

Materials and Methods

Description of the study area

The study was conducted in Bahir Dar city, the capital of the Amhara, National Regional State in the Northern part of Ethiopia. It is located at 11º 38'N, 37º 10'E on the southern side of Lake Tana (http:/en.wikipedia-org/wiki Bahir Dar). The lowest and the highest annual average temperatures of the city are 10.3ºC and 26.3ºC, respectively. The annual average rainfall is 1,224mm (Bahir Dar City Administration, 2009). Bahir Dar is one of the leading tourist destinations in Ethiopia, with a variety of attractions in the nearby Lake Tana and Blue

Nile River. Street food vendors in the city around main road, bus station and hospital areas are common practice

Study design

A cross-sectional prospective study was conducted in Bahir Dar city from December 2013 to June 2014 to assess the bacteriological quality of street vended legume and vegetable based foods in three purposive selected sites within assessing of handling practices of food vendors

Sample description and collection of food sample

Commonly served ready to eat foods (RTE) in the street vendor; legume based (made from roasted and ground faba bean or split pea or lentil) and vegetable based (a classic dishmade from cabbage, potato, carrot and kale flavored with spice).

These foods are normally cooked at over 85^{o}C for 30-60 minutes or even longer and after cooling the food to be ready to serve and sell throughout the day by venders without reheating.

A total of 60 samples (30 legume-based and 30 vegetable based foods) were collected from each of the three sampling outlets (around Bus station, *Belay zelekkebele* and Hospital) in the town and stored in refrigerator until bacteriological analysis was carried out within an hour of collection.

Microbiological analysis of food

Enumeration of aerobic mesophilic bacteria

The total count of aerobic mesophilic bacteria was determined as the procedure described by (Kiiyukia, 2003; Azanza, 2005). One milliliter from each decimal dilution up to 10^{-3} was dispensed into triplicate sterilized Petri dishes and plate count agar was poured and incubated at 37^{0}C for maximum of 48 hours.

Total coliforms and fecal coliforms

Test for the presence of total coliforms and fecal coliforms in the food samples was based on the procedure described in the Manual of Food Quality Control of FAO (Andrews, 1992). And the results of the test were reported as the most probable number (MPN) per gram of food. The same procedure was carried out for fecal coliforms except incubated period

Staphylococcus aureus

One ml in each sample of prepared serial dilution was transferred into triplicate sterile Petri dishes and Mannitol salt agar (Oxoid, England) was poured and swirled gently and finally incubated at 37ºC for a maximum of 48 hours (Robers and Greenwood, 2003). Yellow and orange colonies surrounded by yellow zones due to mannitol fermentation were enumerated and reported as mean cfu/g of food.

Bacteriological analysis of water

Two hundred (200) ml of each water sample was collected in a sterile glass bottle from each location and were transported into the laboratory followed by bacteriological analysis for total coliforms according to the procedure described by APHA (Adetunde and Glover, 2011) and results reported as MPN/100ml.

Assessments of the hygienic practices of venders and vending area

The observation checklist covering topics on the personal hygiene of the food handlers, food hygiene practices (modes of cleaning and sanitizing utensils) and hygiene of the cooking area to assess whether the vending food exposed to flies, insects and animals, presence of solid and liquid waste and latrine facilities around the food vending area.

Data analysis

ANOVA and t-test was used if there is a mean statically difference between the two food items for microbial load counts from different locations. SPSS software version 20 was used and Significance of difference held at if $p< 0.05$.

Results and Discussions

Microbiological analysis of food

Aerobic mesophilic counts

In the present study, the range of aerobic mesophilic bacteria was 3.28 to 5.95 log10cfu/g with a mean value of 4.50 log10cfu/g in legume based and 2.72 to 5.79 log10cfu/g with a mean value of 4.54 log10cfu/g in vegetable based food (Table 1). There is no statistically significant difference between the mean bacterial count of legume and vegetable based foods (i.e., p=0.850). The mean count of aerobic mesophilic bacteria of legume based (4.50 logcfu/g) and vegetable based (4.54 log cfu/g) foods in this study fall under acceptable limit and compared to this finding with the study done in Cape Coast, Ghana was revealed that legume based foods of microbial contamination ranges from 4.41to 7.11 log10 cfu/g with mean of 5.8 log 10 cfu/g (Annan *et al.*, 2011) which exceed the acceptable level (<5 log10 cfu) and another study of fully processed food of legume based dish in Nigeria, AMC ranges from 3.74 to 5.08 log10cfu/g with a mean value of 5.48 log10cfu/g (Bukar*et al.*, 2010).

As shown in Table 1, total mean AMC of street vended foods (5.12 log cfu/g) fell above the standard limit (≥5 log10cfu/g) set by PHLS (2000) and NSW (2009) which categorized as unsatisfactory for consumption and similarly agreed to study conducted by Azanza (2005) and Tambekar *et al.,* (2009). On the other hand, all food samples were positive for mesophilic bacteria (Table 1) whereas Mensah *et al.,* (2002) reported that of 511 street food items examined in Accra, only 69.7% contained mesophilic bacteria.

The current study has a low mean bacterial count compared to the study done in South Africa, the mean value of aerobic bacterial count of vegetables was 6.8 log10 cfu/g with a range of 6.3–6.8 log10 cfu/g (Mirriam*et al.*, 2012) whereas in this study had a higher mean bacterial count of legume based (4.50 log10cfu/g) than study conducted in street foods in Accra, Ghana (2.5log10cfu/g±0.03 SD) of aerobic mesophilic count (Mensah *et al.*, 2002). Similarly, the aerobic count of the present study in both food types had higher mean value than the study done in Sudan revealed that the mean total viable count of cooked vegetable sauce and legume based food (*foul*) was 4.5 and 4.2 log10 cfu/g, respectively (Abdella *et al.*, 2009).

It is believed that high aerobic mesophilic bacteria in foods indicate greater risks of pathogens being present in consumable products, poor implementation of sanitation procedures or problems in process controls, temperature abuse during vending and inadequate cooking (Azanza, 2005). In the current study, 43/60 (71.7%) in which 14 (23.3%) and 29 (48.3%) of the total sample categories as good, and acceptable, respectively, and therefore, most of the food samples were satisfactory for consumption and the remaining 17/60 (28.4%) categorized as unsatisfactory or above accepted limits (Table 2).

The finding of the result showed that higher mean counts of aerobic mesophilic bacteria was recorded in vegetable (5.02 log10cfu/g) followed by legume based (4.72 log10cfu/g) from Bus station. Whereas, the lowest mean value of AMC was obtained from vegetable based food (4.12 log10 cfu/g) from *Belay zelekekebele* and legume based food (4.32 log10cfu/g) from hospital surroundings. Even though mean variation among sites, there is no statistically significance difference of mean aerobic bacterial count (f=0.707; p=0.502) in legume based food. But statistical significance difference of the mean aerobic count was obtained in vegetable based food (f=3.632; p=0.04) among sites (Figure 1).

The differences of AMC among the study sites may be due to variations in hygienic condition of the vending environment and practices of the food vendors. The highest count around Bus station may be due to the venders achieved their daily activities under crowded area and poor practice of garbage disposals around the vending area. Similarly, study in Nigeria to analyze the microbial quality of RTE foods revealed that the vegetables recorded the highest ($1.8x10^6$cfu/g) bacterial population in one study location than the others (Odu and Akano, 2012).

Total coliform counts

The present study demonstrated that total coliform counts of legume based food range from 3.6 to 1100 with mean value of 231.4 MPN/g; and in vegetable based food range 7.2 to 1100 with mean of 308.6 MPN/g. However, there was no statistically significant variation in coliform counts between food types (p=0.467) (Table 3).

The presence of indicator bacteria in RTE food, although not inherently a hazard, can be indicative of poor practice that may be one or more of the following (Roberts and Greenwood, 2003); poor environmental sanitation is largely responsible for much of the contamination, and poor personal hygiene, particularly among food handlers, accounts specifically for the contamination of foods while improper storage leads to multiplication of bacteria in food to infective doses. Foods are often preserved at ambient temperatures, long before consumption, improperly handled by food vendors, and sold in streets in the dirty and unhygienic environment (Roberts and Greenwood, 2003).

The finding of the study also revealed that 37 (61.7%), 12 (20 %) and 11 (18.3%) out of the total samples had levels of coliform contamination as good, acceptable and unsatisfactory, respectively in which 5 (16.7%) in legume based and 6 (20%) in vegetable based food; above the accepted limit (≥1000MPN/g) recommended by the Food Quality Check Program (2011) fell within unsatisfactory for consumption (Table 4). Presence of coliforms in street foods might also be due to inadequate handling, water used for food preparation and serving which may be contaminated with fecal coliforms (Gitahi *et al.*, 2012).

As shown in (Figure 2), the mean values of total coliforms of legume based food samples obtained from *Belay zelekekebele*, Bus station and Hospital surrounds were 144.4, 372.4 and 177.6 MPN/g, respectively, whereas mean total coliforms in vegetable based foodwere 220.2, 409 and 296.5 MPN/g, respectively. However, there was no statically significant difference in legume based food (f=0.931; p=0.406) and vegetable based food (f=0.510; p=0.606) among the sites. The mean value of total coliform among sites in the present study in both food types fall into acceptable limit (>100MPN/g) whereas other study demonstrate that total coliforms were detected in vegetables of all locations at unsafe levels and the lowest counts of total coliforms were in legume based foods (Gitahi *et al.*, 2012).

Fecal (Thermotolerant) coliforms count

Fecal coliforms (thermotolerant coliforms) are more restricted in their source to the gastrointestinal tract of warm-blooded animals. Their presence in ready to eat foods could indicate fecal contamination and sometimes the presence of pathogens. Fecal contamination can arise through the use of contaminated water, poor hygiene of food workers in contact with the food product, or through contact with flies or other insect pests (Nawas *et al.*, 2012).

In this study, the mean of fecal coliform counts of the legume based food was 23.46 with a range of 3 to 120 MPN/g and similarly the mean count of vegetable food were 27.08 with a range of 3.6 to 240 MPN/g (Table 5). Although mean variation between food items, there was no statistical significant differences between mean fecal coliforms count between the foods (p=0.835).

The present study had comparatively higher maximum value (240MPN/g) than the study carried out in Nigeria by Odu and Akano (2012), revealed that, the fecal coliform count in vegetables ranged from 3.6 to 9.2MPN/100ml.

The present study also revealed that the percentage of vegetable and legume based foods contaminated by fecal coliforms were 13 (43.3%) and 16 (53.3%), respectively categorized as good and the remaining 14 (46.7%) in legume based and 17 (56.7%) in vegetable based food categorized as unsatisfactory. Nearly half of the samples (48.3%) classified into satisfactory level and the remaining (51.7%) as unsatisfactory for consumption (Table 6). Similarly, a study conducted in Pakistan; in six cooked vegetables only two samples were positive for fecal coliforms (Yasin *et al.*, 2012)

The highest mean contamination of vegetable based samples by fecal coliforms was obtained in the cite *Belay zelekekebele* (50.6 MPN/g), Hospital surround (17.6MPN/g) followed by Bus station (10.3MPN/g), whereas the legume based food had the highest mean count (MPN/g) at *Belay zelekekebele* 28.3), Bus station (22.7) followed by Hospital surround (19.2 MPN/g) (Figure 3).

There is no statically significant difference in legume based food (f=0.75; p=0.929) and in vegetable based food among sites (f=0.815; p=0.463). Overall, the presence of coliforms particularly in processed food which indicative of recent contamination and there is a greater risk of pathogens (Yasin*et al.*, 2012).

Staphylococcus aureus count

The study showed that the mean value of legume and vegetable based food was 2.97 and 2.91 log10 cfu/g with range value of 1.74–4.52 and 1.50 to 4.24 log10 cfu/g, respectively. There was no statistically significance difference in the mean count of *S. aureus* between the two food items (p=0.775) (Table 7). The present study agrees with the study carried out in Nigeria in which the range for staphylococci count of vegetables was 0 to 4.58 log10 cfu/g (Odu and Akano, 2012). In the present study, the higher detection rate of coagulase positive Staphylococcus was obtained from vegetable based sauce (86.7%) than legume based foods (70%) and compared to other study conducted in Taiwan, the percentage of positive samples of *S. aureus* in vegetable based food were 13.6% (Fang *et al.*, 2003).

S. aureus detected in food could possibly source from vendors' hands while cooking the food or through coughing and sneezing as well as storage of food at high temperature (Rabbi *et al.*, 2011). The finding of the study had comparatively higher mean log10 cfu/g of *S. aureus* in legume based foods than study done in street foods in

Accra (0.6 mean log10 cfu/g) of *S. aureus* (Mensah *et al.*, 2002) while mean *S. aureus* count was lower in both food types than the study conducted in Sudan, *S. aureus* count of cooked vegetable sauce and legume food was 3.1 and 3.2 log10 cfu/g, respectively. The differences among the findings of the studies could be variations in storage temperature, time of sample collection, location of the study sites and handling practices of the venders (Tambekar *et al.*, 2009). Improper handling and improper hygiene might lead to the contamination of food with *Staphylococcus aureus* and this might eventually affect the health of the consumers (Odu and Akano, 2012). Foods that require considerable handling during preparation and are kept at slightly elevated temperatures after preparation are frequently the ones involved in staphylococcal food poisoning (Fahed, 2003). *S. aureus* is amongst the most common pathogens found on hands and there is every possibility of contamination before or after cooking of a food as well as during serving. Possible sources of contamination may account forwashing water, insects and rodents, hair or hair products infood, unhygienic kitchen environment, contaminated equipment, contaminated air or dust and lack of adequate sanitation (Rabbi *et al.*, 2011).

The prevalence of *S. aureus* in this study was 47(78.3%)of the total sample analyzed (Table 7). The results were contrary to the findings of Mirriam *et al.*, (2012) who reported low prevalence of *Staphylococcus aureus* (3.2%) in street-vended foods. On the contrary, in a study conducted in Malaysia, coagulase-positive Staphylococci were not found in all the examined samples (Alyaaqoubi *et al.*, 2009). Similarly, Hanashiro *et al.*, (2005) stated that *Staphylococci* were not detected in street-prepared RTE meal samples in Brazil. Differences in geographical location and personal hygiene of the food handlers might help to explain this variation. When *Staphylococcus aureus* is allowed to grow in foods, it can produce a toxin that causes illness. Although, cooking destroys the bacteria, the toxin produced by *Staphylococcus aureus* is heat stable and may not be destroyed even by heating, let alone by refrigeration. Foods that are handled frequently during preparation are prime targets for Staphylococci contamination (Ghosh *et al.*, 2004).

As the result of the current study, out of isolates of *Staphylococcus aureus*, only 4 (13.3%) of legume based and 3 (10%) of vegetable based food were hazardous (Table 8) due to *S. aureus* $\geq 10^4$ based on (NSW, 2009). Compared this finding with the study done in Accra, 31.9% of *S. aureus* out of total samples of street vended foods was isolates (Mensah *et al.*, 2002) and in another study, it was observed that, only 16% of street vended RTE food contaminated with *S. aureus* (Umoh and Odoba, 1999). The presence of *S. aureus* in high numbers (>4 log10 /g) in ready to eat foods may indicate a possible contamination either after cooking or under processing. While the remaining of the food samples as satisfactory level in which, 13(43.3%) and 9(30%) of legume based food categorized as good, and acceptable, respectively, and similarly 7 (23.3%) and 11 (36.7%) of vegetable food categorized as good, and acceptable, respectively (Table 8).

As shown in (Figure 4), the mean count of *S. aureus* (log10 cfu/g) in legume based food, lower count from Hospital area (2.35 log10 cfu/g), Bus station (3.06 log10 cfu/g) followed by *Belay zelekekebele* (3.61 log10 cfu/g) was recorded. There were statistical significant differences in legume based food among three sites (f=6; p=0.01). Similarly, mean count of *S. aureus* in vegetable based food was 2.37, 2.94 and 3.24 log10 cfu/g from Hospital, Bus station and *Belay zelekekebele*, respectively. There was also a statistical significant difference in count of *S. aureus* in vegetable based food among three sites (f=4.059; p=0.031). The reasons for bacterial count differences among sites may be due to handling practice and personal hygiene of vendors as well as time and temperature abuse.

Bacteriological analysis of water

The water samples collected, along with the food samples, were those presented for drinking, washing utensils for serving the foods and hand washing. Water gets contaminated in the household during storage or time of fetching. The contaminated water samples could be the direct sources of enteric pathogens or they could introduce pathogens to the foods through serving plates when water is used for washing (Ray, 2004). The present study showed that total coliform counts of the water sample varied from <2 and >1600MPN/100ml in different sites. The result revealed that the bacteriological quality of only two of water samples analyzed (<2 MPN/100ml) was within the acceptable limits based on WHO (2001) guidelines and the remaining water samples were above the acceptable limit in which four samples were above the upper detection limit (>1600MPN/100ml). The WHO (2001) and Ethiopian drinking water guidelines (FDRE, 2011) require there should be no coliform bacteria/100 ml of treated water in the distribution as tested by multiple tube tests.

According to Nawas *et al.*, (2012), 33.33% of water samples had a total coliform count more than 1100 CFU/100ml and 73.33% of the samples were contaminated with total and fecal coliform bacteria, which were unacceptable for human consumption. The water used to prepare the foods and to clean the eating utensils sometimes may be sources of contamination because venders can use waste water as recycled for washing and cleaning purpose (Ray, 2004; Muhammed *et al.*, 2010). Although coliform organisms may not always be directly related to the presence of fecal contamination, the presence of coliforms in water suggested the potential presence of pathogenic enteric microorganisms such as *Salmonella* spp., *Shigella* spp., and *Vibrio cholera*. Thus, water quality can greatly influence the microbial quality of foods. In addition to bacteria, contamination of foods with pathogenic viruses, and parasites from water is commonly reported (Ray, 2004; Muhammed *et al.,* 2010).

Assessments of the hygienic practices of venders and the vending environment

Vendors handling practices, personal hygiene and the vending environment have been significant role for contamination of street vended RTE food. In the present study, 21 (58.3%) and 24 (66.7%) did not dress appropriate overcoat and hair cover, respectively (Table 9). Because hair is known to harbor *S. aureus*, it is essential to prevent loose hair, and dandruff from falling onto the food or food preparation areas (Lues *et al.*, 2006). Twenty three (63.9%) of the venders were observed had no short and cleaned nail and majority of the food handlers achieved their activity without proper and clean dressing (Table 9) in which the food can get contaminated with *S. aureus* during preparation and handling of foods. Conversely, hand washing is an essential component of infection control (Larson, 2003). During the study, observations revealed that 27 (75%) of the vendors did not practice hand washing while preparing and serving street foods, even the remaining 9 (25%) of the venders wash their hands without the use of soap. Another study demonstrated that out of 128 street vendors in Indonesia, 70 (55%) of the vendors did not wash their hands before food preparation. Although vendors washing their hands after defecation during working hours, non-use of soap or Sanitizers (Vollaard *et al.,* 2004). This could have promoted transfer of the pathogens from the hand to the food (Taulo *et al.*, 2008). Wear of jewelry was observed in 29 (80.6%) of the vendors (Table 9). Overall, personal hygiene should be kept because street vendors are the largest contamination sources of food.

Table.1 Mean and range of aerobic mesophillic bacteria (log10cfu/g) of street vended legume and vegetable based foods in Bahir Dar town (n=60)

Food type	No. of samples	Mean ± SD	Range (log cfu/g)	P value
Legume based	30	4.50 ± 0.76	3.28 – 5.95	
Vegetable based	30	4.54 ± 0.82	2.72 – 5.79	0.850
Total	60	5.12 ± 0.56	2.72 - 5.95	

Table.2 The number and percentage of good, acceptable and unsatisfactory level of AMC in street vended legume and vegetable based foods in Bahir Dar

Parameter	Food type	Good (%)	Acceptable (%)	Unsatisfactory (%)	Total
AMB	Legume	8 (26.7%)	14 (46.6%)	8 (26.7%)	30
	Vegetable	6 (20%)	15 (50%)	9 (30%)	30
Total		14 (23.3%)	29 (48.3%)	17 (28.4%)	60

AMB* Aerobic-mesophilic bacteria

Table.3 Mean and range of total coliform count (MPN/g) of street vended legume and vegetable based foods in Bahir Dar town (n=60)

Food type	No. of samples	Mean	Minimum	Maximum	P value
Legume based	30	231.4	3.6	1100	
Vegetable based	30	308.6	7.2	1100	0.467
Total	60	554.6	3.6	1100	

Table.4 The number and percentage of good, acceptable and unsatisfactory level of total coliforms count in street vended legume and vegetable based foods in Bahir Dar town

Parameter	Food type	Good (%)	Acceptable	Unsatisfactory	Total
Total-coliforms	Legume	21 (70%)	4 (13.3%)	5 (16.7%)	30
	Vegetable	16 (53.3%)	8 (26.7%)	6 (20%)	30
Total		37 (61.7%)	12 (20 %)	11 (18.3%)	60

Table.5 Mean and range of fecal coliforms count (MPN/g) of street vended legume and vegetable based foods in Bahir Dar town (n=60)

Food type	No. of samples	Mean	Minimum	Maximum	P value
Legume based	14	23.46	3	120	
Vegetable based	17	27.08	3.6	240	0.835
Total	31	25.44	3	240	

Table.6 The number and percentage of good and the unsatisfactory level of fecal coliforms in street vended legume and vegetable based foods in Bahir Dar

Parameter	Food type	Good (%)	Acceptable (%)	Unsatisfactory	Total
Fecal-coliforms	Legume	16 (53.3%)	N/A	14 (46.7%)	30
	Vegetable	13 (43.3%)	N/A	17 (56.7%)	30
Total		29 (48.3%)	-	31 (51.7%)	60

N/A-Not applicable

Table.7 Mean and range of *S.aureus* count (log10cfu/g) of street vended legume and vegetable based foods in Bahir Dar town, 2013 (n=60

Food type	No. of samples	Mean (log cfu/g) ± SD	Range (log cfu/g)	P value
Legume based	21	2.97 ± 0.87	1.74 - 4.52	
Vegetable based	26	2.91 ± 0.70	1.50 - 4.24	0.775
Total	47	2.78 ± 0.68	1.50 - 4.52	

Table.8 The number and percentage of good, acceptable and unsatisfactory level of *S. aureus*

Parameter	Food type	Good (%)	Acceptable (%)	Unsatisfactory (%)	Hazardous (%)	Total
S. auerus	Legume	13(43.3%)	9 (30%)	4 (13.3%)	4 (13.3%)	30
	Vegetable	7 (23.3%)	11 (36.7%)	9 (30%)	3 (10%)	30
Total		20(33.3%)	20 (33.3%)	13 (21.7)	7 (11.7%)	60

Table.9 Vendors' personal hygiene, in Bahir Dar town

Characteristics	**Frequency (n=36)** **Yes**	**No**
Wearing of appropriate over coat	15 (41.7%)	21 (58.3%)
Vendors dressed clan	17 (47.2%)	19 (52.8%)
Wear of appropriate hair cover	12 (33.3%)	24 (66.7%)
Short trimmed and cleaned nail	13 (36.1%)	23 (63.9%)
Hand washing before serving the-food to the consumer	9 (25%)	27 (75%)
Wear of jewelry	29 (80.6%)	7 (19.4%)

Table.10 Vendors' food handling practices in Bahir Dar town, 2013 (n=36)

Characteristics	Frequency	Percent
Food reheats before sale		
Yes	-	-
No	36	100
Adequate cooking of the foods		
Yes	15	41.7
No	21	58.3
Left over RTE foods stored at refrigerated temperature		
Yes	-	-
No	36	100
Modes of cleaning and sanitizing utensils:		
Cold water with detergent (soap)	11	30.6
Hot water with detergent	-	-
Only cold water without detergent	25	69.4
How many times water used for washing dish:		
Once	-	-
Twice	4	11.1
Several	32	88.9
Vendors handling money when serving food		
Yes	36	100
No	-	-

Table.11 Assessments of vending environment in Bahir Dar town, 2013 (n=36)

Characteristics	Frequency	percent
Presence of refuse receptacles for solid waste		
Yes	30	83.3
No	6	16.7
Proper covering of the refuse receptacle		
Yes	8	22.2
No	28	77.8
Presence of a drainage system for collection and handling of liquid Waste		
Yes	9	25
No	27	75
Harbor vectors such as flies?		
Yes	23	63.9
No	13	36.1
Are the refuse receptacles far from the vending site?		
Yes	5	13.9
No	31	86.1
Source of water:		
Privately installed from municipal supply	9	25
From communal distribution	-	-
Buy from privately installed pipe	27	75
From tanker	-	-
Final Disposal of liquid waste:		
Open dumping in the area	25	69.4
Septic tank	-	-
Municipal sewage	11	30.6
Latrine facilities:		
Flush type	-	-
Dry pit latrines	20	55.6
Open latrines around the vending area	9	25
Not available	7	19.4

Figure.1 Aerobic mesophillic bacteria (log10 cfu/g) of street vended legume and vegetable

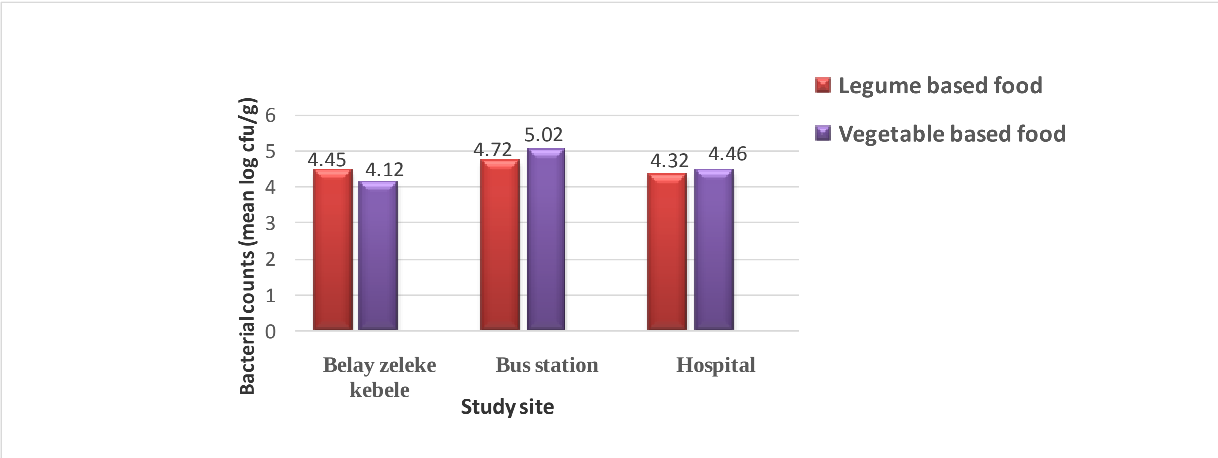


Figure.2 Total coliforms count (MPN/g) of legume and vegetable based foods among three sites in Bahir Dar town

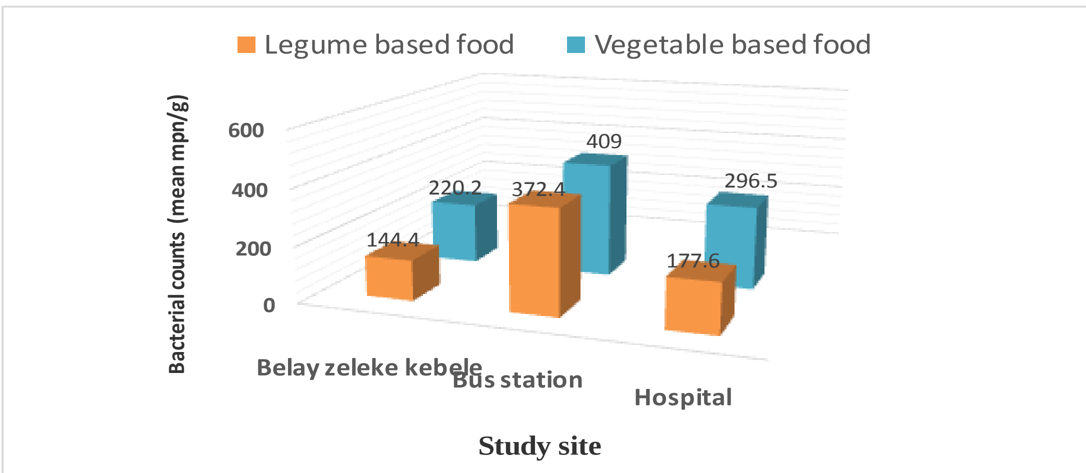


Figure.3 Fecal coliforms count (MPN/g) of legume and vegetable based foods among three sites in Bahir Dar town

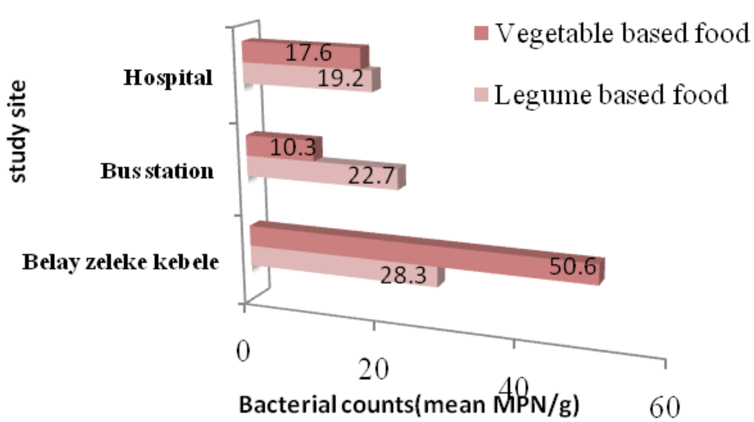
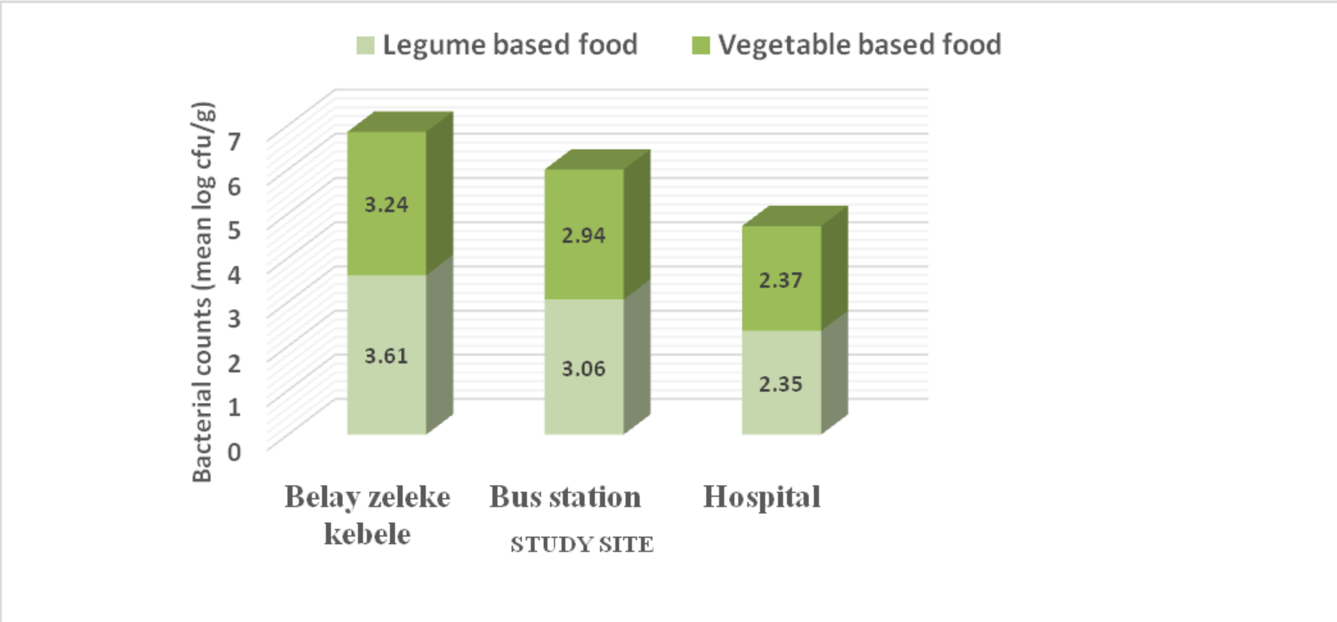


Figure.4 *S. aureus* counts (log10 cfu/g) of street vended legume and vegetable based foods among three sites in Bahir Dar, 2013



In the present study, all of the vendors handling money when serving food (Table 10) can increase the chance of cross contamination into the foods. Similar observation in Nairobi, Kenya was stated by Muinde and Kuria (2005), all the vendors handled money while serving food. In this study, the majority of the food handlers (88.9%) recycles water for several times without replacement of clean equipment (Table 10) which agreed with the study done by Comfort (2010) and Vollaard *et al.,* (2004) stated that vendors renewing the dishwater in buckets up to 20 times during working hours. Most of the street food vendors cleaned their utensils with stored water without replacement in buckets before serving the food and this practice makes pathogens can be transferred to food from utensils with contaminated water. Therefore the water might have contaminated the utensils during cleaning and then cross-contaminated the food, as revealed by high incidence of pathogens in the street food (Taulo *et al.,* 2008).

In contrast the present study showed that, none of the outlets were using refrigerators to store RTE foods after cooking or raw foods before cooking and again,none of the vendors reheated food before serve to consumers and only 11 (30.6%) of the vendors did use cold water with soap and the remaining without detergent to clean and sanitize utensils (Table 10). Another study conducted in Ghana are marked that, only 3 (6%) vendors, keeping of leftover food in the refrigerator and the remaining were no refrigerators (Annan *et al.,* 2011). Conversely, Mensah and others (2002) reported that 7% of the vendors were used refrigerators to store the poultry before cooking. Infrequent hand washing, non-use of soap, direct hand contact with foods and inadequate dishwashing in food stalls are likely to result in bacterial contamination of street food. From the literature, it is evident that proper hand washing is one of the most effective measures to control the spread of pathogens in food handling (Montville *et al.,* 2002).

In the current observation, most of the street food outlets were located near the road and some of them were near the municipal garbage bin for this reason only 11 (30.6%) of the vendors disposed liquid waste into municipal sewage whereas the remaining 25 (69.4%) of the vendors disposed into the vending area (open dumping) as a result a dirty environment that attracted houseflies, the presence of which compromise sanitation. The presence of flies is an indication of poor hygiene and sanitary practices. Although most of the vending area had refused receptacles for solid waste, only a few had proper covering of the refuse receptacle and the receptacle could not far from the vending site (Table 11). Inadequate disposal of wastewater and garbage derived from street food vending also adds to the potential for microbial disease transmission, partly by encouraging the proliferation of insects and rodents linked to enter disease transmission (Arambulo *et al.,* 1994). On the other hand, 27 (75%) of the food vendors buy water from privately installed pipe and only 9 (25%) venders privately installed from a municipal supply, and also most of the venders encounter problem of shortage of water near the vending site (Table 11). According to FAO (1999), adequate drainage and waste disposal systems and other facilities should be provided in the street food industry and designed properly so that the risk of contamination of food and potable water could be minimized.

The present study suggested that, the surroundings of the vending sites were not predominantly clean; in other ways, quality of street foods is affected due to exposure of food to fly; working with food at ground level; and inadequate cooking results in the survival of bacterial pathogens; cooking utensils can also add to the bacterial load (Mensha *et al.,* 2002).

Safe food storage temperatures rarely applied to street foods;the present study showed that all of the food handlers store both raw and ready to eat food at ambient temperature for several hours and without care. Similarly, a study carried out by Muinde and Kuria (2005) stated that, vendors after preparing the food, kept it at ambient temperatures and serve it without heat at high temperatures and these practices enhance high microbial load. On the other hand, most of the street vendors are less educated, rough methods and work under crude unsanitary conditions might be cause of heavy contaminations of pathogenic bacteria in street vended foods which lead to food borne diseases for consumers (Feng *et al.,* 2001). Overall, the level of microbial contamination has been increased from improper sanitation practices and lack of proper storage during the processing and selling period.

Conclusion

In this study, themajority of the food samples contaminated with fecal coliforms, *Staphylococcus aureus*, aerobic mesophilic bacteria and total coliforms indicating the poor bacteriological quality of foods and a possible post-cooking contamination. Even if most of the food samples were within satisfactory and acceptable quality range, high count of mean aerobic mesophilic bacteria and total coliforms were obtained from the area around Bus station and high mean count of *S.aureus*and fecal coliforms were detected around *Belay zelekekebele* and Bus station. In turn, bacteriological analysis of water samples which used for washing equipment and food preparation implies all most all of the samples were unsatisfactory and unfit for use or consumption. Absence of tap water near the vending site, lack of liquid waste disposal, lack of hand washing and proper hair coat besides other facilities were some problems in the study area during observation. So, special attention should be given to environmental hygiene and handling practices. Good food practices, such as adequate cooking, hygienic food processing and proper handling can greatly minimize the risk of food contamination.

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