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

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ABSTRACT

Street vending foods are readily available sources of meals for many people butthe micro- biological quality of such food is always in doubt. This is due to widespread food borne diseases and the increment of wayside food vendors who lack an adequate understanding of the basic food safety issues. The aim of this study was to determine the microbial quality of legume and vegetable based foods and the hygienic practices of street venders who sold legume and vegetable based foods in Bahir Dar town from December 2013 to June 2014. Sixty food samples were collected from different locations Aerobic mesophilic, total coliforms, fecal coliforms and Staphylococcus aureus counts were determined using standard methods. 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%) of the total sample was hazardous due to high mean count of S. aureus. There was no statistically significance differences in bacterial counts between legume and vegetable based food ($p>0.05$). On the other hands, most of the water samples used to wash ready to eat foods and utensils in food preparation were contaminated and fell above WHO drinking water standards and are therefore doubtful quality. In addition, observational checklist shows majority of the handlers did not practice hand washing during food preparation and without reheating to serve prepared foods. Most of the ready-to-eat foods had acceptable levels of contamination; however can posing potential risks to consumers and it requires the local authority emphasize on

educating the ready-to-eat food handlers on food and personal hygiene to ensure the hygienic standards and food safety.

Key words/phrases:*Bacterial count,Coliform, Contamination, Food hygiene, Street food*

INTRODUCTION

Street-vended foods are foods and beverages prepared and sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation [53, 2, 24]. 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. At present, street food offers a chance for self-employmentand to develop business skills with low capital investment. In many developing countries, street food sector provides a source of attractive and varied foods for tourists [16, 53, 57]. In addition, the street food industry feeds millions of people daily with a wide variety of foods that are cheap and easily accessible [24].

Many studies have examined the characteristics of vendors and have found that street food vendors do not form a homogenous group, but differ according to various socio-economic and demographic criteria, classified into stationary and ambulatory [46]. In many countries stationary vending stalls may be permanent or semi-permanent structures, sale their wares from small stalls, kiosks, pushcarts. They operate from selected strategic locations, including bus and trains, markets and shopping areas, commercial districts, outside schools and hospital, residential suburbs, factories, and construction sites. In some places, the vendors have regular clientele [48]. On the other hands, street foods show great variation in terms of ingredients, processing, methods of marketing andconsumption. They often reflect traditional local cultures and exist in an endless varietyencompassing meals, drinks and snacks. These categories reflect a growing difficulty to provide adequate infrastructure and environmental hygiene to ensure the safe production of food.There is much diversity in the raw materials as well as inthe method of preparation of street foods and there are also differences in the places

wherestreet foods are prepared; however, majority of the vendors, prepared their food at home and brought to the streets for marketing [31,57].

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 [54]. The people who depend on such foods are often more interested in its convenience than its safety, quality and hygienic aspects of the consumed food. However 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, a major health problem associated with street foods [21]. Food borne bacterial pathogens commonly detected in street vended foods are *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus* and *Salmonella* spp. [54, 15]. People, who patronize street food, have been reported to suffer from food borne diseases like diarrhea, cholera, typhoid fever and food poisoning [28].

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 [12]. 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 [4].

In Ethiopia, different researchers revealed that pathogens and indicators are enumerated above the acceptable limit from different categories of street vended foods. Study done in Jemma town, highlighted*Staphylococcus* countinstreet foods was much higher (5.39 log cfu/ml) than the standard and dominated by almost the same load of aeorbic mesophilic bacteria (6.13 log cfu/ml) and Enterobacteriacae (5.96 log cfu/ml) [52].Additionally according to Deriba and Mogessie [15], 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, study done in Bahir Dar town, the total coliform counts on the surface and from the core of street vended white lupin ranged from 15 to 1100MPN/g and 11to1100MPN/respectively;

and out of 40 samples,92.5% on the surface &the core was contaminated with fecal coliforms [40].

The two major sources from where the contaminants can enter the preparation area are: improper food handling and waste disposal around the vending area due to lack of knowledge of basic food hygiene issues. Street food is a public health concern, since safe food hygiene can be difficult to practice at street level in settings where resources are scarce and surroundings with low environmental and sanitary standards [46]. Food handlers had poor knowledge in practice when handled raw materials for food without washing their hands; wore hand jewelries and fondled their bodies while preparing food. For instance, research was done among 160 street food stalls in Ghana showed that only three (1.8%) of the proprietors met the requirements for basic hygiene based on a five-point checklist [46].

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 such as pepper and lettuce, sambussa and fried fish, spaghetti and meat sauce in Bahir Dar, and according to the finding of the study most of these foods highly contaminated with aerobic mesophilic bacteria, total coliforms, *S.aureus* above the acceptable level and *Salmonella* was detected [5,35,33]. However there is no information on microbiological quality and safety of cooked legume and vegetable based foods sold in streets and around the Bus station which are the most popular food in Ethiopia.

Among the traditional foods, most of them prepared from legumes and vegetables based product and the vendors sell foods throughout the day with local pancake like bread called *Ingera*. Poor handling, processing, and use of unsafe raw materials and equipment for preparation of food can result in health threat. Therefore,the present study was conducted;to determine bacterial detection and count in relation to food qualityas well as to examine the bacteriological quality of water used for food preparation and washing equipment and also to assess the hygiene and handling practices of food handlers (vendors).

1. MATERIALS AND METHODS

1.1.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 11° 38'N, 37° 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 10.3℃ and 26.3℃, respectively. The annual average rainfall is 1,224mm [11]. 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 venders in the city around main road, bus station and hospital areas are common practice.

1.2. Study design

A cross-sectional prospective study was conducted in Bahir Dar city December 2013 to June 2014 to assess the bacteriological quality of ready- to- eat foods in three study sites (around Bus station, Belay zeleke kebele and Hospital); and handling practices of street vended legume and vegetable based foods.

1.3. Sample description and collection of food sample

Commonly served RTE foods in the street vendor: legume based (made from roasted and ground faba bean or split pea or lentil) and vegetable based (a classic dish of Ethiopian vegetables stewed made 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. Two hundred g of each food was placed in sterile beakers and kept in ice box during transport to the post-graduate microbiology laboratory of Bahir Dar University. Samples were stored in refrigerator until bacteriological analysis was carried out within an hour of collection. The samples were collected between 2 pm to 3 pm from each of the three sampling locations are purposely selected areas in Bahir Dar town.

1.4.Microbiological analysis of food

1.4.1. Enumeration of aerobic mesophilic bacteria

To determine aerobic mesophilic bacteria in ready- to- eat legume and vegetable based foods, decimal dilutions up to 10^{-4} were made. From dilutions up to 10^{-4}, three consecutive appropriate dilutions for each sample of food were taken. The total count of aerobic mesophilic bacteria was determined as the procedure described by [29, 10]. One milliliter from each dilution was dispensed into triplicate sterilized Petri dishes and plate count agar was poured to each plate and incubated at 37^0C for 48 hours. The numbers of colonies were counted using colony counter and the results was reported as mean cfu/g of food.

2.4.2. 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 [7]. From serial dilution (0.1,0.01and 0.001), one ml of each dilution was inoculated into triplicate test tubes containing sterile Lauryl Tryptose Broth (Blulux Laboratories(p) Ltd, India) with inverted Durham tubes and incubated at 37ºC for a maximum of 48 hours. Then gas positive lauryl tryptose broth tubes at the end of the incubation period were gently agitated and loopful of each culture was transferred to tubes of brilliant green bile (2%) broth (Oxoid, England) with inverted Durham tubes and incubated at 37ºC for a maximum of 48 hours. And positive 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, triplicate tubes containing Lauryl Tryptose broth (BluluxLaboratorie Ltd, India) with inverted Durham tubes incubated at 44^OC for 24 hours. Then, confirmatory test for fecal coliforms was done using MacConkey broth with inverted Durham tubes and incubated at 44.5^OC for a maximum of 48 hours. Negative tubes, re-incubated and examined again at 48 hours. Confirmation was obtained by gas production. The result was reported as the most probable number (MPN) per gram of food.

2.4.3. *Staphylococcus aureus*

One ml of the homogenized food (10^{-1}) was transferred into 9ml of sterile normal saline solution to prepare 10^{-2} dilution then 1ml of 10^{-2} dilution into 9ml of sterile saline solution blanks to made 10^{-3} dilution. From each samples of prepared serial dilution, one ml was

transferred into triplicate sterile Petri dishes and Mannitol salt agar (Oxoid, England) was poured and swirled and finally incubated at 37ºC for a maximum of 48 hours [49]. Yellow and orange colonies surrounded by yellow zones due to mannitol fermentation was enumerated and reported as mean cfu/g of food.

2.5. **Bacteriological analysis of water**

A total of 30 water samples in morning were collected which used to food preparation, washing equipment or as an ingredient. Two hundred (200) ml of each sample was collected in 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 [3].Fifteen culture tubes was used per sample; five tubes contained sterile 10 ml double strength and the remaining ten contained 10 ml single strength MacConkey broth (BluluxLaboratorie Ltd, India) with inverted Durham tubes. Each water sample was shaken vigorously several times before transferring into broth to obtain a homogenous dispersion of microorganisms. With a sterile pipette, 10 ml of the water sample was aseptically dispensed into each of the first five culture tubes containing the double strength MacConkey broth. One milliliter of the sample was then inoculated into each of the second five culture tubes and 0.1 ml inoculated into the remaining five tubes all containing sterile single strength MacConkey broth. After 48 hours of incubation at 37°C, the cultures were observed for the presence of acid production (color change) or gas formation (displacement of medium from inverted Durham tube). The procedure was repeated for all samples and finally results reported as MPN/100ml using Most Probable Number method.

2.6. **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 asses weather the vending food exposed to flies, insects and animals, presence of solid and liquid waste and latrines facilities around food vending area.

2.7. **Data analysis**

Statistical analysis of the data from the two food items was performed using t-test to test whether there is a statically significance difference between the two food items for microbial load. One way ANOVA using SPSS software version 20 was also used to compare mean

bacterial count of food samples from different locations. Significance of differences was considered at p value less than 0.05. The mean bacterial count in the food samples were expressed as log10 cfu /gof food in case of *S. aureus* and aerobic mesophilic bacteria. Foods were classified as acceptable or not (potentially hazardous) according to the public health laboratory service [44, 42, 23].

3. RESULTS AND DISCUSSION

Aerobic mesophilic counts

In the present study, the range of aerobic mesophilic bacteria were 3.28 to 5.95 log10cfu/g with mean value of 4.50 log10cfu/g in legume based and 2.72 to 5.79 log10cfu/g with 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 [8] which exceed the acceptable level (<5 log10 cfu) and other study of fully processed food of legume based dish in Nigeria, AMC ranges from 3.74 to 5.08 log10cfu/g with mean value of 5.48 log10cfu/g [13].

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)

As shown in Table 1, total mean AMC of street vended foods (5.12 log cfu/g) fell above standard limit (≥5 log10cfu/g) set by PHLS [44] and NSW [42] which categorized as unsatisfactory for consumption and similarly agreed with study conducted by [10] and[50]. On the other hand, all food samples were positive to mesophilic bacteria (Table1) whereas Mensah *et al*. [34] reported that of 511 street food items examined in Accra, only 69.7% contained mesophilic bacteria.

The current study has low mean bacterial count compared to the study done in south Africa, the mean value of aerobic bacterial count on vegetables was 6.8 log10 cfu/g with range of

6.3–6.8 log10 cfu/g [36] whereas in this study had higher mean bacterial count of legume based (4.50 log10cfu/g) than study conducted in street foods in Accra, Ghana (2.5log10cfu/g±0.03SD) of aerobic mesophilic count [34]. 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 [1].

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 [10]. 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 limit (Table 2).

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

The finding of the result showed, 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, lowest mean value of AMC was obtained in vegetable based food (4.12 log10 cfu/g) from *Belay zelekekebele*and legume based food (4.32 log10cfu/g) from hospital surrounding. 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 mean aerobic count was obtained in vegetable based food (f=3.632; p=0.04) among sites (Figure 1).

Figure 1: Aerobic mesophillic bacteria (log10 cfu/g) of street vended legume and vegetable based foods among three sites in Bahir Dar town

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 venders. The highest count around Bus

station may be due to the venders achieved their daily activates under crowded area and poor practice of garbage disposals around the vending area. Similarly study conducted 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 location than the others [43].

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).

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)

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: 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 unhygienic environment [49].

The finding of the study also revealed that 37 (61.7%),12 (20 %) and 11 (18.3%) out of the total samples had level 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 Food Quality Check Program [23]fell within unsatisfactory for consumption (Table 4). Presence of coliforms in street foods might also be due inadequate handling, water used for food preparation and serving which may be contaminated with fecal coliforms [26].

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.

As shown in (Figure 2), the mean values of total coliforms of legume based foodsamples obtained from *Belay zeleke kebele*, 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 significantdifference among the sites in legume based food (f=0.931; p=0.406) and in vegetable based food amongsites (f=0.510; p=0.606). 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 legumes based foods [26].

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

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 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 [41].

In this study, the mean of fecal coliform counts of the legume based food was 23.46 with range of 3 to 120 MPN/g and similarly the mean count of vegetable food was 27.08 with range of 3.6 to 240 MPN/g (Table 5). Although mean variation between food items, there are 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 [43], revealed that, the fecal coliform count in vegetables ranged from 3.6 to 9.2MPN/100ml.

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)

The present study also revealed that the percentage of vegetable and legume based foods contaminated by fecal coliformswere 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. All most half of (48.3%) the total samples classified into satisfactory level and the remaining (51.7%) as unsatisfactory for consumption (Table 6). Similarly study conducted in Pakistan; in six cooked vegetables only two samples were positive for fecal coliforms [58].

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

The highest mean contamination of vegetable based samples by fecal coliforms was obtained in *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).

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

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 that pathogens may also be present [58].

***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 to 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 in vegetables was 0 to 4.58 log10 cfu/g [43]. In the present study, the higher detection rate of couglasepositive Staphylococcus was obtainedin

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 was 13.6% [18].

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

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 [45]. The finding of the study had comparatively higher mean log10 cfu/g of *S. aureus* inlegume based foods than study done in street foods in Accra (0.6 mean log10 cfu/g) of *S. aureus* [34] 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 practice of the venders [50]. Improper handling and improper hygiene might lead to the contamination of food with *Staphylococcus aureus* and this might eventually affects the health of the consumers [43]. Entero-toxin producers *S. auerus* withstand high temperature which on ingestion can cause vomiting and diarrhea. Foods that require considerable handling during preparation and are kept at slightly elevated temperatures after preparation are frequently the ones involved in staphylococcalfood poisoning [17]. *S. aureus* is amongst the most common pathogensfound on hands and there is every possibility of contamination before or after cooking of a food aswell as during serving. Possible sources of contamination may account from washingwater, insects and rodents, hair or hair products infood, unhygienic kitchen environment, contaminated equipment, contaminated air or dust and lack of adequate sanitation [45].

The prevalence of *S. aureus* inthisstudy was 47(78.3%)of the total sample analyzed(Table 7). The results were contrary to the findings of Mirriam *et al.* [36] who reported low prevalence of *Staphylococcusaureus* (3.2%) in street-vended foods. On the contrary, in a study conducted in Malaysia, coagulase-positive Staphylococciwere not found in all the examined samples [6]. Similarly, Hanashiro *et al*. [27] 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 Staphylococcicontamination [25].

As the result of the current study, out of 47/60 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 [42]. Compared this finding with the study done in Accra, 31.9% of *S. aureus* out of total samples of street vended foods was isolates [34] and in other study, it was observed that, only 16% of street vended RTE food contamination with *S. aureus* [54].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 fell into 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).

Table 8: The number and percentage of good, acceptable and unsatisfactory level of *S. auerus* count in street vended legume and vegetable based foods in Bahir Dar town

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 was 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 statistical significant difference in count of *S. aureus* in vegetable based food among three sites (f=4.059; p=0.031). The reasons of bacterial count differences among sites may be due to handling practice and personal hygiene of venders as well as time and temperature abuse.

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

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 [47]. The present study showed that total coliform counts of the water sample varied from <2 and >1600MPN/100ml from 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 [56]guidelines and the remaining water samples were above the acceptable limit in which four samples were above the upper detection limit (>1600MPN/100ml). If large numbers of coliforms are found in water, there is a high probability that other pathogenic bacteria or organisms exist. The WHO [56] and Ethiopian drinking water guidelines [20] require there should be no coliform bacteria/100 ml of treated water in distribution as tested by multiple tube tests.

According to [41], 33.33% of water samples had 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 source of contamination because venders can use waste water as recycled for washing and cleaning purpose. 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 microbial quality of foods. In addition bacteria, contamination of foods with pathogenic viruses, and parasites from water is commonly reported [47, 38].

Assessments of the hygienic practices of venders and the vending environment

Venders handling practices, personal hygiene and the vending environment have significance role for contamination of street vended RTE food. In the present study, 21 (58.3%) and 24(66.7%) did not dressing appropriate overcoat and hair cover, respectively (Table 10). 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 [32]. 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 properly and clean dressing (Table10) 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 [30]. 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 soup. Other study demonstrated that out of 128 street venders in Indonesia, 70 (55%) of the vendors did not wash their hands before food preparation (55). This could have promoted transfer of the pathogens from the hand to the food [51]. Wear of jewelry was observed in 29 (80.6%) of the venders (Table 10). Overall, personal hygiene is important because human beings can be the largest contamination sources of food.

Table 9: Venders' personal hygiene, in Bahir Dar town

In the present study, all of the vendors handling money when serving food (Table 11) can increase chance of cross contamination into the foods. Similar observation in Nairobi, Kenya was stated by [39], all the vendors handled money while serving food. In this study, majority of the food handlers (88.9%) recycle water for several times without replacement to clean equipment (Table 11) which agreed with the study done by [14, 55] 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. Pathogens can be transferred to food from utensils that are not properly cleaned 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 [51].

Table 10: Venders' food handling practices in Bahir Dar town, (n=36)

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 venders reheated food before serve to consumers and Only 11 (30.6%) of the venders did use cold water with soap and the remaining without detergent to clean and sanitize utensils (Table 11). Other

study conducted in Ghana remarked that, concerning handling of street foods, only 3 (6%) vendors, keeping of leftover food in refrigerator and the remaining were lacking refrigerators [8]. Conversely, Mensah and others [34] 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 [37].

In the current observation, most of the street food outlets were located in near the road and some of them were located near municipal garbage bin for this reason only 11 (30.6%) of the venders disposed liquid waste into municipal sewage whereas the remaining 25 (69.4%) of the venders disposed into the vending area (open dumping) as a result a dirty environment that attracted houseflies, the presence of which compromise sanitation. Presence of flies is an indication of poor hygiene and sanitary practices. Although most of the vending area had refuse receptacles for solid waste, only few had proper covering of the refuse receptacle and the receptacle could not far from the vending site (Table 12). 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 [9]. On the other hand, 27 (75%) of the food venders buy water from privately installed pipe and only 9 (25%) venders privately installed from municipal supply, and also most of the venders encounter problem of shortage of water near the vending site (Table 12). According to FAO [19], 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.

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

This study suggest that, the surroundings of the vending sites were not predominantly clean; in other ways, quality of street foods are affected due to exposure of food to flies; 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 [34].

Overall, safe food storage temperatures are 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, study carried out by Muinde and Kuria [39] stated that vendors, after preparing their foods, kept and served them at ambient temperatures. Food was not heated at high temperatures before serving. These are the main leading facts for the contamination of street vended foods. On the other hand, the street vendors are less educated, rough methods and work under crude unsanitary conditions were cause of heavy contaminations of pathogenic bacteria in street vended foods which might be leads to food borne diseases for consumers [22]. The level of microbial contamination could come from improper sanitation practices during the processing and selling period. Lack of good sanitation practices and proper storage will increase microbial contamination.

CONCLUSION

In this study,majority of the food samples contaminated with fecal coliforms, *Staphylococcus aureus,* aerobic mesophilic bacteria and total coliforms indicating poor bacteriological quality of foods and a possible post-cooking contamination. Even if most of the food samples were within satisfactory and acceptable quality rangethis may be due to the food is cooked before storage for long period of time.In which, high count of mean aerobic mesophilic bacteria and total coliforms were obtained from the area around Bus station whereas high mean count of *S.aureus* and fecal coliforms was detected around *Belay zeleke kebele* 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, in appropriate liquid waste disposal, lack of hand washing and proper hair coat besides other facilities were some problems in study area during observation. Sospecial attention should be given environmental hygiene and handling practices. Good food practices, such as adequate cooking, hygienic food processing and handling can greatly minimize the risk of food contamination.

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