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ARTICLE

Microbiological quality and safety of street vended meat sauce in Bahir Dar Town	14
Alemayehu Getahun Kassa and Mulugeta Kibret Azene	

Full Length Research Paper

Microbiological quality and safety of street vended meat sauce in Bahir Dar Town

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Street vended foods are readily available sources of meals for many people across the world, the microbial quality and safety of such food is always uncertain. In developing countries, the major sources of food-borne illnesses are street vended foods because they provide a source of affordable nutrients to the majority of the low income groups. The aim of this study was thus to assess the microbiological quality and safety of street vended meat sauce in Bahir Dar Town. A total of 60 samples (30 each in morning and afternoon) were assessed to reveal indicator bacteria and pathogens from December, 2010 to June, 2011 using standard bacteriological techniques. Mean aerobic mesophilic count of 4.16×10^4 and 4.71×10^4 cfu/g were recorded in the morning and afternoon, whereas mean total coliform count and *S. aureus* were 4.00×10^4 and 4.53×10^4 and 3.52×10^4 and 4.39×10^4 cfu/g in the morning and afternoon, respectively. Only the count of aerobic mesophilic bacteria was below the recommended limit. The mean microbial loads were significantly different in the morning and afternoon ($p < 0.005$). *Salmonella* was detected in all the samples of meat sauce analyzed in the morning and afternoon. The bacteriological analysis of water samples indicate the contamination of water within mean microbial load of 2.67 MPN/100 ml of water, which is beyond the acceptable limit of 2.2 MPN/100 ml of water. The observational checklist of vendors' appearance and the environment indicates lack of personal and environmental sanitation and gives warning signal for the possible occurrence of foodborne contamination. The study publicized that contamination of street vended meat sauce is a possible health problem to consumers. Proper cooking and storage of processed foods and education of vendors on the environmental sanitation and food handling practices should be recommended.

Key words: Meat sauce, microbial quality, sanitation practice, street vended.

INTRODUCTION

Street foods are defined as ready to eat foods and beverages prepared and/or sold by vendors, especially

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on streets and other public places for immediate consumption (WHO, 1996). These foods are well appreciated by consumers, mostly by urban workers because of their taste, low cost, nutrient value, different varieties and availability for immediate consumption (Abdalla et al., 2009). They can be found wherever there is a heavy flow of people, since their marketing success depends exclusively on location and word-of-mouth promotion (Winarno and Allain, 1991). This is not surprising when one considers that bacteria and fungi are ubiquitous and are plentiful in soil and around us and easily contaminate foods (Bukar et al., 2010). Economic situation, social difficulties and urbanization, among other factors, promote the growth of informal sector of the economy including street food vending (Hanashiro et al., 2005). These foods may be consumed without heat treatment and cause foodborne illness, a health problem in developing countries (WHO, 1996).

Meat is an important food that contains a large amount of proteins and its cut surfaces support the growth of large numbers of microorganisms. Food safety is one of the most important issues in marketing any kind of food, particularly meat and its products (Okonko et al., 2010). The most serious safety issues resulting in immediate consumers health problems is associated with bacterial pathogens (Sousa, 2008). The most common bacterial agents are *Campylobacter*, *Salmonella*, *Escherichia coli*, *Shigella*, *Staphylococcus* and *Clostridia* (Agbodaze et al., 2005). Street foods displayed on open work area can easily be contaminated by dust, exhaust smoke, insects and hands of the buyers. Thus, food vendor services is on the increase and responsibility for good manufacturing practices of food such as good sanitary measures and proper food handling practices (Clarence et al., 2009). On top of this, availability of tap water is limited to washing of hands, utensils in the vending site, hence, they are forced to be used repeatedly. There is no waste disposal facilities thus garbage is discarded close to the vending site and this attract insects and rodents to double the problem through cross contamination (Tamebaker et al., 2008). In Ethiopia, the wide spread habit of raw beef consumption is a potential cause for foodborne illness (Haimanot et al., 2010). Therefore, meat sauce is widely consumed by people at home, on the streets and in the groceries. However, there is no information on microbiological quality and safety of street vended meat sauce in Bahir Dar Town. The aim of this study was thus to assess the bacteriological safety of meat sauce and water in Bahir Dar Town, Ethiopia.

MATERIALS AND METHODS

Study design and location

A cross-sectional study was conducted to assess the

microbiological quality and safety of ready-to-eat meat sauce and water in Bahir Dar Town from December 2010 and June 2011. The town is located at 11° 36' 0" North and 37° 23' 0" East on the southern side of Lake Tana. The town has a total population of 256,999 (CSA, 2010) and one of the leading tourist destinations with a variety of attractions in the nearby Lake Tana and Blue Nile River.

Sampling techniques

The study site was selected purposively and a total of 60 food samples (30 each in the morning and afternoon) were collected for microbiological analysis. Two hundred grams of meat sauce was collected using sterile glass containers and immediately transported to the post graduate microbiology laboratory of Bahir Dar University. Samples were stored in refrigerator until microbiological analysis was carried out. Microbiological analysis was carried out as described by the methods of Fawole and Oso (2001). Twenty five grams of the homogenized meat sauce was mixed with 225 ml of sterilize peptone water (Oxoid LTD., Basingstoke, and Hampshire, England) for 5 min in a flask. The samples prepared were used for enumeration of aerobic mesophilic bacteria, total coliforms and *S. aureus*. For isolation of *Salmonella*, the flasks were incubated at 37°C for 24 h for primary enrichment. Thirty water samples were also collected in the morning for bacteriological analysis. Standard methods were used for the enumeration, isolation and identification of bacteria. Observational checklist was used to collect data on, personal hygiene of the vendors and assessment of the vending environment.

Enumeration of bacteria from food samples

Aerobic mesophilic count

The aerobic mesophilic counts were enumerated on standard plate count agar (Donwhitley Scientific Eqp. Pvt.Ltd. India) and incubated at 37°C for a maximum of 48 h. The total aerobic mesophilic count of bacteria was determined using the procedure described by Azanza (2005). The numbers of colonies were counted with colony counter (Stuart Scientific Colony Counter made in the UK). The result was reported as means of cfu/g of food sample analyzed.

Total coliform count

The total coliform counts were enumerated on sterile MacConkey agar (Blulux Laboratorie (p) Ltd, India) and incubated at 37°C for a maximum of 48 h. The total coliform counts were determined using the procedure described by Chaiba et al. (2007). The numbers of colonies were counted with colony counter (Stuart Scientific Colony Counter made in the UK). The result was reported as means of cfu/g of food sample analyzed.

Staphylococcus aureus count

Twenty five grams of meat sauce were then homogenized into 225 ml sterile peptone water solution (Oxoid LTD., Basingstoke, and Hampshire, England) for 5 minutes. This was used as enrichment after 24 h of incubation at 37°C. The number of colonies were counted on sterile mannitol salt agar (Blulux Laboratorie (p) Ltd, India) and incubated at 37°C for a maximum of 48 h. The numbers

Table 1. Food handling practices of vendors in Bahir Dar town.

Statement	Response	
	Yes	No
Wash food before cooking	7	13
Heat food during serving	9	11
Food cooked during sale	12	8
Food prepared on the same surface more than once	17	3
Food exposed to flies	11	9
Food re-heated before sale	10	10
Adequate cooking of the food	4	16
Handling money while serving food	19	1
Handled food with bare hands	20	0

of colonies were counted with colony counter (Stuart Scientific Colony Counter made in the UK). The result was reported as means of cfu/g of food sample analyzed. Typical colonies of *S. aureus* as (golden yellow colonies) were picked, purified and preserved at -4°C on nutrient agar slants and further characterized through a series of biochemical tests.

Detection of *Salmonella*

Twenty five grams of street vended meat sauce samples were enriched on Selenite cysteine broth (Oxoid LTD., Basingstoke, and Hampshire, England) for 5 min prior to inoculation on sterile Bismuth sulfite agar (Oxoid LTD., Basingstoke, and Hampshire, England). The plates were incubated at 37°C for 24 – 48 h under aerobic conditions. Colonies considered as *Salmonella* on bismuth sulfite agar were purified and preserved at -4°C on nutrient agar slants (Merck KGaA 64271 Darmstadt, Germany) and further confirmed by biochemical characterization.

Bacteriological analysis of water

The total coliform counts of water were determined using multiple test tubes with the MPN method and Lauryl tryptose broth with inverted Durham tubes (Blulux Laboratorie (p) Ltd, India) were used for the presumptive tests (Addo et al., 2009). The number of positive and negative tubes were used for calculation of the most probable number (MPN/l) using the MPN tables as provided in the standardized procedure.

Observation of vendors' hygienic practice and vending environment

An observational check list was used for the assessment of food safety and sanitary practices of vendors with workability of the vending environment as depicted in Tables 1 to 3.

Data analysis

The data was compiled and analyzed with Statistical Package for Social Science software, version 16 for windows (SPSS inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used to determine if significant differences exist between mean

counts in morning and afternoon and level of significant was set at $p < 0.05$. Descriptive statistics was used to state the data obtained through observational check list.

RESULTS

Aerobic mesophilic count

The mean aerobic mesophilic count (AMC) detected in the morning and afternoon was 4.16×10^4 and 4.71×10^4 cfu/g, respectively and the range were between 2.96×10^4 - 5.32×10^4 and 3.92×10^4 - 5.80×10^4 cfu/g (Table 4).

Coliform count

The coliform count ranged from 2.57×10^4 to 5.18×10^4 and 3.34×10^4 - 5.86×10^4 cfu/g (Table 5) and the mean counts between 4.00×10^4 and 4.53×10^4 cfu/g in the morning and afternoon, respectively.

Staphylococcus aureus

The mean microbial count of *S. aureus* was 3.52×10^4 to 4.39×10^4 cfu/g (Table 6) and ranged between 2.33×10^4 - 4.40×10^4 and 3.48×10^4 - 5.22×10^4 cfu/g in morning and afternoon, respectively.

Detection of *Salmonella*

Salmonella was detected in all meat sauce samples collected from Bahir Dar town in the morning and afternoon.

Bacteriological examination of water

The presence of coliform bacteria in the water was

Table 2. Personal hygiene of vendors in Bahir Dar town.

Statement	Response	
	Yes	No
Vendors use aprons	2	18
Vendors hair covering	3	17
Vendors dressed clean	6	14
Storage of the prepared foods by vendors		
Proper		
Improper	8	12
	12	8
Leftover food management used by vendors		
Throw away	-	20
Eaten at home	11	9
Refrigerated and re-heated	-	20
Stored for use next day	9	11
	2	18
How many times water used before replacement by vendors		
Once	5	15
Twice	13	7
Severally		
What was used to wash utensils by vendors		
Bucket	6	14
Basin	14	6

Table 3. Assessment of the vending environment in Bahir Dar town

Statement	Response	
	Yes	No
Environment, waste disposal and water supply		
Clean	4	16
Dirty	10	10
Harbor vectors	6	14
Waste disposal		
In bush	1	19
In waste bin	5	15
Near the vending site		
Presence of garbage receptacles	14	6
Presence of water containers	7	13
Liquid waste disposal	9	11
Open area dumping	5	15
To septic tanks	1	19
Nearby the vending site	13	7
Water supply		
Pipe private	2	18
Pipe shared	7	13
Pipe neighbors	11	9
Latrines facilities		
Flush type	4	16

Table 3. Cont'd.

Dry pit latrines	6	14
Open latrines around the vending area	10	10

Table 4. Mean, range and acceptable limit of aerobic mesophilic count (cfu/g) in the morning and afternoon, Bahir Dar town.

AMC	Morning	Afternoon	P value
Mean	4.16×10^4	4.71×10^4	0.00
Range	2.96×10^4 - 5.32×10^4	3.92×10^4 - 5.80×10^4	
Acceptable limit	Did not exceed the acceptable limit		

Table 5. Mean, range and acceptable limit of total coliform bacteria (cfu/g) in the morning and afternoon, Bahir Dar town.

Total coliform	Morning	Afternoon	P value
Mean	4.00×10^4	4.53×10^4	0.00
Range	2.57×10^4 - 5.18×10^4	3.34×10^4 - 5.86×10^4	
Acceptable limit	Exceeded the acceptable limit		

Table 6. Mean, range and acceptable limit of *S. aureus* (cfu/g) in the morning and afternoon, Bahir Dar town.

<i>S. aureus</i>	Morning	Afternoon	P value
Mean	3.52×10^4	4.39×10^4	0.00
Range	2.33×10^4 - 4.40×10^4	3.48×10^4 - 5.22×10^4	
Acceptable limit	exceeded the acceptable limit		

between 31 and >16000 MPN/100 ml and had mean microbial load of 2.67 MPN/100 ml of coliforms (Table 7).

Observation of vendors' hygienic practice and vending environment

DISCUSSION

The total colony counts of AMC obtained in this study is illustrated in Table 4. There was a significant differences ($p=0.00$) in aerobic mesophilic count detected in the morning and afternoon. The AMC of meat sauce analyzed did not exceed the typical guide line of AMC value set at $<10^5$ cfu/g for ready to eat food products. According to Food and Agricultural Organization (Bukar et al., 2010), standard limit for AMC should be less than

10^5 cfu/g. In this study, the results was less than standard limit in the morning and afternoon. Similarly, microbiological qualities of processed food (ready to eat beef products) showed the count of 3.3×10^4 for total aerobic plate count (Ologhobo et al., 2010). This is agrees with the result of Okonko et al. (2010) that ranged between 2.62×10^4 and 4.48×10^4 cfu/g. In comparing the bacterial contamination in morning and afternoon, one-way analysis of variance indicates significant difference ($p=0.00$). This difference is most importantly due to improper storage time. Similarly, Tambekar et al. (2008) reported that foods that were prepared long before consumption were more contaminated than food prepared just before consumption. The presence of Coliform bacteria in ready-to-eat foods indicates unhygienic conditions during processing, handling and distribution or post processing contamination. The total counts of coliforms from the meat sauce and the probable presence

Table 7. Mean, range and acceptable limit of total coliform bacteria (MPN/100 ml) in the morning from water sample, Bahir Dar town.

Total coliform	Morning
Mean	2.67 MPN/100 ml
Range	31 MPN/100 ml- >16000 MPN/100 ml
Acceptable limit	Beyond the acceptable limit

Table 8. Food handling practices of vendors of meat sauce in Bahir Dar town (n = 20).

Statements/parameters	Frequency (%)
Wash food before cooking	7(35%)
Heat food during serving	9 (45%)
Food cooked during sale	12(60%)
Food prepared on the same surface more than once	17(85%)
Food exposed to flies	11(55%)
Food re-heated before sale	10 (50%)
Adequate cooking of the food	4(20%)
Handling money while serving food	19(95%)
Handled food with bare hands	20(100%)

in the water are presented in Tables 5 and 7. The result shows a significant differences in the means of coliform count in the morning and afternoon ($p=0.00$). This variation could exist as a result of the street food vendors that bought the meat and prepared it early in the morning. It was cooked and stored at ambient temperature that leads to the exposure of the food to dust, flies and other vectors from the surrounding environment.

The presence of coliform could be attributed to the use of contaminated water at different stages of processing (Hamdan et al., 2008). A similar report was recorded in Accra with the highest mean coliform count ($5.12\log_{10}$ cfu/g) (Agbodaze et al., 2005). Correspondingly, the mean total coliform count on fresh meat (Okonko et al., 2010) ranged between 2.24×10^4 and 5.0×10^4 cfu/g. These values exceeded the acceptable limit of 10^3 cfu/g for coliform count. Microbiological count for meat sauce from street food vendors is higher for meat which seems raw inside (van Kampen et al., 1998). Agbodaze et al. (2005) reported mean coliform count of $3.70\log_{10}$ cfu/g in khebab sample analyzed. High level of coliform contamination indicated that the ingredient or the product had bad personal hygiene. Microbial contamination, unhygienic practices and lack of basic facilities including potable water are some of the many associated problem with street food vending as discussed (WHO, 1996).

The result of water analysis for coliforms is indicated in Table 7 and the mean of indicator organisms in water

(coliforms) exceed the standard limit which is 2.67MPN/100 ml of water. WHO standard for drinking water shows water sample should have an MPN value of 2.2 MPN/100 ml of water (Addo et al., 2009). Similar result was reported by Lues et al. (2006) having various means of obtaining water and water collected in the morning was used until the end of the day. The initial contaminated water used for washing the raw meat is also used for hands and utensils used in production. Water is a major means by which coliforms and *E.coli* are spread. This is the reason why the water sample was examined for coliforms. Ethiopia is the worst of all with regards to water quality problems. It has the lowest water supply and sanitation coverage in sub-Saharan countries with only 42 and 28% for water supply and sanitation, respectively (Milkiyas et al., 2011).

The mean microbial count of *S. aureus* on the meat sauce is shown in Table 6. There was a significant differences ($p=0.00$) in the mean counts of *S. aureus* in the morning and afternoon. This disparity is as a result of improper storage time, handling and exposure to environmental contaminants at ambient temperature for long period before serving. *S. aureus* is frequently isolated from the meat sauce analyzed. This is due to the high mean count of the organism beyond the acceptable limit for *S. aureus* which is less than 10^2 cfu/g. Similar result is shown by Clarence et al. (2009) on *S. aureus* count of 2.5×10^4 to 4.0×10^4 cfu/g of meat pie. According

Table 9. Personal hygiene of vendors of meat sauce in Bahir Dar town (n = 20).

Statement/parameters	Frequency (%)
Vendors use aprons	2(10%)
Vendors hair covering	3(15%)
Vendors dressed clean	6(30%)
Storage of the prepared foods by vendors	
Proper	8(40%)
Improper	12(60%)
Leftover food management used by vendors	
Throw away	-
Eaten at home	11(55%)
Refrigerated and re-heated	-
Stored for use next day	9 (45%)
How many times water used before replacement by vendors	
Once	2(10%)
Twice	5(25%)
Severally	13(65%)
What was used to wash utensils by vendors	
Bucket	6(30%)
Basin	14(70%)

to Ologhobo et al. (2010), *S. aureus* from ready to eat beef suya before and after roasting contained 10^2 and 10^4 cfu/g, respectively. This indicates that subsequent contamination might be due to improper handling by vendors. Especially, hands can be source of contamination if infected cuts are present (Podpecan et al., 2007).

Salmonella was detected in all the meat sauce samples collected from Bahir Dar town in the morning and afternoon. Foods of animal origin are considered to be the major sources of foodborne salmonellosis (Bayleyegn et al., 2003). The presence of *Salmonella* spp. in cooked foods is often attributed to inadequate refrigeration, sanitation and poor personal hygiene. Proliferation of this organism in foods may therefore, result from handling cooked foods by workers who are carriers of *Salmonella* (Lues et al., 2006). The improper handling of the meat sauce and utensils by food handlers during preparation and serving alarms the presence of the organism. This agrees with the result of Molla and Mesfin (2003) which states that cross-contamination of the hands of workers, working equipment and utensils. Karaboz and Dincer (2002) report the same result from frozen meat products. The cross contamination of the hands of workers, working equipment and utensils could also serve as a means of spread of *Salmonella* to uncontaminated

carcasses and giblets. Mohammed et al. (2009) highlight that *Salmonella* pet poses threat to human, and public practitioners should consider potential means of *Salmonella* transmission. Spread of *Salmonella* in meat during slaughtering and preparation is more common. Okonko et al. (2010) agreed with this result. Contaminations of ready to eat foods and might eventually affect the health of consumers. This was illustrated by the presence of indicator organisms. The disease caused by *Salmonella* is a major health problem in developing countries (Asia and Africa); especially in Ethiopia due to poor sanitary conditions and lack of inadequate potable water and food (Okonko et al., 2010; Molla and Mesfin, 2003). In addition, outbreaks of infections somehow related with poor hygiene and consumption of contaminated food were reported in Ethiopia and somewhere to be caused by *Salmonella* and *Shigella* (Haimanot et al., 2010). Food handlers are an important vehicle for microorganisms and improper handling practices may cause food contamination and consequently foodborne diseases to the consumers. Causes of improper food handling practices could be related to either lack of facilities or lack of knowledge on habits concerning hygiene. This study assessed the food handling practices of the vendors as shown in Table 8.

Only 35% of the vendors wash the food before cooking.

Table 10. Assessment of the vending environment in Bahir Dar town (n = 20).

Statements/parameters	Frequency (%)
Environment, waste disposal and water supply	
Clean	4(20%)
Dirty	10(50%)
Harbor vectors	6(30%)
Waste disposal	
In bush	1(5%)
In waste bin	5(25%)
Near the vending site	14(70%)
Presence of garbage receptacles	7(35%)
Presence of water containers	9(45%)
Liquid waste disposal	
Open area dumping	5(25%)
To septic tanks	1(5%)
Nearby the vending site	13(70%)
Water supply	
Pipe private	2(10%)
Pipe shared	7(35%)
Pipe neighbors	11(55%)
Latrines facilities	
Flush type	4(20%)
Dry pit latrines	6(30%)
Open latrines around the vending area	10(50%)

It was noted that foods were prepared on the same surface more than once by 85% of them. Of the vendors, 95% handled food with bare hands, whereas 100% handled money while serving food. Cooked street food should not be handled with bare hands.

According to revised guidelines for the design of control measures for street-vended foods in Africa (FAO, 1997), clean tongs, forks, spoons or disposable gloves should be used when handling, serving or selling food. Handling with bare hands may result in cross contamination, hence introduction of microbes on safe food. The person handling money should not handle food. This is because money is dirty and can contaminate safe food (FAO, 1997). Contamination of equipment, utensils and hands of workers can spread pathogens to uncontaminated carcass and parts with subsequent handling processing transport, storage, distribution and preparation for consumption (Ejeta et al., 2004). Based on the observational check list, the vendors did not appear clean

during serving (30%) and they were not appropriately dressed and did not wear aprons (10%) and head restraints (15%) (Table 9). Because hair is known to harbor *S. aureus*, it is essential to prevent loose hair in the food or food preparation areas. About 50% of the vendors given that the vending site was dirty and waste were conspicuously close to the stalls, still 70% of the vendors threw waste water just beside the stalls making the environment surrounding the eateries quite filthy (Table 10).

Water for street food preparation was not enough. A similar result was recorded in Accra, Ghana on the safety of street vended food as the running water is limited (Mensah et al., 2002). This resulted in vendors using little water for washing utensils hence hygiene was compromised. The vendors provided open bins for the disposal of garbage. There was no drainage system for channeling the waste water from the vending area of the food. It was noted that the food was prepared on the

same surface more than twice without replacement.

Conclusion

Based on the present study, it can be concluded that, street vended meat sauce in Bahir Dar is unsafe for consumption particularly, if stored for long periods. High level of coliform and *S. aureus* contamination indicated that the ingredient or the product had bad sanitation and personal hygiene. The counts and more importantly types of microorganisms on the meat sauce sampled in this study was indicative of a degree of ignorance regarding proper hygiene practices on the part of food handlers. Therefore, there is a need to reduce the problems of street food contamination, growth of microorganisms and intoxication through education of street food sellers and the public on the importance of environmental sanitation and safe practices in the handling of cooked foods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest

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