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Microbial Safety of Street Vended Foods Sold in Thohoyandou, South Africa

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ABSTRACT Street vended foods (SVFs), if prepared under hygienic and regulated conditions, play a significant role in feeding the urban population with cheap, accessible and nutritious diet. This study investigated the microbial safety of 28 food samples obtained from four different locations in Thohoyandou. Standard microbiological methods were used for enumeration of *Staphylococcus aureus* and Coliforms. Results of the study show that isolated *S. aureus* was <2.4771 $\log_{10}$ cfu/g in all samples and locations, while there was no significant difference ($p > 0.05$) in total coliform count (<2.1761 $\log_{10}$ cfu/g) among samples and across all locations. Microbial contamination of SVFs using the total plate count method was observed in the food samples except fried potato chips, with marked significant difference ($p < 0.05$) recorded across locations in cereals and meat samples. Majority of SVFs obtained from all locations met the microbiological standard of ready-to-eat foods.

INTRODUCTION

Reliability by consumers on street vended foods (SVFs) has been attributed mainly to their availability and relatively cheap price compared to packaged and processed foods. This has made SVFs the preferred choice for low income earners (Muinde and Kuria 2005; Asiegbu et al. 2016). Street foods are appreciated for their unique flavours and convenience as well as for maintaining the nutritional status of the population. In the work of Simpson (2005) approximately 40 percent of the total energy intake and 44 percent of the iron intake among all age groups are said to be supplied from street foods. SVFs also assure food security for low income urban population in many developing countries (Kumar et al. 2006; Nonga et al. 2015). In most developing countries with high rate of unemployment, street foods serve as a veritable source of employment and income generation (Riet 2002).

According to Gitahi et al. (2012), food safety is the assurance that food will not cause harm to the consumer when prepared and consumed according to its intended use. Ackah et al. (2011) also defined food safety as the conditions and measures that are necessary during the production, processing, storage, distribution and preparation of food to ensure that it is safe, wholesome and suitable for human consumption. SVFs have long been associated with food contamination which is perceived to be a major public health risk due to the lack of basic infrastructure and services for storage and processing, difficulty in controlling large numbers of street food vending operations, mobility and the temporary nature of street food vending operation (Rane 2011; Campos et al. 2015).

The main health hazard associated with street foods is microbial contamination while pesticide residues, transmission of parasites, unpermitted chemical additives, environmental contamination due to poor sanitation and limited access to safe water are also identified as other possible hazards (Abdussalam and Kaferstein 1993; Tchamba et al. 2016). Whereas, food risk is influenced by food type, method of preparation, pH, water availability, handling, exposure temperature, and holding time (Mathee et al. 1996). The shelf life of SVFs depend on the interaction of chemical, physical and microbial factors (Suneetha et al. 2011). Foodborne bacterial pathogens commonly associated with SVFs include faecal coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* species, *Clostridium perfrigens* and *Bacillus cereus* (FAO/WHO 2005; Rane 2011).

Most street food vendors undergo little or no training and lack the required knowledge on

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food safety and hygiene (Aluko et al. 2014; Liu et al. 2014; Asiegbu et al. 2016). This makes them develop their own way of handling foods which they perceive to be hygienic and conventional (Gitahi et al. 2012). Street foods are prepared by vendors at home or at road side stalls (Muinde and Kuria 2005; Campos et al. 2015) by boiling, frying, roasting, baking, juicing or fermenting. Upon preparation, the food is not reheated to high temperature before serving. Often, stalls where SVFs are sold are poorly constructed and built in the open thereby increasing their exposure to contamination by dust and combustion from vehicles on the road side (Muinde and Kuria 2005).

Objectives of the Study

This study seeks to: (i) assess the microbial safety of SVFs that are sold in Thohoyandou South Africa; (ii) assess the microbial safety of SVFs sold in four different locations (shopping malls, taxi ranks and public areas) of Thohoyandou, South Africa; (iii) determine if the SVFs meet the required microbiological standards of ready-to-eat foods.

MATERIAL AND METHODS

Study Area and Sampling Procedure

The study was conducted in Thohoyandou (coordinates 22.9500°S 30.4833°E), Limpopo Province of South Africa. Thohoyandou is a town in South Africa with an estimated population of 618, 462 people and an annual population growth rate of 0.62 percent. Street foods were collected in four locations of shopping mall (L1), street stalls (L2), taxi rank (L3) and bus station (L4) all located in Thohoyandou.

Sampling was conducted based on the availability of different varieties of street-vended food prepared in the streets of Thohoyandou. Seven modified FAO food groups (FAO 2011) including cereals, mixed dishes, starchy roots, beverages, vegetables, meats and legumes were sampled (Table 1). A total of 28 samples were collected in sterile polythene bags and transported to the laboratory of the Department of Food Science and Technology, University of Venda. The samples were stored at a temperature of 4 ^{0}C and analyzed within 2 hours of collection.

Table 1: Sampled food according to FAO groupings

Consumed food	*Food samples*
Cereals	Unfermented porridge
Mixed dishes	Boiled cabbage and carrots
Legumes	Boiled peanuts
Vegetables	Salads
Starchy root	Potato chips
Meat	Stewed beef and grilled chicken
Beverages	Traditional mageu

Source: FAO 2011

Microbial Analysis

Total Plate Count

Approximately 10 g of sample was weighed and put into 90 mL peptone water before getting placed in a Stomacher for 2 min. Subsequent 10-fold dilutions were made to 10^{-3}. About 1 mL of all dilutions was plated by the pour plate method, in duplicate petri dishes using Plate Count Agar (PCA). The plates were incubated at 30 °C for 72 h and duplicate plates containing between 30 and 300 colonies were counted. Average counts obtained were expressed as colony forming units per gram of food (cfu/g).

Coliforms

Approximately 10 g of sample was weighed and put into 90 mL peptone water before getting placed in a Stomacher for 2 min. Subsequent 10-fold dilutions were made to 10^{-3}. Approximately 1 mL of dilutions was plated in duplicate petri dishes and Violet Red Bile Agar was plated using pour plate method, according to SABS ISO method 4832: 1991. Plates were incubated at 37 °C for 24 h. Duplicate plates containing between 15 and 150 typical coliform colonies were counted and average counts obtained were expressed as cfu/g.

Staphylococcus aureus

About 10 g of sample was weighed and put into 90 mL peptone water before getting placed in a Stomacher for 2 min. Approximately 0.1 mL of the sample was poured in duplicate petri dishes and spread on Baird Parker agar. All plates were incubated at 37 °C for 48 h. Typical *S. aureus* colonies were counted and the average counts obtained were expressed as cfu/g (Biorad 2011).

Data Analysis

Quantitative data on the microbial counts obtained from the experiment were subjected to the analysis of variance (ANOVA). Observed difference among the mean values of samples were compared using Duncan Multiple Test using SPSS 20 for windows (SPSS Inc., Chicago, Illinois) statistical software package. Results of enumeration were expressed as mean ± standard deviation $\log_{10}$ cfu/g for all food samples.

RESULTS

Results of analysis obtained from Total Plate Count (TPC) of various food groups (Table 2) show that TPC differed significantly ($p < 0.05$) in cereals (3.8084 ± 1.44 $\log_{10}$ cfu/g) and grilled chicken and beef (3.0299 ± 0.63 $\log_{10}$ cfu/g) when compared to other food groups. Cooked cabbage and carrots (2.4748 ± 0.00 $\log_{10}$ cfu/g) had significantly low TPC when compared to other food samples. In cereals, TPC from L1 (5.0849 ± 0.16 $\log_{10}$ cfu/g) and L2 (5.0343 ± 0.07 $\log_{10}$ cfu/g) was significantly different ($p < 0.05$) from L3 (2.6376 ± 0.25 $\log_{10}$ cfu/g) and L4 (<2.4771 ± 0.0 $\log_{10}$ cfu/g). Conversely, TPC obtained in cooked cabbage and carrots showed that there was no significant difference in mixed dishes in all locations. However, a study conducted by Gitahi et al. (2012) in Nairobi, Kenya, showed a result of 4.14 $\log_{10}$ cfu/g in mixed dishes.

The result for traditional mageu showed that TPC was found to be highest in L3 (3.5905 $\log_{10}$ cfu/g) and lowest in L2 and L4 (<2.4771 ± 0.00 $\log_{10}$ cfu/g). There was no marked significant difference in TPC present in the traditional beverage at L1 (2.5191 ± 0.27 $\log_{10}$ cfu/g), L2 (<2.4771 ± 0.00 $\log_{10}$ cfu/g), and L4 (<2.4771 ± 0.00 $\log_{10}$ cfu/g) while L3 (3.5905 ± 0.03 $\log_{10}$ cfu/g) differed significantly ($p < 0.05$). A comparison of traditional mageu with the same study that was conducted in South Africa by Nyadzi (2007) showed similar results of 3.8028 $\log_{10}$ cfu/g in traditional mageu. Results of TPC obtained from street vended salads, potato chips and boiled peanuts showed that there was no significant difference in the microbial contamination of all three types of street-vended foods sold in all locations. Studies conducted by Nyenje et al. (2012) on foodborne pathogens recovered from ready-to-eat foods from roadside cafeterias and retail outlets in Alice, South Africa showed that vegetable salads recorded a TPC of 6.8 $\log_{10}$ cfu/g. In grilled chicken and beef, there was no signifi-

Table 2: Microbial count of street foods from various food groups collected in Thohoyandou

Microorganisms	*Food groups (Log_{10} cfu/g)*						
	Cereals	*Cooked cabbage and carrots*	*Traditional mageu*	*Salads*	*Potato chips*	*Grilled chicken and beef*	*Boiled peanuts*
TPC*	3.8084 ± 1.44^{b}	2.4748 ± 0.00^{a}	2.7659 ± 0.55^{a}	2.5174 ± 0.07^{a}	<2.4771 ± 0.0^{a}	3.0299 ± 0.63^{b}	2.4979 ± 0.04^{a}
TCC**	<2.1761 ± 0.00	<2.1761 ± 0.00	<2.1761 ± 0.00	<2.1761 ± 0.00	<2.1761 ± 0.00	<2.1761 ± 0.00	<2.1761 ± 0.00
S. aureus	<2.4771 ± 0.00	<2.4771 ± 0.00	<2.4771 ± 0.00	<2.4771 ± 0.00	<2.4771 ± 0.00	<2.4771 ± 0.00	<2.4771 ± 0.00

Means with different letters across rows are significantly different ($p < 0.05$). Means without superscript letters across rows are not significantly different ($p > 0.05$).
* Total plate count
** Total coliform count

cant difference in TPC obtained from L1 (3.6305 ± 2.06 $\log_{10}$ cfu/g) and L2 (3.5351 ± 1.92 $\log_{10}$ cfu/g). Results of L3 and L4 (<2.4771 ± 0.00 $\log_{10}$ cfu/g) also showed no significant difference whereas TPC of L1 and L2 were significantly different ($p < 0.05$) from L3 and L4 (Table 3). A study conducted by Tavakoli and Riazipour (2008) at Tehran showed that the TPC of meat was 4.7945 $\log_{10}$ cfu/g. Other studies conducted by Adzitey et al. (2011) also obtained a high TPC of 5.76 $\log_{10}$ cfu/g in meat.

Total coliform count (TCC) of all food samples in the food groupings was <2.1761 ± 0.00 $\log_{10}$ cfu/g with no significant difference recorded among the food groups. The absence of Coliforms in food groups showed that the SVFs were prepared under appropriate hygienic conditions. Microbial count of *S. aureus* was <2.4771 ± 0.00 $\log_{10}$ cfu/g in all food groups with no significant difference among the groupings. Seven different food products were tested at all locations in Thohoyandou, South Africa, in which the TCC of all the products analysed was less than <2.4771 ± 0.00 $\log_{10}$ cfu/g (Table 4). There was no significant difference in all locations.

Microbial analysis of *S. aureus* in cereals, cooked cabbage and carrots, traditional mageu, salads, fried potato chips, grilled chicken and beef and boiled peanuts showed that *S. aureus* was not present (Table 5). The results obtained were 2.4771 $\log_{10}$ cfu/g in each location. Results obtained from all locations also showed that there

Table 3: Total plate count (TPC) of street foods sampled in four different locations at Thohoyandou

Products	*Location (Log_{10} cfu/g)*			
	L1	*L2*	*L3*	*L4*
Cereals	5.0849 ± 0.16^{b}	5.0343 ± 0.07^{b}	2.6376 ± 0.25^{a}	<2.4771 ± 0.0^{a}
Cooked cabbage and carrots	2.4682 ± 0.12	<2.4771 ± 0.0	<2.4771 ± 0.0	<2.4771 ± 0.0
Traditional mageu	2.5191 ± 0.27^{a}	<2.4771 ± 0.0^{a}	3.5905 ± 0.03^{b}	<2.4771 ± 0.0^{a}
Salads	2.4888 ± 0.13	2.6269 ± 0.05	<2.4771 ± 0.0	<2.4771 ± 0.0
Potato chips	<2.4771 ± 0.0	<2.4771 ± 0.0	<2.4771 ± 0.0	<2.4771 ± 0.0
Grilled chicken and beef	3.6305 ± 2.06^{b}	3.5351 ± 1.92^{b}	<2.4771 ± 0.0^{a}	<2.4771 ± 0.0^{a}
Boiled peanuts	<2.4771 ± 0.0	<2.4771 ± 0.0	2.5603 ± 0.12	<2.4771 ± 0.0

Means with different letters across rows are significantly different ($p < 0.05$). Means without superscript letters across rows are not significantly different ($p > 0.05$).

Table 4: Total coliform count of SVFs in four different locations at Thohoyandou

Products	*Location (Log_{10} cfu/g)*			
	L1	*L2*	*L3*	*L4*
Cereals	<2.1761	<2.1761	<2.1761	<2.1761
Cooked cabbage and carrots	<2.1761	<2.1761	<2.1761	<2.1761
Traditional mageu	<2.1761	<2.1761	<2.1761	<2.1761
Salads	<2.1761	<2.1761	<2.1761	<2.1761
Potato chips	<2.1761	<2.1761	<2.1761	<2.1761
Grilled chicken and beef	<2.1761	<2.1761	<2.1761	<2.1761
Boiled peanuts	<2.1761	<2.1761	<2.1761	<2.1761

Means without superscript letters across rows are not significantly different ($p > 0.05$).

Table 5: Microbial analysis of *S. aureus* in street vended food samples in four locations at Thohoyandou

Products	*Location (Log_{10} cfu/g)*			
	L1	*L2*	*L3*	*L4*
Cereals	<2.4771	<2.4771	<2.4771	<2.4771
Cooked cabbage and carrots	<2.4771	<2.4771	<2.4771	<2.4771
Traditional mageu	<2.4771	<2.4771	<2.4771	<2.4771
Salads	<2.4771	<2.4771	<2.4771	<2.4771
Potato chips	<2.4771	<2.4771	<2.4771	<2.4771
Grilled chicken and beef	<2.4771	<2.4771	<2.4771	<2.4771
Boiled peanuts	<2.4771	<2.4771	<2.4771	<2.4771

Means without superscript letters across rows are not significantly different ($p > 0.05$).

was no significant difference in the amount of *S. aureus* present in the street vended foods.

DISCUSSION

Total Plate Count of Street Vended Food Samples

The observed significant differences reported in the TPC of cereals, grilled chicken and beef as well as in cabbage and carrots may be attributed to the fact that the SVFs were served in unhygienic conditions (Nonga et al. 2015), hence resulting in contamination from serving utensils. There was no significant difference in the TPC of cooked cabbage and carrots, beverages, salads and fried potato chips ($p < 0.05$).

As stated in the results, TPC was significantly high in the cereals prepared at L1 due mainly to the fact that the street vended cereals were served in unhygienic conditions and contaminated serving utensils at the different locations. Das et al. (2010) who investigated the microbiological quality of street vended Indian chaats also reported similar results for cereals as a result of unhygienic conditions and contaminated serving utensils. When compared to other locations, L1 was found not to be in a clean hygienic condition. The results obtained in this study were significantly higher than the results of Omafuvbe et al. (2007). This may be due to climatic variations with the subtropical nature of South Africa and the fact that cereals sampled in this study were not in good condition. The results of TPC showed that the cereal products tested were below the limit set by the South African Microbiological Standards (1997) for cooked food which is < 6.00 $\log_{10}$ cfu/g.

From the results of TPC obtained in cooked cabbage and carrots, there was no significant difference in the mixed dishes in all locations, especially with the research conducted by Gitahi et al. (2012) in Nairobi, Kenya, showing a result of 4.14 $\log_{10}$ cfu/g in mixed dishes. According to South African Microbiological Standards (1997), cooked food should contain a TPC of less than 6.00 $\log_{10}$ cfu/g, thus the cooked cabbage and carrots met the South African Microbiological Standards because they had TPC of less than 6.00 $\log_{10}$ cfu/g.

Reported low microbial counts in beverages used in this study could be explained by the fact that the beverages were subjected to heat treatment during their preparation. This is contrary to the observations reported in the work of Tchamba et al. (2016) who stated that beverages sold in streets are mostly prepared in unhygienic conditions, hence implicating the beverages as vehicles of food contamination. The reported presence of 6.8 $\log_{10}$ cfu/g TPC in the vegetables as seen in the result of the study meant that they did not meet the microbial standards of salads of below 6.00 $\log_{10}$ cfu/g. According to New Zealand Food Regulations (1995), raw vegetables must not contain more than 6.00 $\log_{10}$ cfu/g of plate count of microorganisms. High amount of microbial contamination in salads can be attributed to increase in microbial load in the vegetables during sprout, exposure of leaves to soil, irrigation water as well as trapped dirt in leaf folds (Seow et al. 2012). Low TPC recorded in boiled peanuts obtained from this study may be attributed to the fact that the peanuts were boiled with the outer coat (Mensah et al. 2002).

The presence of TPC in these foods could be attributed to the fact that foods were prepared in an open space and exposed to contamination from gaseous emissions and atmospheric gases such as oxygen which supports the growth of aerobic microorganisms (Suneetha et al. 2011). TPC recorded in majority of all SVFs indicated that raw materials in perishable products were contaminated and might also indicate unsuitable time/temperature storage conditions.

Total Coliform Counts of Street Vended Food Samples

The absence of Coliforms in food groups showed that street foods were not contaminated with skin infections and nose nares of food handlers which also inferred that hygienic practices were applied during the preparation of the food samples. Results obtained from this study differed from the study conducted by Gitahi et al. (2012) which recorded the results of 3.27 $\log_{10}$ cfu/g in cereals, 3.32 $\log_{10}$ cfu/g in mixed dishes, 3.37 $\log_{10}$ cfu/g in legumes, 4.63 $\log_{10}$ cfu/g in vegetables and 3.45 $\log_{10}$ cfu/g in meat. Differences in microbial enumeration obtained from both studies could be attributed to contamination of foods by street vended food sellers during handling, processing and vending.

Across the locations, no significant difference was observed in the food samples examined. Absence of coliforms showed that the SVFs prepared at Thohoyandou mall, shops and taxi ranks were safe to eat because they contained no pathogenic microorganisms which could result in diarrhea, headache and nausea. However, other studies in other regions of the world showed the presence of Coliforms in meat, vegetables, legumes and porridge. Tavakoli and Riazipour (2008) in a study conducted at Tehran showed that TCC of meat was 2.0212 $\log_{10}$ CFU/g and (1.0020 $\log_{10}$ cfu/g). The research conducted by Gitahi et al. (2012) showed that the highest microbial load of TCC in meat was (3.73 $\log_{10}$ cfu/g). Similar studies done by Osamwonyi et al. (2013) and Seow et al. (2012) also recorded coliform counts of 2.06 $\log_{10}$ cfu/g and 4 – 6 $\log_{10}$ cfu/g in vegetable salads and fruits. Coliforms were also found in peanuts (3.91 $\log_{10}$ cfu/g) in an experiment conducted by Kayode et al. (2007). The results of TCC obtained from peanuts in this research were in line with the results reported by Kayode et al. (2007).

Absence of Coliforms indicated adequate processing and its presence indicated post process recontamination due to cross contamination by raw materials, dirty equipment or poor hygienic handling. The absence of coliforms in street foods might also be due to good quality of water used for washing utensils and cooking. Adequate storage temperatures and personal hygiene of food vendors were applied during food preparation. Absence of Coliforms in these foods might also be attributed to adequate handling of SVFs during display and also the sale of food in closed protective environment. Use of clean uncontaminated water for cooking and serving is another factor that resulted in absence of coliforms (Khalil et al. 1994). Hence, the results of this study will increase consumers' confidence in the safety of SVFs. In a study done by Asiegbu et al. (2016) on the food safety knowledge and microbial hazards awareness of consumers of ready-to-eat street-vended food in South Africa, about 73 percent on consumers indicated awareness and concern of the bacterial safety of SVFs.

Occurrence of Staphylococcus aureus (*S. aureus*) in SVFs

The result of the study shows that *S. aureus* was not present in all food samples examined with no significant difference observed across the locations. This result is in line with that reported by Ng et al. (2013) in ready-to-eat foods in some shops in Hong Kong. In similar studies conducted by Neela et al. (2003), *S. aureus* was reported in meat (4.2 $\log_{10}$ cfu/g) by) in Trinidad and Tobago. Williamson et al. (2006) also reported an amount of 2.0 $\log_{10}$ cfu/g in vegetable salads in Preston, North West Province of South Africa. According to the author, the reported *S. aureus* present in vegetable salads may be attributed to vegetable salads been served raw (Suneetha et al. 2011).

The absence of *S. aureus* is usually an indicator to the absence of contamination of foods prepared by street vendors. It also serves as an indicator of good hygienic and food handling practices by street vendors (Gitahi et al. 2012). Absence of *S. aureus* may also indicate the absence of enterotoxin which produces strains of *S. aureus*. This may be attributed to the various heat processing steps that are applied during food preparation.

CONCLUSION

A majority of the SVFs analyzed for microbial contamination from all four different locations met the microbiological standards of ready-to-eat foods. The enumerated TPC values obtained in this study for unfermented porridge, boiled cabbage and carrots, boiled peanuts, salads, potato chips, stewed beef and grilled chicken and traditional mageu food samples were within the specifications set by the South African Microbiological Standards which indicates that cooked food should contain less than $\log_{10}$ 6.00 cfu/g. This implies that street food vendors in Thohoyandou, South Africa apply standard hygiene practices in the processing and preparation of street-vended ready-to-eat foods. Thus the absence of Coliforms and *S. aureus* is an indication that street foods in Thohoyandou are safe for consumption.

RECOMMENDATIONS

As ready to eat SVFs prepared and sold in the streets and taxi ranks of Thohoyandou have been studied and shown to be safe for consumption, regular trainings on ways of maintaining and increasing food safety, hygiene levels and environmental sanitation is needed for the food handlers, sellers and vendors. This is paramount to ensure that food safety measures are regularly put in place in guaranteeing that standards are constantly maintained in the preparation of

SVFs. This will ensure that SVFs are not vehicles for pathogens nor the transmission of diseases to people who depend on them for their nutritional needs.

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