Food Research 6 (2) : 465 - 474 (April 2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Microbiological quality of street-vended foods sold in Thulamela Municipality of South Africa

[1,*]Mathaulula, M.A., [1]Francis, J., [1]Mwale, M. and [2,3]Jideani, A.I.O.

[1]*Institute for Rural Development, Faculty of Science, Engineering and Agriculture, University of Venda, Private Bag X 5050, Limpopo Province, South Africa*
[2] *Department of Food Science and Technology, Faculty of Science, Engineering and Agriculture, University of Venda, Private Bag X 5050, Limpopo Province, South Africa*
[3]*Special Interest Group Post harvest Handling, ISEKI-Food Association, Muthgasse 18, 1190 Viena/Austria*

Article history:
Received: 2 March 2021
Received in revised form: 13 April 2021
Accepted: 17 June 2021
Available Online: 28 April 2022

Keywords:
Contaminants,
Food safety,
Informal markets,
Microbiological quality,
Ready-to-eat

DOI:
https://doi.org/10.26656/fr.2017.6(2).150

Abstract

The objective of the study was to examine the microbial quality of street-vended foods in Sibasa and Thohoyandou markets of Thulamela Municipality, South Africa. Gravy, salad, beef and chicken stews were randomly sampled from seven markets. Microbiological international standard methods were used for the Total plate counts, coliform bacteria, *Salmonella* spp., *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus*, yeast and mould counts. The microbial counts (log_{10} CFU/g) of foods sold at Thohoyandou ranged from 2.0±2.08 to too numerous to count for Total plate count, 2.0±1.00 to 6.6±7.57 for *Salmonella* spp., 2.0±2.64 to 3.9±6.03 for *S. aureus*, 2.3±1.73 to too numerous to count for yeast. At Sibasa, microbial counts (log_{10} CFU/g) ranged from 2.1±6.24 to 6.9±5.30 for total plate count, 2.0±0.00 to 3.8±10.00 for coliform bacteria, 2.0±2.64 to 4.7±8.33 for *Salmonella* spp., 2.0±6.03 to 3.9±9.30, for *S. aureus*, 2.1±1.00 to 3.7±39.58 for yeast and 2.0±1.15 to 4.9±21.66 for *B. cereus*. Mould was not detected in all the foods sold at both locations. The total plate count was significantly different ($P<0.05$) between salads and chicken stews. For *Salmonella* spp., significant differences ($P<0.05$) were observed between salads and beef stews. For *S. aureus*, a significant difference was found in salads ($P<0.05$). For yeast, significant differences ($P<0.05$) were observed between salads and beef stews. The fact that most street-vended foods were contaminated with a range of microorganisms is a matter of public concern. Department of Health, South Africa should initiate a food safety program for the vendors to be trained in hygienic preparation of foods and good sanitation practices to better safeguard the health and wellness of consumers. There is also a need for Environmental Health Practitioners to mount a better monitoring system that would contain selling street-vended food that is unfit for human consumption.

1. Introduction

Street-vended (SV) foods are prepared and sold on the roadside and in other public places (FAO, 2013). Street food vending business is popular in the world, especially in developing countries such as South Africa. Von Holly and Makhoane (2006) claim that the street food sector has substantially reduced unemployment by offering great business opportunities through its sales. Swai (2019) reports that the food vending business has adequately influenced the financial system of local development in developing countries. In South Africa, various types of SV foods are commonly sold. These include thick porridge (commonly called *pap*), beef, chicken, salads, gravy, fat cakes, fish and potato chips. As is the case in other developing countries, SV foods are popular in both urban and rural areas.

Mazizi *et al*. (2017) indicate that SV foods are appreciated because they have unique flavours, are readily available, inexpensive and generate income for those involved. Low salaries and limited social programmes to cushion poor and vulnerable families force some people to resort to SV foods for their livelihoods (Mafune *et al*., 2016). Moreover, as they sell SV foods, vendors provide vital services to workers, travellers and people whose incomes are low. Consumers of SV foods mainly consider convenience or ease of

*Corresponding author.
Email: *agnes.mathaulula@univen.ac.za*

eISSN: 2550-2166
Published by Rynnye Lyan Resources

access rather than quality, safety and hygiene aspects (Bakobie *et al*., 2017). This justifies that consumers of SV foods should receive basic education and training focusing on quality, safety, hygiene aspects, food poisoning and prevention.

Throughout the world, public health experts and international bodies are concerned about the safety of SV foods, mainly due to the commonly observed unhygienic handling practices (Kubde *et al.,* 2016). It is acknowledged that outbreaks of foodborne illnesses harm people's health and adverse economic performance (Amoah, 2014). For example, Ghana and the United States of America spend $69 million and $152 billion per year respectively, to run programmes designed to combat outbreaks of foodborne diseases (Abakari *et al*., 2019). Food safety is crucial in achieving better human nutrition through healthy nutritious diets. Improving food safety is thus, a key in achieving Sustainable Development Goal number 3 which is good health and wellbeing. Governments should make food safety a public health priority, as they play a pivotal role in developing policies and regulatory frameworks. Thus, strengthening SV food policies and proper enforcement would undoubtedly ensure a significant reduction in the hazards of street food consumption.

Contamination of SV foods is mainly attributed to negligence and inadequate or non-enforcement of legislation governing safety and vending establishments. Thus, the sale of food in street markets raises health concerns. Microbial contamination is the main health hazard associated with these foods. A study carried out in the Central Business District of the Tamale Metropolis reported high microbial counts of *Salmonella* spp*., Bacillus cereus* and *Staphylococcus aureus* detected in SV foods (Abakari, 2019). Contaminated foods expose consumers to risks of foodborne illnesses such as diarrhoea, *Salmonellosis*, listeriosis and cholera (Liu *et al.,* 2014). Hence, good safety and hygiene practices are crucial in preventing foodborne diseases as contamination can occur at any stage from purchasing to consumption of food.

Outbreaks of bacterial foodborne diseases can be controlled if food health experts carry out frequent inspections. Incorporation of safety as a supporting component that influences food security and consumer nutrition may result in healthy livelihoods for consumers (Mazizi *et al.,* 2017). It is important to note that implementing food safety principles is most feasible if the public is educated about the risks of not adhering to laid down protocols (Bereda *et al.*, 2016). Although consumption of SV foods is widespread in South Africa, not much research has been conducted to unravel the microbial status of gravy, salad, chicken and beef stew, which are commonly sold. Yet knowledge of the microbial quality of the foods may help formulate appropriate safety enhancement interventions. Thus, the purpose of the current study was to examine the microbial quality of commonly consumed foods sold in street food vending markets within Thulamela Municipality of South Africa.

2. Material and methods

2.1 Study area and sampling procedure

The study was conducted in Sibasa and Thohoyandou, which are both located in Thulamela Local Municipality in Limpopo Province of South Africa. Twenty-eight (28) ready-to-eat food samples were collected from three markets in Sibasa and four in Thohoyandou. Gravy, salad, and beef and chicken stews were collected from August to November 2018 between 12:00 pm to 2:00 pm using a random sampling procedure. Sterilised serving utensils obtained from the vendors were used to place food samples into sterilized containers. Samples were placed into a Rotomolded cooler box with ice packs and transported to the food microbiology laboratory of the University of Venda's Department of Food Science and Technology. The food samples were stored in the refrigerator at 4^{o}C. Microbial analyses were conducted within 2 hrs after collection (Mafune *et al.,* 2016; Abakari *et al.,* 2019).

2.2 Sample preparation

Dilutions were prepared following instructions indicated by the Merck manufacturer. Approximately, 10 g of each food sample were weighed and placed into 90 mL of buffered peptone water (BPW) and stomached (230 oscillations per min) for 2 mins. Buffered peptone water diluent was prepared from 10^{-1} to 10^{-5} dilution. Sterilized pipette tips were used to transfer 1 mL of each dilution into petri dishes in triplicates.

2.2.1 Total plate count

Plate count agar (PCA) and BPW were prepared. Approximately, 15 mL of PCA was pour plated into Petri dishes and mixed with 1 mL of each dilution. After setting, plates were incubated at 37°C for 72 hrs. Colonies were countered following instructions indicated on ISO method 4833 (ISO, 2003). The results were expressed as $\log_{10}$ CFU/g) .

2.2.2 Estimation of coliform bacteria and Escherichia coli

Chromocult coliform agar and BPW were prepared. Approximately, 15 mL of Chromocult were pour plated into petri dishes and mixed with 1 mL of each dilution. The plates were inverted when set and incubated at 37°C

for 24 hrs, following instructions stipulated in ISO method 4832 (ISO, 1991). Colonies were counted, taking into account that pink and blue colonies represented coliforms and *E. coli*, respectively. The results were expressed as $\log_{10}$ CFU/g.

2.2.3 Estimation of Salmonella spp.

Xylose lysine deoxycholate agar (XLD) and BPW were prepared and used as a diluent. Approximately, 15 mL of XLD agar was poured into Petri dishes and mixed with 1 mL of each dilution. The prepared dishes were incubated at 37°C for 24 hrs. After the incubation period, plates were colony counted following instructions on ISO method 6579 (ISO, 2002). The results were expressed as $\log_{10}$ CFU/g.

2.2.4 Estimation of Staphylococcus aureus

In each diluted food sample, the streak method was used on plates of Baird Parker agar and left to solidify overnight as indicated in the ISO method 4833 (ISO, 2003). About 0.5 mL of each food sample was transferred in triplicates into Petri dishes using a sterile pipette. Plates were incubated at 37°C for 48 hrs. The colonies were counted, and results were expressed as $\log_{10}$ CFU/g.

2.2.5 Estimation of Bacillus cereus

Bacillus cereus (BC) agar and BPW were prepared and used as a diluent. About 15 mL of BC agar were pour plated into Petri dishes and mixed with 1 mL of each dilution as stated in ISO 7932:2004 (ISO, 2004). The plates were inverted when set and incubated at 37°C for 48 hrs. The colonies were counted, and results were expressed as $\log_{10}$ CFU/g.

2.2.6 Estimation of yeast and mould

Potato dextrose agar (PDA) and BPW were prepared following the Merck manufacturer's instructions. Each dilution (1 mL) was transferred into Petri dishes in triplicates. An estimated 15 mL of PDA was poured into Petri dishes and mixed with 1 mL of each dilution. Plates were inverted when set. They were incubated at 25°C for 5 days. Colonies were counted. The results were expressed as $\log_{10}$ CFU/g in line with the ISO method 7954 (ISO, 1987).

2.3 Data analysis

Data obtained from the experiments were first tested for normality before the ANOVA and T-test were performed. The results revealed that data were normally distributed. Thereafter, the data were subjected to the analysis of variance using the IBM Statistical Package for Social Sciences (SPSS) version 25.0. The significance test level was set at ($P<0.05$). Duncan's multiple range test was used to separate means of microbial load (Tallarida and Murray, 1987). This test was deemed appropriate because of its ability to measure specific differences between pairs of means. Just as was the case with ANOVA, significance was set at $P<0.05$. The t-test was used to compare the means obtained from the two locations, namely Sibasa and Thohoyandou vending sites.

3. Results

3.1 Total plate count

Tables 1 and 2 show the results of the mean microbial counts ($\log_{10}$ CFU/g) of the cooked ready-to-eat SV foods sold at Thohoyandou and Sibasa markets. Mean microbial counts ($\log_{10}$ CFU/g) of samples sold at Thohoyandou ranged from 2.0±2.08 to too numerous to count for TPC. A significant difference ($P<0.05$) was found in gravy sold at Thohoyandou market 4 while the lowest was found in gravy sold at market 2. No statistically significant differences in TPC were observed in the gravy sampled at markets 1 and 3 (2.6335±10.53 $\log_{10}$ CFU/g). At Sibasa markets, the mean count of TPC ranged from 2.1±6.24 CFU/g to 6.9±5.30 CFU/g. A significant difference was observed in chicken stew sold at market 1 compared to markets 2 and 3.

3.2 Coliform bacteria

Coliform bacteria were neither found in all the food samples sold in the Thohoyandou markets (Table 1) nor have they been observed in gravy sampled at Sibasa market 1 (Table 2). However, gravy collected at Sibasa markets 2 (3.8451±10.00 $\log_{10}$ CFU/g) and 3 (2.3010±1.73 $\log_{10}$ CFU/g) were contaminated with coliform bacteria. The latter results significantly differed ($P<0.05$) from each other. High mean coliform bacteria concentrations were found in salad prepared at market 2 (2.2304±2.08 $\log_{10}$ CFU/g) with the lowest being at market 1 (2.000±6.24 $\log_{10}$ CFU/g). High mean coliform counts (3.45±11.37 $\log_{10}$ CFU/g) were also observed in chicken stew sold at market 2 ($P<0.05$) than from the other markets. The lowest coliform count was detected at market 3 (2.00±0.00 $\log_{10}$ CFU/g). Coliform bacteria were not found in all beef stews sold at Sibasa markets.

3.3 Escherichia coli

Escherichia coli was not detected in all food samples sold at Sibasa markets including gravy samples prepared at Thohoyandou markets 1 and 2. Mean microbial counts ($\log_{10}$ CFU/g) of samples sold at Thohoyandou ranged from 2.6±5.20 to 7.0±8.08 for *E. coli*. The highest *E. coli* count was detected in salad sold at market 4 and was significantly different ($P<0.05$) from counts detected at

Table 1. Microbial analysis (log_{10} CFU/g) of street-vended foods (n = 4) sampled in different markets at Thohoyandou

Location	Gravy	Salad	Chicken	Beef
		Total plate count		
Thohoyandou market 1	2.6±10.53[a]	7.3±11.85[a]	6.6±4.51[b]	5.9±5.77[c]
Thohoyandou market 2	2.0±2.08[b]	3.9±11.59[c]	3.7±5.86[c]	2.9±5.00[d]
Thohoyandou market 3	2.6±10.53[a]	2.4±5.69[d]	2.2±6.08[d]	6.7±9.45[b]
Thohoyandou market 4	TNTC	6.8±2.52[b]	6.8±9.07[a]	6.9±11.01[a]
		Escherichia coli		
Thohoyandou market 1	ND	4.9±3.51[b]	ND	ND
Thohoyandou market 2	ND	ND	ND	ND
Thohoyandou market 3	2.6±5.20[b]	ND	ND	3.7±3.78[b]
Thohoyandou market 4	6.8±15.31[a]	7.0±8.08[a]	6.5±4.04	6.8±6.11[a]
		Salmonella spp.		
Thohoyandou market 1	ND	4.6±3.00[b]	5.81±11.15[a]	2.7±2.64[b]
Thohoyandou market 2	ND	ND	ND	ND
Thohoyandou market 3	ND	2.5±3.51[c]	2.0±1.00[c]	2.5±6.56[c]
Thohoyandou market 4	ND	5.9±2.52[a]	4.9±1.73[b]	6.6±7.37[a]
		Yeast		
Thohoyandou market 1	3.8±7.02[b]	3.7±16.52[a]	3.8±5.51[a]	4.7±14.52[a]
Thohoyandou market 2	2.4±3.21[d]	2.3±2.00[b]	3.8±7.50[a]	2.7±4.04[c]
Thohoyandou market 3	2.7±9.02[c]	2.3±1.73[b]	3.6±4.00[b]	2.9±4.51[b]
Thohoyandou market 4	5.8±4.58[a]	3.7±7.64[a]	TNTC	2.9±3.60[b]

Values are mean±standard deviation, n = 3. Values followed by the same letters in the same column are not significantly different (P > 0.05). CFU = colony-forming unit, ND = not detected, TNTC = too numerous to count. Coliform bacteria, *B. cereus* and mould were not detected in all samples.

Table 2. Microbial analysis (log10 CFU/g) of street-vended foods (n = 4) sampled in different markets at Sibasa

Location	Gravy	Salad	Chicken	Beef
		Total plate count		
Sibasa market 1	4.9±10.02[a]	2.1±6.24[c]	6.9±5.30[a]	2.7±6.66[c]
Sibasa market 2	4.8±9.02[b]	2.2±1.73[b]	3.9 ±11.00[c]	4.9±11.50[a]
Sibasa market 3	4.8±8.02[b]	5.6±3.78[a]	5.73±13.58[b]	3.6±10.82[b]
		Coliform bacteria		
Sibasa market 1	ND	2.0±6.24[c]	ND	ND
Sibasa market 2	3.8±10.00[a]	2.2±2.08[a]	3.5±11.37[a]	ND
Sibasa market 3	2.3 ±1.73[b]	2.11±1.53[b]	2.0±0.00[b]	ND
		Salmonella spp.		
Sibasa market 1	2.1±0.58[b]	ND	2.6±2.31[b]	2.0±2.64[c]
Sibasa market 2	3.7±7.00[a]	2.3±2.00[b]	4.7 ±8.33[a]	2.5±2.00[a]
Sibasa market 3	2.1± 0.58[b]	2.8±0.58[a]	2.4 ±0.58[c]	2.5±1.73[a]
		Yeast		
Sibasa market 1	2.6±0.58[b]	ND	ND	ND
Sibasa market 2	3.7±39.58[a]	2.4±2.08[b]	ND	2.1±1.00
Sibasa market 3	ND	2.7±2.00[a]	ND	ND
		Bacillus cereus		
Sibasa market 1	ND	2.3±0.58[b]	2.0±1.15[c]	ND
Sibasa market 2	3.9±12.50[a]	ND	3.8±5.77[a]	4.9±21.66
Sibasa market 3	2.2±0.58[b]	2.6±14. 22[a]	2.4±6.66[b]	ND

Values are mean±standard deviation, n = 3. Values followed by the same letters in the same column are not significantly different (P > 0.05). CFU = colony-forming unit, ND = not detected, TNTC = too numerous to count. ND = not detected. *Escherichia coli* and mould were not detected in all samples

markets 1, 2 and 3. The lowest *E. coli* count was found in gravy purchased at market 3.

3.4 Salmonella spp.

The mean microbial counts (log_{10} CFU/g) in food samples sold at Thohoyandou markets varied from 2.0±1.00 to 6.6±7.37 for *Salmonella* spp. The highest mean count (log_{10} CFU/g) was observed in the beef stew (6.6±7.37) sold in market 4, followed by salad (5.9±2.52) sold at market 4, respectively. At Sibasa markets the mean microbial counts (log_{10} CFU/g) for *Salmonella* spp. ranged from 2.0±2.64 to 4.7±8.33. The highest mean count was found in chicken stew sold at market 2, which was significantly different from all other markets ($P<0.05$). No statistically significant differences ($P > 0.05$) were observed in gravy purchased at markets 1 and 3 (2.1±0.58 CFU/g) and in beef stews sold at market 2 (2.4±2.00) and market 3 (2.4±1.73).

3.5 Staphylococcus aureus

Figures 1 and 2 show the results of the mean microbial counts (log_{10} CFU/g) for *S. aureus* found in the cooked ready-to-eat SV foods sold in Thohoyandou and Sibasa markets. The mean microbial (log_{10} CFU/g) counts varied from 2.0±0.00 to 3.9±6.03 across Thohoyandou food markets. The highest mean count (log_{10} CFU/g) was found in the gravy (3.9±6.03) followed by chicken stew (3.7±19.09) sold at market 1 and were statistically different ($P<0.05$). There was no significant difference ($P>0.05$) in *S. aureus* concentrations in the salads sold at markets 1 and 3. There was no *S. aureus* in the salad sold at market 2 and chicken stews at markets 3 and 4. At Sibasa markets, mean microbial (log_{10} CFU/g) counts for *S. aureus* ranged from 2.2±6.03 to 3.9±6.03. The highest mean count (log_{10} CFU/g) was found in the chicken stew (3.9±6.03) sold at market 2. Thus, market 2 was significantly different ($P<0.05$) from others. Tests for *S. aureus* in gravy and beef stews in Sibasa yielded negative results.

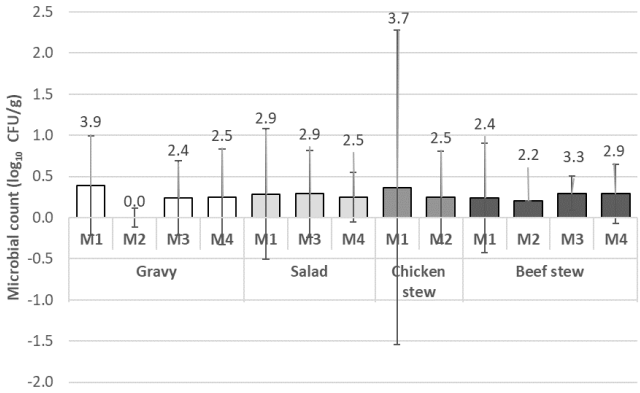

Figure 1. Mean counts (log10 CFU/g) of *S. aureus* isolates in gravy, salad, chicken and beef stews sold at different markets at Thohoyandou. *Staphylococcus aureus* was not found in salad sample sold at market 2, chicken samples at markets 2 and 4.

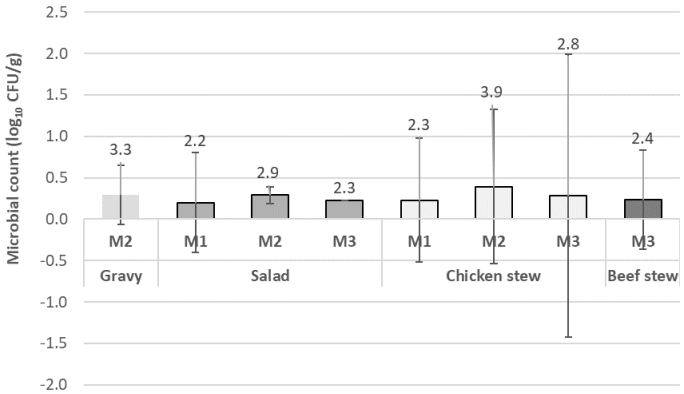

Figure 2. Mean counts (log_{10} CFU/g) of *S. aureus* in gravy, salad, chicken and beef stew sold at different markets at Sibasa. *Staphylococcus aureus* was not found in gravy samples sold at markets 1 and 2; beef stew sample sold at market 1 and 2.

3.6 Bacillus cereus

As indicated in Table 1, *B. cereus* was not present in all food items purchased from Thohoyandou markets. The mean microbial counts (log_{10} CFU/g) for *B. cereus* ranged from 2.0±1.15 to 4.9±21.66 across all the Sibasa markets. The mean counts (log10 CFU/g) for *B. cereus* were the highest in the beef stew (4.9±21.66) followed by gravy (3.9±12.50) and chicken stew (3.8 ±.5.77) sold at market 2. However, *B. cereus* was not isolated in gravy sold at market 1 and salad sold at market 2. Similar results were obtained for beef stews sold at markets 1 and 3 in Sibasa.

3.7 Yeast and mould

Mould was not detected in all food items sold in both Sibasa and Thohoyandou. The mean microbial counts (log_{10} CFU/g) for yeast extended from 2.3±1.73 to too numerous to count across all the markets in Thohoyandou (Table 1). Chicken stew sold at market 4 was found to have the highest mean count (log_{10} CFU/g) of yeast compared to all the other markets ($P<0.05$). The lowest was in salad (2.3±1.73) prepared at market 3. There was no difference in yeast counts in salads sold at markets 2 (2.3±2.00 log_{10} CFU/g) and 3 (2.3±1.73 log_{10} CFU/g). The mean counts (log_{10} CFU/g) for yeast varied from 2.1±1.00 to 3.7±39.58 across all the markets in Sibasa ($P<0.05$). Gravy (3.7±39.58 sold at market 2 was found to have the highest mean count of yeast compared to all the other markets ($P<0.05$). In contrast, there was neither yeast in the gravy sold at market 3 and other Sibasa selling points, nor was there any yeast detected in beef stews prepared at markets 1 and 3.

Table 3. Microbial load comparison of food samples from Thohoyandou and Sibasa locations

		TPC			*Salmonella spp.*			*Staphylococcus aureus*			Yeast		
	Location	n	Mean	P value	n	Mean	P value	n	Mean	P value	n	Mean	P value
Gravy	Thohoyandou	12	99.33	0.49	6	30.33	0.45	10	35.30	0.06	12	53.08	0.09
	Sibasa	9	70.44		9	18.56		6	4.83		6	29.67	
Salad	Thohoyandou	12	97.25	0.01*	9	40.33	0.00*	9	62.00	0.00*	12	36.08	0.00*
	Sibasa	9	24.22		9	3.22		9	9.78		6	3.50	
Chicken	Thohoyandou	12	43.42	0.00*	9	51.56	0.07	10	34.70	0.06	12	114.75	0.17
	Sibasa	9	74.67		9	20.44		9	58.00		6	44.50	
Beef	Thohoyandou	12	69.92	0.06	9	28.11	0.00*	12	29.00	0.34	12	54.75	0.01*
	Sibasa	9	56.33		9	5.67		6	15.5		6	14.00	

*Significant at P<0.05, n = Number, TPC = Total plate count

3.8 Microbial comparison of food samples purchased at Sibasa and Thohoyandou markets

Table 3 presents a comparison of microbial concentrations in foods sampled in Sibasa and Thohoyandou. As shown in Table 3, for TPC, significant differences were observed in salads (P<0.05) and chicken stews (P<0.05). However, no significant differences (P<0.05) were observed in gravy and beef stew samples obtained from both locations. Regarding *Salmonella* spp*.,* significant differences were observed in salad (P<0.05) and beef stew (P<0.05) samples. The results for gravy and chicken stew sample analyses were the same. Significant differences in *S. aureus* were found in salads (P<0.05). Contrasting observations were made for gravy, chicken and beef stew samples collected from both Sibasa and Thohoyandou. For yeast, significant differences (P > 0.05) were observed in salad and beef stew samples. No statistically significant differences existed for gravy and chicken stew collected from selling points in both sites.

4. Discussion

The mean TPC, 2.0±2.08 to TNTC observed in the current study agrees with the findings of studies conducted in Nigeria (Odu and Akano, 2012) and South Africa (Njenje *et al.,* 2012). In South Africa, the Department of Health, South Africa (2000) guidelines for ready-to-eat cooked foods reveal that TPC of $<10^4$ CFU/g, 10^4 to 10^5 CFU/g and $>10^5$ CFU/g signify satisfactory, acceptable and unsatisfactory results, respectively. This implies that the mean counts of gravy, salad, beef and chicken stews obtained in the current study were within the acceptable level (10^5 CFU/g) range and thus, fit for human consumption. Soepranianondo and Wardhana (2019) report similar results (1.62 $\log_{10}$ CFU/g) from their beef sample-based studies in East Java, Indonesia.

The high TPC for some salads and chicken stew sampled from some markets in Sibasa and Thohoyandou is a serious cause for concern. Such foods were not fit for human consumption given that they failed to meet the Department of Health, South Africa's recommended standards of safety. Njenje *et al*. (2012) made similar observations in their study conducted in Eastern Cape in South Africa. In that study, the scholars observed an unsatisfactory mean value (6.8 $\log_{10}$ CFU/g) of aerobic bacterial count in a vegetable salad. High microbial counts of ≥ 6.0 log CFU/g were also reported in a study conducted in Dhaka Metropolis, Bangladesh (Akter *et al.,* 2019).

The evidence of bacterial count in food samples in the above studies indicates that they were contaminated after cooking during handling procedures, thus suggesting overall substandard hygiene practices of food vendors. High TPC in the salad is attributed to its being eaten raw, without heat processing. Differences in TPC among different markets reflect variations in hygiene in the vending environments and practices of the food vendors. Furthermore, it is possible that raw materials in perishable products were contaminated or unsuitable time, temperature and storage conditions were used in the vending sites. The highest counts for Thohoyandou markets may be due to the vendors operating in crowded areas where garbage disposal was poorly managed.

The absence of coliform bacteria in all food samples sold at Thohoyandou markets, beef stew purchased in some markets at Sibasa, gravy and chicken stew sold at one Sibasa market is a reflection of sound hygiene practices and adequate food processing. In this regard, clean water was most likely to be used for washing dishes and cooking food. Mafune *et al*. (2016) conducted studies in South Africa in which none of the street-vended foods samples tested contained coliform bacteria.

Coliform counts for salad, gravy and chicken stews sold at Sibasa markets were higher than the minimum standards of quality that the Department of Health, South Africa (2000) recommends for the fitness of foods for human consumption. Similar observations were made in a study conducted in Bangladesh (Jahan *et al.,* 2018). Taking into account the Akindele *et al.* (2016) contention, the presence of coliform bacteria in food samples suggests there was faecal contamination. In the

current study, food vendors were observed cleaning chicken intestines within the vending stalls. They even handled food without thorough washing of hands. This means that the coliform bacteria emanated from contamination from chicken intestines. Substandard hygiene practices during food handling in the vending sites cannot be ruled out. Pets frequented vending sites and coliforms in meat were likely to be due to animal skin contamination.

The absence of *E. coli* in samples collected at Sibasa markets and the most food items sold at Thohoyandou markets suggested that hygiene practices were effective. However, of concern was the observation that there were foodstuffs with high concentrations of *E. coli* which rendered them unfit for human consumption. The Centre for Food Safety (2014) classifies *E. coli* counts <20, 20 to $\leq 10^2$ and $>10^2$ as satisfactory, borderline and unsatisfactory, respectively. Results obtained in the current study confirm those of Amissah and Owusu (2012) who report high levels ($>10^2$) of *E. coli* in fufu collected from street vendors in Ghana. Kwiri *et al.* (2014) report even higher (8×10^4 CFU/g) counts of *E. coli* in 77% of street-vended soup in Mbare Musika in Harare, Zimbabwe.

In the current study, the results for *E. coli* counts in foodstuffs varied considerably among the vending markets. The Bakobie *et al.* (2017) contention that trading location, street vendor's hygiene regime and environmental conditions in the vending site influence extent of *E. coli* contamination of foods might explain these results. Cross-contamination after cooking often explains the presence of *E. coli* in food. It is also worth noting that the presence of *E. coli* in the food may indicate that faecal contamination was occurring during preparation or from the material used. In support of the preceding argument, street food vendors in the current study were concerned that some people who passed by relieved themselves around the food stalls, especially after trading hrs. Compounding this problem was the fact that food vendors did not have adequate water to wash their hands. Hence, Thulamela Municipality should provide basic infrastructures such as adequate potable water and proper sanitation for the street-vending sector.

It has been observed that some foodstuffs that street vendors sold in both Sibasa and Thohoyandou were contaminated with *Salmonella* spp. and thus unfit for human consumption (Centre for Food Safety, 2014). Available literature confirms that this problem is found elsewhere. For instance, in Tamale Metropolis of Ghana *Salmonella* spp. were found in 63% of soup samples tested and their concentrations were as high as 9.6×10^4 CFU/g (Abakari *et al.,* 2019). *Salmonella* spp. are usually implicated in most foodborne diseases (Hull-Jackson *et al.,* 2019). Even a small number of pathogens in foods have the potential to cause severe illness (Health Protection Agency, 2009; Hull-Jackson *et al.,* 2019). In the current study, the presence of *Salmonella* spp. in foods may have been due to poor hygiene practices and cross-contamination. As reported above, food vendors were observed using the same equipment to serve different types of foods without proper washing in between. Limited water in the vending stalls compelled vendors to wash hands in previously used water after handling raw food and visiting the toilet. Such risky practices predispose food to recontamination with eventual devastating consequences on consumers' health.

The absence of *Salmonella* spp. in gravy samples purchased at Thohoyandou markets, salad, chicken and beef stews agrees with the results of a study conducted in Eastern Cape Province of South Africa (Mazizi *et al.,* 2017). It suggested that food vendors applied good hygiene practices such as thorough washing of hands after visiting toilets and handling non-food materials. Health Protection Agency (2009) also explains the absence of *Salmonella* spp. in foods as confirmation of food vendors managing to control temperature and time during food production and sales, which prevents cross-contamination and its multiplication.

Although the concentration of *S. aureus* detected in foods in the current study fell within the acceptable range ($<10^4$ CFU/g) (Centre for Food Safety, 2014), it was higher than what was observed in the Eastern Cape Province of South Africa (Mazizi *et al.,* 2017). However, it was lower compared to the results of Abakari *et al.* (2019) study in which 83.3 % of soup samples had a high *S. aureus* (9.2×10^4 CFU/g) count. In Bangladesh, Jahan *et al.* (2018) found higher counts ($\geq10^5$ CFU/g) of *S. aureus* in street-vended foods. This is a major concern in public health.

The presence of *S. aureus* in food is a significant warning of a potentially hazardous situation and also an indication of contamination from the skin, mouth or nose of food vendors (Bereda *et al.,* 2016). Inadequately cleaned utensils or raw animal products may also be a source of contamination. Apart from this, it might reveal that there are poor hygiene and temperature control (Naas *et al.,* 2019). In the current study, raw and cooked food were stored together, mainly because storage facilities were inadequate Given that water facilities were inadequate the possibility of food vendors being compelled to wash their hands and cooking utensils in used water cannot be dismissed. Most vendors handled food with their bare hands, in addition to using dirty cloths when cleaning utensils and covering containers.

Stefano and Marina (2018) report that *S. aureus* in foods may secrete toxins that cause poisoning. Street-vended foods are widely consumed, readily available and affordable to most consumers. Thus, the presence of *S. aureus* in food should not be tolerated because of the possibility of widespread food poisoning it can cause.

The microbial counts ($\log_{10}$ CFU/g) of *Bacillus cereus* were within the levels ($<10^5$ CFU/g) that are recommended for foods to be fit for human consumption (Centre for Food Safety, 2014). Similar findings were observed in a study conducted in Nigeria (Oluwafemi *et al.,* 2013). The results level of *B. cereus* was higher when compared to those from Johannesburg, South Africa (Mosupye and von Holy, 2000) and Ethiopia (Nemo *et al.,* 2017). However, they contrasted those from the Himalayas (Kharel *et al.,* 2016) where unacceptable levels ($>10^6$ log CFU/g) of *Bacillus* were found in SV foods. High levels of *B. cereus* suggest poor handling controls. Consumption of such contaminated foods may result in foodborne illnesses (Centre for Food Safety, 2014).

It is worth noting that the presence of *B. cereus* in foods as reported in the current study is possibly confirming the presence of spores in raw materials such as meat, spices, onion and pepper used during processing (Ishaq *et al.,* 2018). Also, poor storage conditions, unsanitary and unhygienic nature of food preparation and service areas may explain the presence of *B. cereus*. Lastly, the isolation of *B. cereus* from prepared foods may mean that its heat-tolerant spores may have survived cooking even though the vegetative form gets eliminated (Nemo *et al.,* 2017).

The yeast count ($\log_{10}$ CFU/g) reported in the current study agrees with what was observed in Benin city, Nigeria where Osakue *et al.* (2016) found the total yeast count in street-vended chicken to be 1.385×10^6 CFU/g to 2.615×10^6 CFU/g. Poor handling of food products, coupled with compromised hygiene and sanitary practices employed in the processing and sales of these foods might explain the presence of yeast in the foods. The presence of yeast in the food is of public health concern because some species such as *Candida* spp., can enter the human body through food and beverages and may cause various types of infections. Therefore, their presence in food should be controlled (Riesute *et al.,* 2021).

5. Conclusion

The findings of this study revealed that some street-vended food samples sold in Thulamela Municipality, South Africa, had a high bacterial load. The results further showed total plate counts, coliform bacteria, *Escherichia coli*, and *Salmonella* spp. counts were above the acceptable limits set by the Department of Health, South Africa (2000) and the Centre for Food Safety (2014). The presence of bacteria in the street-vended food analysed may be attributed to poor hygienic practices, faecal and cross-contamination during food preparation, inadequate food processing, inadequately cleaned utensils, poor storage and temperature control. Therefore, it is recommended that Thulamela Municipality should provide basic infrastructures such as adequate potable water and proper sanitation for the street-vending sector. Also, coverage of food items and prevention of vector breeding near vending stalls should be practised. Furthermore, relevant agencies in public health and food safety must provide training specifically focusing on food preparation, safety, environmental hygiene and waste management. Lastly, there is a need for Environmental Health Practitioners to mount a better system that would monitor selling street-vended foods that are unfit for human consumption.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The work was financially supported by the Research and Publications Committee of the University of Venda [grant number: SARDF/16/IRD/14/2111]. The authors would also like to extend their gratitude to Mr. M. Mutshinyani, Drs. B. Nethathe and S.E. Ramashia in the Department of Food Science and Technology for providing immense support during laboratory work.

References

Abakari, G., Adusei, A. and Cobbina, S.J. (2019). Microbial quality of soups served with "tuo-zaafi" vended in the Central Business District of the Tamale Metropolis. *Journal of Food Industry Microbiology*, 5(1), 1000129. https://doi:10.4172/2572-4134.1000129

Akindele, P.A. and Ibrahim, K.A. (2016). Microbiological analysis of ready-to-eat foods obtained from Bukaterian within the Ekiti State University and Environment Ado-Ekiti, Nigeria. *Journal of Advances in Microbiology*, 1(2), 1-8. https://doi: 10.9734/JAMB/2016/30948

Akter, M., Sultana, S., Munshi, K. and Munshi, S.K. (2019). Microbiological quality assessment of ready-to-eat fried chicken and chicken soup samples sold in Dhaka Metropolis, Bangladesh. *Sumerianz Journal of Biotechnology,* 2(7), 48-54.

Amissah, A. and Owusu, J. (2012). Assessing the

microbial quality of food sold on and around Koforidua Campus in Ghana. *Annals. Food Science and Technology*, 13(1), 60-67.

Amoah, D. (2014). Microbial risk assessment of mixed vegetable salads from selected canteens in the Kumasi metropolis. Ghana: Kwame Nkrumah University of Science and Technology, MSc. Thesis.

Bakobie, N., Addae, A.S., Duwiejuah, A.B., Cobbina, S.J. and Miniyila, S. (2017). Microbial profile of common species and spice blends used in Tamale, Ghana. *International Journal of Food Contamination*, 4, 10. https://doi:10.1186/s40550-017-0055-9

Bereda, T.W., Emerie, Y.M, Reta, M.A. and Asfaw, H.S. (2016). Microbiological safety of street vended foods in Jigjiga city, Eastern Ethiopia. *Ethiopian Journal of Health Sciences*, 26(2), 163-172. https:// doi:10.4314/ejhs.v26i2.10

Center for Food Safety. (2014). Microbiological guidelines for ready-to-eat food in general and specific food items. Retrieved on March 28, 2020 from Website: https://www.cfs.gov.hk/english/ food_leg/files/ food_leg_Microbiologucal_Guidelines_for_Food_e. pdf.

Department of Health, South Africa. (2000). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Republic of South Africa. Retrieved on January 16, 2021 from Website: https:// pdfs.semanticscholar.org/285f/0dbac1fc870a3586a2 2d58220f891af86ca3.pdf

FAO. (2013). Food for the cities: Street foods. Retrieved on February 2, 2021 from Website: http:// www.fao.org/fcit/food-processing/street-foods/en/.

Health Protection Agency. (2009). Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods Placed on the Market. Retrieved on December 12, 2020 from Website: http:// www.hpa.org.uk/webc/ HPAwebFile/ HPAweb_C/1259151921557.

Hull-Jackson, C. and Adesiyun, A.A. (2019). Foodborne disease outbreaks in Barbados (1998–2009): A 12-year review. *Journal of Infection in Developing Countries*, 13, 1–10. https://doi.org/10.3855/ jidc.10404

ISO (International Standard Organisation). (2002). Microbiology of Food and Animal Feeding Stuffs – Horizontal Method for the Detection of *Salmonella* spp., ISO 6579:2002. Geneva, Switzerland: ISO.

ISO (International Standard Organisation). (2004). Microbiology of food and animal feeding stuff-Horizontal method the determination of low number of presumptive *Bacillus cereus*. ISO 7932:2004. Geneva, Switzerland: ISO.

ISO (International Standard Organisation). (2003). Microbiology of food and animal feeding stuff-Horizontal method the determination of low number of presumptive *S. aureus*. ISO 4833. Geneva, Switzerland: ISO.

Ishaq, F., Ocholi, Y. and Ladan, Z. (2018). Isolation, characterization, antibiotic susceptibility and molecular profile of *Enterotoxigenic Bacillus cereus* from fried soya bean cake. *American Journal of Bioscience*, 6(4), 45-51. http://doi: 10.11648/ j.ajbio.20180604.11

Jahan, M., Rahman, M., Rahman, M., Sikder, T., Uson-Lopez, R.A., Selim, A.S., Saito, T. and Kurasaki, M. (2018). Microbiological safety of street-vended foods in Bangladesh. *Journal of Consumer Protection and Food Safety*, 13, 257–269. https:// doi.org/10.1007/s00003-018-1174-9

Kharel, N., Palnib, U. and Tamang, J.P. (2016). Microbiological assessment of ethnic street foods of the Himalayas. *Journal of Ethnic Foods*, 3(3), 235-241. https://doi.org/10.1016/j.jef.2016.01.001

Kubde, S.R., Pattankar, J. and Kokiwar, P.R. (2016). Knowledge and food hygiene practices among food handlers in food establishment. *International Journal of Community Medicine and Public Health*, 3(1), 215-256. https://doi.org/10.18203/2394-6040.ijcmph20151572

Kwiri, R., Winini, C., Tongonya, J. and Muredzi, P. (2014). Microbiological safety of cooked vended foods in an urban informal market: A case study of Mbare Msika, Harare, Zimbabwe. *International Journal of Nutrition and Food Sciences*, 3(3), 216-221. http://doi: 10.11648/j.ijnfs.20140303.24

Liu, Z., Zhang, G. and Zhang, X. (2014). Urban street foods in Shijiazhuang city, China: Current status, safety practices and risk mitigating strategies. *Food Control*, 41, 212-218. https://doi.org/10.1016/ j.foodcont.2014.01.027

Mafune, T.S., Takalani, T.K., Anyasi, T.A. and Ramashia, S.E. (2016). Microbial Safety of street Vended Foods Sold in Thohoyandou, South Africa. *Journal of Human Ecology* 53(3), 205-212. http:// doi:10.1080/09709274.2016.11906973

Mazizi, B.E., Muchenje, V., Makepe, M. and Mutero, G. (2017). Assessment of aerobic plate counts, *Staphylococcus aureus*, *Escherichia coli* and *Salmonella* in meat sold by street vendors in the Eastern Cape Province, South Africa. *Journal of Food and Nutrition Research*, 5(6), 436-442. https://

doi.org/10.12691/jfnr-5-6-11

Mosupye, F.M. and von Holy, A.L. (2000). Microbiological quality and safety of ready-to-eat street-vended foods in Johannesburg, South Africa. *International Journal of Food Microbiology,* 61(2-3), 137-145. https://doi:10.1016/s0168-1605(00)00264-6

Naas, H.T., Edarhoby, R.A., Garbaj, A.M., Azwai, S.M., Abolghait, S.K., Gammoudi, F.T, Moawad, A.A., Barbieri, I. and Eldaghayes, I.M. (2019). Occurrence, characterization, and antibiogram of *Staphylococcus aureus* in meat, meat products, and some seafood from Libyan retail markets. *Veterinary World*, 12(6), 925-931. https://doi:10.14202/vetworld.2019.925-931

Nemo, R., Bacha, K. and Ketema, T. (2017). Microbiological quality and safety of some-street vended foods in Jimma Town, Southwestern Ethiopia. *African Journal of Microbiological Research,* 11(14), 574-588. https://doi.org/10.5897/AJMR2014.7326

Oluwafemi, F. and Semisaye, M.T. (2005). Extent of Microbial Contamination of Sausages Sold in Two Nigerian Cities. Annual Conference of General Meeting. Abeokuta, Nigeria: Microbes Society for Microbiology (MSM), University of Agriculture.

Osakue, O.P., Igene, J.O., Ebabhamiegbebho, P.A. and Evivie, S.E. (2016). Proximate analysis and microbial quality of ready-to-eat fried chicken parts. *Journal of Food Industry Microbiology,* 2(1), 1000107. https://doi:10.4172/2572-4134.1000107

Riesute, R., Salomskiene, J., Moreno, D.S. and Gustiene, S. (2021). Effects of yeast on food quality and safety and possibility of their inhibition. *Trends in Food and Technology*, 108, 1-10. https://doi.org/10.1016/j.tifs.2020.11.022

Soepranianondo, K. and Wardhana, D.K. (2019). Analysis of bacterial contamination and antibiotic residue of beef meat from city slaughterhouses in East Java Province, Indonesia. *Veterinary World*, 12 (2), 243-250. https://doi.org/10.1155/2019/2707064

Stefano, Z. and Marina, B. (2018). Growth of *Staphylococcus aureus* and enterotoxin production in fresh egg pasta. *Journal of Food Processing and Preservation*, 42(9), 37-53. https://doi.org/10.1111/jfpp.13753

Swai, O.A. (2019). Architectural dynamics of street food-vending activities in Dar es Salaam city centre, Tanzania. *Urban Design International*, 24, 129-141. https://doi.org/10.1057/s41289-019-00083-9

Tallarida, R.J. and Murray, R.B. (1987). Duncan Multiple Range Test. In: Manual of Pharmacologic Calculations. New York, USA: Springer. https://doi.org/10.1007/978-1-4612-4974-0_38

von Holy, A. and Makhoane, F.M. (2006). Improving street food vending in South Africa: Achievements and lessons learned. *International Journal of Food Microbiology*, 111(2), 89-92. https://doi: 10.1016/j.ijfoodmicro.2006.06.012

