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Research Journal of Food Science and Nutrition
Volume 9(6), pages 155-162, December 2024
Article Number: C8E7C5F61
ISSN: 2536-7080
https://doi.org/10.31248/RJFSN2024.188
https://integrityresjournals.org/journal/RJFSN

Full Length Research

Comparative evaluation of the bacteriological quality of ready-to-eat soups from local vendors and eateries within Calabar metropolis, Cross River State, Nigeria

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Received 22nd October 2024; Accepted 20th November 2024

ABSTRACT: Bacteriological evaluation of 3 different kinds of soups, 9 from local vendors and 9 from eateries was carried out to comparatively evaluate ready-to-eat soups from local vendors and eateries in the Calabar metropolis, Cross River State, Nigeria in order to assess their safety and potential public health risks. The mean colony count for the freshly analysed sample ranged from 4.7- 9.2×10^7Cfu/mL obtained from local vendors while that obtained from eateries was 1.2-11.0×10^7 Cfu/mL. The frequency of the genera of microorganisms isolated were; *Staphylococcus* sp. (23.7%), *Streptococcus* (20.3%), 8.5% for *Lactobacillus, Corynebacterium* and *Bacillus*, 3.4% for *Micrococcus*, *Arthrobacter*, *Listeria*, *Klebsiella*, *Paenibacillus* and *Yersinia* and 1.7% for *Lactoplantibacillus*, *Clostridium, Seratia*, *Actinomyces, Citrobacter* and *Enterococcus*. Among the identified organisms, gram-positive organisms had a high occurrence rate with 13(76.4%) compared to gram-negative organisms 4(23.5%). There was no significant difference ($p\leq0.05$) in the distribution of isolated organisms across all experimented locations although there was a higher occurrence rate of organisms from local vendors (52%) than from eateries (48%). *Staphylococcus* sp. was the most abundant and present in all soup samples purchased from both local vendors and eateries. The results of the index study report an unacceptable colony count in ready-to-eat food samples according to the Microbiological guidelines for food (2014). The isolated organisms are prominent indicator pathogens of foodborne infection. The results of this study therefore imply that stringent supervision and regular education on food and personal hygiene among food vendors are required to ensure food safety.

Keywords: Bacteriological evaluation, Calabar metropolis, eateries, foodborne infection, food safety, local vendors, ready-to-eat soups, *Staphylococcus* sp.

INTRODUCTION

The handling and quality of ready-to-eat foods along the supply chain is a global concern because contaminants can affect the health of consumers along the chain. Ready-to-eat (RTE) foods are prepared foods sold to consumers for consumption which do not require significant further processing except re-heating or completion of the cooking process (Ma *et al*., 2019). Soups are primarily liquid foods, which are usually savoury, generally served hot and made by combining ingredients such as meat, vegetables, fish and several other condiments. There are numerous types of soups consumed as meals in various parts of the world such as Che soup, Ginataan soup, Shiruko, Tong Sui, fruit soup and Asian soups. In Nigeria, there are different types of soups unique to different tribes and cultures. They include Afang soup, Ewedu, Editan, Egusi soup, Edikan ikong soup, Okra soup and a whole lot of others. Soups are widely consumed as essential meals in the Nigerian culture which can either be accompanied by pounded yam,

Tuwo shinkafa, Eba, Amala, Tuwo masara and Cassava fufu or served as drinking soups without starch accompaniment.

Over the years, food vending has become typical of urban living because many urban dwellers consume food from local vendors and eateries as part of their everyday dining habits. Ready-to-eat foods are preferred by many people because it is quicker and time-saving to get meals from vendors and eateries than to prepare them at home (Al Mamun and Turin, 2016). Local vendors offer lower costs of meals and are easily accessible, thereby enjoying high patronage from consumers. Fast food centers/eateries are also highly patronized especially from the middle class to the high socioeconomic groups. Research has shown that ready-to-eat foods, though a preferred option by many, pose significant public health risks. These foods are often contaminated with high microbial loads due to the poor nature of the ingredients used and the associated hygiene practices of the vendors (Fowoyo and Baba-Ali, 2015). A number of observational studies have also shown that these foods are sometimes held at improper temperatures, handled improperly by food vendors and sold in very dirty environments. Also, foods from these fast-food centers are usually sold from enclosed buildings and there are little or no studies that have analyzed their microbial quality (Addo-Tham et al., 2020).

A report by Lambu *et al.* (2022) presented information on the bacteriological quality assessment of some ready-to-eat food sold in Kust Wudil campus, Kano State. Henry *et al.* (2017) also presented information on the microbiological assessment of some ready-to-eat street foods sold in Calabar and its environs. Existing literature has shown that there is little or no information regarding the microbiological quality of soups prepared and sold by local vendors and major eateries/fast food centres from Calabar south to the Calabar municipality axis. Hence, the present study was undertaken to comparatively evaluate the bacteriological quality of ready-to-eat soups prepared and sold by local vendors and eateries in the Calabar metropolis. Whether these meals meet the acceptable microbiological standards and specifications for foods. This research will be of great benefit to the consumers, health agencies, vendors/eatery managers and the general public.

MATERIALS AND METHODS

Sample collection and preparation

A total of 18 soup samples were purchased from local vendors and eateries from Calabar south and Calabar municipality axis, Cross River State, Nigeria. The soup samples comprised of Afang soup, white soup and melon soup. Three sterile plates of each soup were purchased from three different local vendors and three different eateries respectively making it a total of 9 soup samples from local vendors and 9 samples from eateries. They were properly labelled, packaged separately in sterile containers and transported to the Microbiology Laboratory, University of Cross River State. The soup samples were analyzed 30 minutes after purchase (labelled as fresh soup samples). Furthermore, they were kept at room temperature (25°C) and further analyzed after 24 hours (These samples were considered spoilt as they were analyzed after 24 hours and had a foul odour and flavour). One millilitre of each sample was taken and suspended in 9 mL of distilled water and diluted down to 10^{-10}. 1mL diluent of 10^{-7} and 10^{-8} were pour-plated in already prepared molten semi-solid nutrient (Chaitanya, RDM-NA-01)) and MacConkey (Chaitanya, RDM_MCA-02) agar respectively. After 24 hours, the morphological characteristics of the emergent colonies were observed and documented, the total heterotrophic bacterial count was also carried out. Pure cultures were obtained for further analysis.

Data analysis

The student-independent T-test was used to compare and determine the significant bacterial mean count of different soup samples analyzed after purchase from local vendors and eateries at $p = 0.5$. Microsoft Excel 2013 was used for the pictorial representation of Pie, Bar and Line graphs for better separation and understanding.

RESULTS

Bacterial cell count

The freshly analysed melon soup purchased from local vendors had bacterial cell counts ranging from 1.0 $x10^7$ to 3.5 $x10^7$ Cfu/mL. The colony count from the soup sample kept at room temperature and analyzed after 24 hours ranged from 1.4 $x10^7$ to 10.0 $x10^7$ Cfu/mL. The freshly prepared melon soup obtained from eateries had bacterial cell count ranging from 3.0 $x10^7$ to 5.0 x 10^7 Cfu/mL while the colony count obtained from the spoilt sample ranged from 2.5 $x10^7$ to 8.0 $x10^7$ Cfu/mL.

Freshly analyzed Afang soup obtained from local vendors yielded 2.0 x 10^7 to 3.4 $x10^7$ while room temperature bacterial cell count ranged from 2.0 $x10^7$to 7.7 x 10^7 Cfu/mL. Afang soup from eateries yielded bacterial cell count ranging from 1.0 x 10^7 to 7.7 x 10^7 Cfu/mL for freshly prepared while room temperature colony count was 1.2 $x10^7$ to 11.0 $x10^7$ Cfu/mL.

White soup obtained from local vendors had bacterial cell count for freshly analyzed to be 4.7 $x10^7$ to 9.2$x10^7$ Cfu/mL. The room temperature colony count analyzed after 24 hours yielded 1.1 x 10^7 to 7.0 $x10^7$ Cfu/mL while that obtained from eateries had bacterial cell count ranging from 2.0× 10^7 to 5.0× 10^7 Cfu/mL for the freshly analyzed

Table 1 Mean bacterial cell counts in colony forming unit (Cfu/mL) of the soup samples from eateries/ local vendors and different analyzed conditions.

Paramters	Fresh	Room temperature
MFLV	1.0-3.5 x 10^7	1.4-10.0 x 10^7
MFE	3.0-5.0 x 10^7	2.5-8.0 x 10^7
AFLV	2.0-3.4 x 10^7	2.0-7.7 x 10^7
AFE	1.0-7.7 × 10^7	1.2-11.0 ×10^7
WSFLV	4.7-9.2 × 10^7	1.1-7.0 × 10^7
WSFE	2.0-5.0 x 10^7	3.0-6.0 x 10^7

Keys: MFLV= Melon from local vendors, MFE= Melon from eateries, AFLV = Afang from local vendors, AFE= Afang from eateries. WSFLV=White soup from local vendors, WSFE= White soup from eateries.

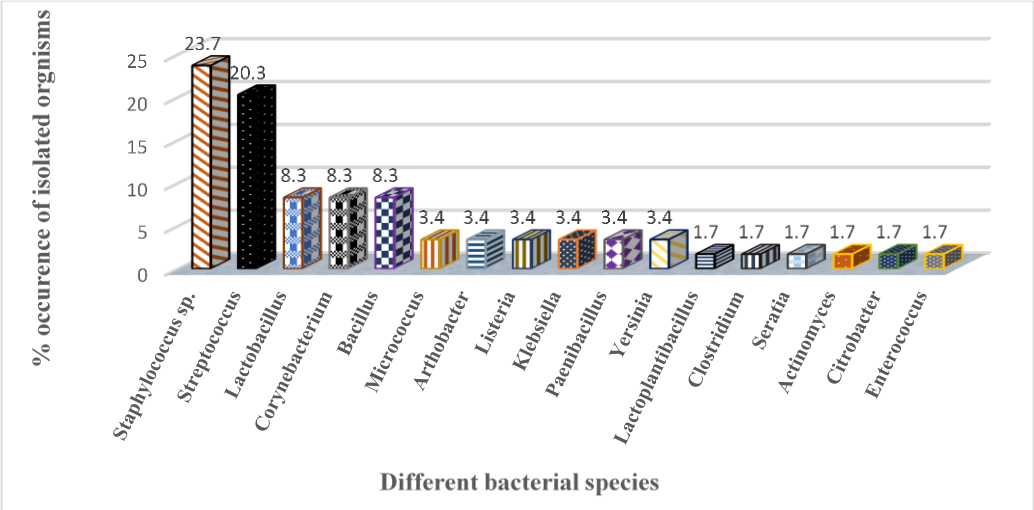

Figure 1. Total number of bacterial isolates from local vendors and eateries and their percentage occurrences.

sample and 3.0×10^7 to 6.0×10^7 Cfu/mL for the sample analyzed after 24 hours (Table 1).

Isolated and Identified organisms

The 17 prominent genera of microorganisms isolated from the soup samples include *Staphylococcus* sp., *Actinomyces* sp., *Listeria* sp., *Corynebacterium* sp., *Streptococcus* sp., *Arthrobacter* sp., *Lactobacillus* sp., *Bacillus* sp., *Clostridium* sp., *Micrococcus* sp., *Lactoplantibacillus* sp., *Klebsiella* sp., *Citrobacter* sp., *Yersinia* sp., *Paenibacillus* sp., *Seratia* sp., *Enterococcus* sp. Their respective frequencies are 23.7% for *Staphylococcus*, 20.3% for *Streptococcus*, 8.5% for *Lactobacillus, Corynebacterium* and *Bacillus*, 3.4% for *Micrococcus*, *Arthrobacter*, *Listeria*, *Klebsiella*, *Paenibacillus* and *Yersinia* and 1.7% for *Lactoplantibacillus*, *Clostridium, Seratia*, *Actinomyces, Citrobacter* and *Enterococcus* (Figure 1).

Distribution of isolates according to analysed conditions and locations

Soup samples from local vendors

The soup samples purchased from local vendors were analyzed fresh immediately after purchase, kept at room temperature for 24 hours and analyzed as spoilt. The Fresh Melon Soup (FMS) had isolates occurring at 3(33.33%) while the spoilt melon soup sample (SMS) kept at room temperature and analyzed after 24 hours had 9(81.81%). Fresh Afang Soup (FAS) and Spoilt Afang Soup samples (SAS) had 3(27.27%) and 8(72.72%) respectively. Fresh White Soup (FWS) had 3(33.33%) while the Spoilt White Soup (SWS) had 6(66.67%) for the soup (Figure 2).

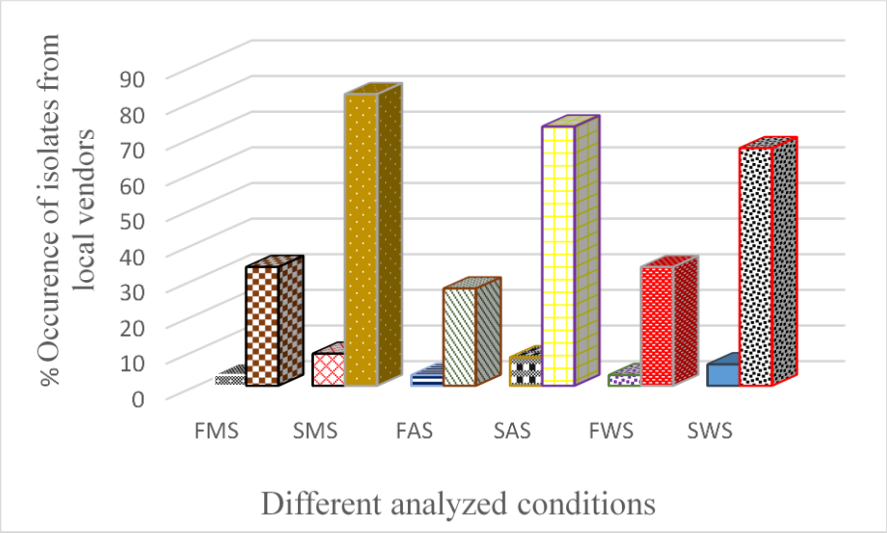

Figure 2. Different analyzed conditions and percentage occurrence of isolates from local vendors. **Legends***:* FMS = Fresh Melon Soup, SMS= Spoilt Melon Soup, FAS= fresh Afang Soup, SAS= Spoilt Afang Soup, FWS = Fresh White Soup, SWS = Spoilt White Soup.

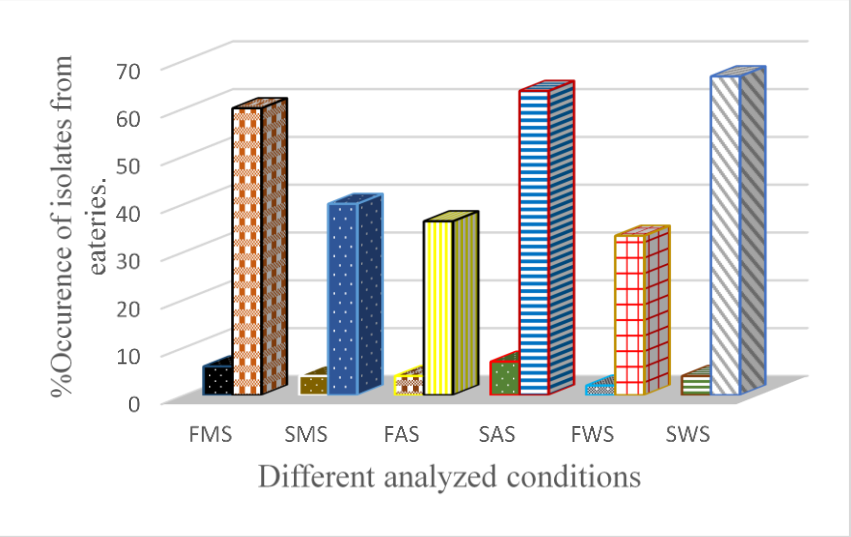

Figure 3. Different analyzed conditions and percentage occurrence of isolates from eateries. **Legends**: FMS = Fresh Melon Soup, SMS= Spoilt Melon Soup, FAS= fresh Afang Soup, SAS= Spoilt Afang Soup, FWS = Fresh White Soup, SWS = Spoilt White Soup.

Soup samples from eateries

The soup samples purchased from eateries were analyzed fresh immediately after purchase, kept at room temperature for 24 hours and analyzed as spoilt. Fresh Melon Soup (FMS) had 6(60%) and 4(40%) isolates for the Spoilt Melon Soup (SMS). Fresh Afang Soup (FAS) purchased from eateries had 4(36.36%) and 7(63.64%) for the Spoilt Afang Soup (SAS) kept at room temperature and analyzed after 24 hours. White soup samples had 2(33.33%) and 4(66.67%) for Fresh White Soup (FWS) and Spoilt White Soup (SWS) respectively (Figure 3).

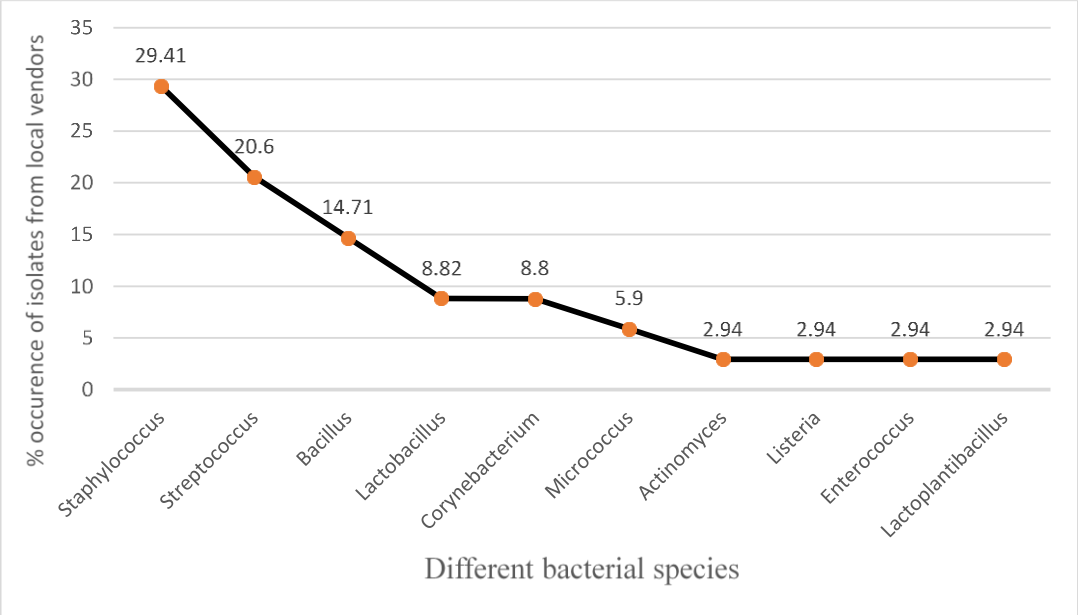

Figure 4. Sum-total of isolated organisms from soup samples purchased from local vendors.

Table 2. Similarities and differences in isolated organisms from local vendors and eateries.

Isolated organisms	Local vendors	Eateries
Staphylococcus sp.	10(29.41%)	4(16.67%)
Streptococcus sp.	1(2.94%)	-
Bacillus sp.	1(2.94%)	1(4.17%)
Lactobacillus sp.	3(8.82%)	2(8.33%)
Corynebacterium sp.	3(8.82%)	2(8.33%)
Micrococcus sp.	2(5.9%)	-
Actinomyces sp.	1(2.94%)	-
Listeria sp.	1(2.94%)	1(4.17%)
Enterococcus sp.	1(2.94%)	-
Lactoplantibacillus	1(2.94%)	-
Arthrobacter sp.	-	2(8.33%)
Klebsiella sp.	-	2(8.33%)
Yersinia sp.	-	2(8.33%)
Paenibacillus sp.	-	2(8.33%)
Clostridium sp.	-	1(4.17%)
Citrobacter sp.	-	1(4.17%)
Serratia sp.	-	1(4.17%)
Total	24(70.59%)	21(87.5%)

Variations in isolated organisms based on experimental locations (local vendors /eateries)

The microorganisms from soup samples purchased from local vendors had *Staphylococcus* sp. as the highest occurring organism with 10(29.41%) followed by *Streptococcus* s p. 7(20.6%), *Bacillus* sp. 5 (14.71%), *Lactobacillus* sp. 3(8.82%), *Corynebacterium* sp. 3(8.8%), *Micrococcus* sp. 2(5.9%), *Actinomyces* sp. 1(2.94), *Listeria* sp. 1(2.94%), *Enterococcus* sp. 1(2.94%), and *Lactoplantibacillus* 1(2.94%) (Figure 4).

From the soup samples purchased from eateries, the microorganisms isolated include *Streptococcus* sp. 5 (20.83), *Staphylococcus* sp. 4(16.67%), *Arthrobacter* sp. 2(8.33), *Corynebacterium* sp. 2(8.33), *Lactobacillus* sp. 2(8.33), *Klebsiella* sp. 2(8.33), *Yersinia* sp. 2(8.33), *Paenibacillus* sp. 2(8.33), *Listeria* sp. 1(4.17), *Citrobacter* sp. 1 (4.17), *Serratia* sp. 1(4.17) (Figure 5).

Furthermore, the results obtained revealed few similarities in isolated organisms from both local vendors and eateries. Meanwhile, the soup samples analyzed from local vendors had a higher number of microorganisms but a lesser occurrence rate but the soup samples analyzed from eateries had a higher occurrence rate of organisms and a lower number of organisms (Table 2).

The study reports that gram-positive organisms had a high occurrence rate with 13(76.4%) compared to gram-negative organisms 4(23.5%) (Figure 6)

A total of 12 microorganisms were isolated from soup samples obtained from local vendors with a percentage occurrence of 52.17%. For the soup samples purchased from eateries, a total of 11 microorganisms were isolated with a percentage occurrence of 47.82% (Figure 7).

DISCUSSION

The comparative evaluation of the bacteriological quality

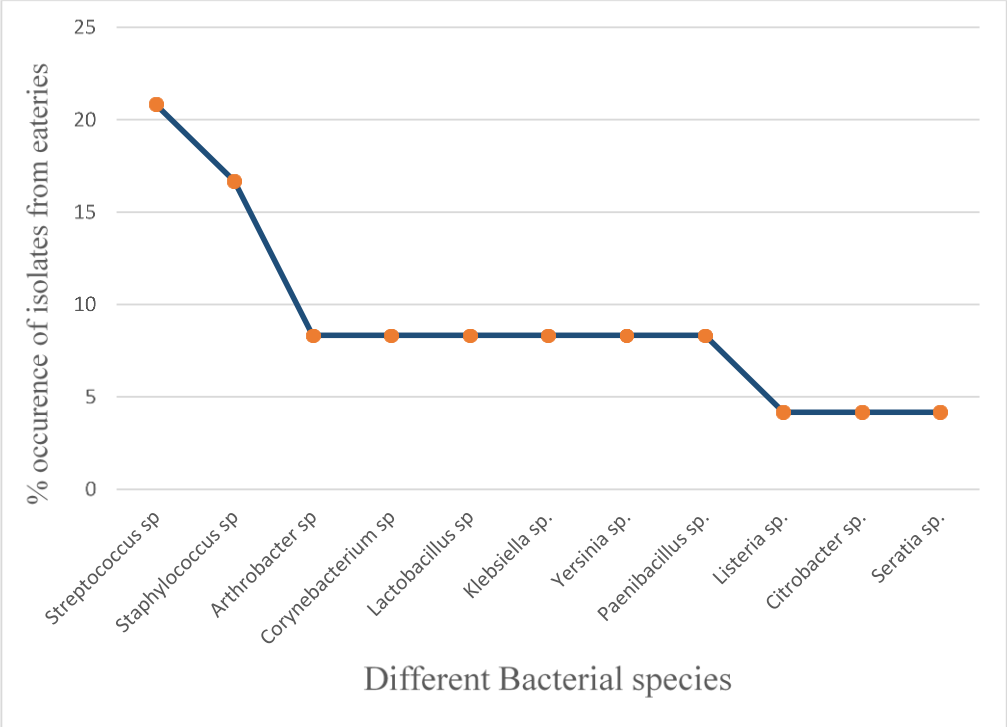

Figure 5. Sum-total of isolated organisms from soup samples purchased from eateries.

Figure 6. Sum-total of isolates based on gram reactions.

of ready-to-eat soups from local vendors and eateries within the Calabar metropolis was carried out to analyze the bacteriological quality of soups at different conditions and compare safety standards of soups from various vendors and eateries in order to identify which sources maintain better hygiene and food safety practices. The cross sum of the mean count for the freshly analyzed soup samples ranged from 1.3×10-9.2×10^7 Cfu/mL and 1.1-11.0×10^7 Cfu/mL for the sample analyzed spoilt after 24 hours. The findings of the bacterial cell count study are strongly worrisome as the colony counts all marginally exceeded the Microbiological Guidelines for Food (2014)

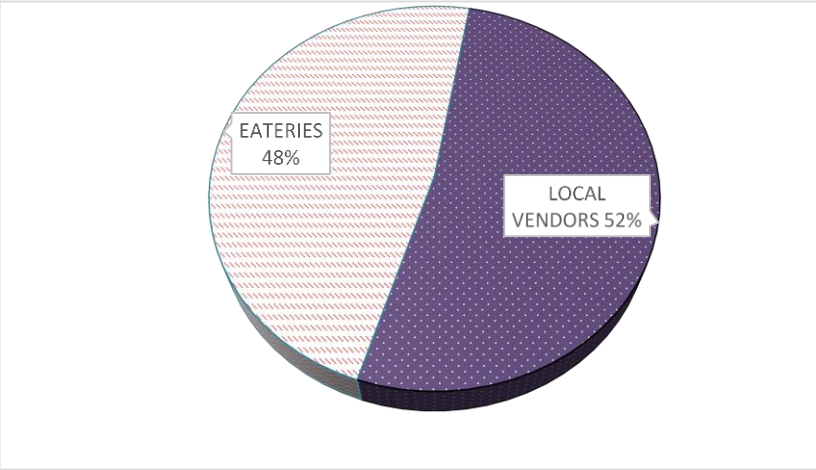

Figure 7. Sum total of isolates obtained from local vendors and eateries.

which stipulates that ready-to-eat foods with plate counts $<10^3$ is satisfactory, between 10^3-$<10^5$ is tolerable and $\geq 10^5$ is unsatisfactory. The aerobic plate count in this study is higher than those reported in similar studies by Henry *et al.* (2017) in an experiment to determine the bacteriological quality of some ready-to-eat food sold in Calabar and its environs but agrees with the findings reported by Ire and Imuh (2016) who also analyzed randomly selected ready-to-eat street foods in Port Harcourt, Nigeria. A total of 17 prominent strains of microorganisms were isolated and identified in the study having *Staphylococcus* sp. as the highest occurring organism with 23.7%, closely followed by *Streptococcus* and other microorganisms highly implicated in food contamination and food spoilage. Some of the prominent genera of microorganisms isolated in this study had correlations with those isolated by Asiegbu *et al*. (2020) in an experiment to determine microbial quality of ready-to-eat street vended food groups sold in the Johannesburg metropolis, South Africa who isolated organisms such as *Staphylococcus* sp., *Listeria* sp., *Bacillus* sp., *Enterococcus* sp. and Ossai (2012) who isolated *Clostridium* spp., *Klebsiella* spp., *Citrobacter* spp., *Staphylococcus* sp., and *Bacillus* sp. in his experiment to determine the bacteriological quality of street vended foods in Delta State. Furthermore, results obtained in this study indicated that for both local vendors and eateries, the spoilt samples had the highest presence of microorganisms. This is an indication that more microorganisms are implicated in food spoilage and are present in spoilt food than in fresh food samples. The results also revealed that *Staphylococcus* sp. was present in high frequencies in all the soup samples purchased from local vendors and eateries. This is similar to the results obtained by Aovare *et al*. (2022) who isolated *Staphylococcus* sp. from all analyzed food samples in Ghana and Ire and Imuh (2016) who also isolated *Staphylococcus* sp from all food samples analyzed in Port Harcourt City. This indicated that commercial ready-to-eat foods are commonly contaminated with *Staphylococcus aureus* which is indicative of potential food poisoning. According to the Centers for Disease Control and Prevention (2016), *Staphylococcus aureus* is very common on the human skin, armpit, nose, throat and groins. The virulent strains can produce toxins (enterotoxins) which can cause food poisoning, after ingestion of the toxins in contaminated food (CDC, 2010). Gram-negative bacteria such as *Klebsiella* sp. was also isolated and this is similar to the results obtained by Oyedeji *et al.* (2023) in Oyo State, Nigeria. The presence of *Bacillus* and *Lactobacillus* in the soup samples purchased from local vendors in quite high amounts can be due to the fact that these genera are psychotrophs, which are ubiquitously distributed in water, soil and the plant and animal environment, thus explaining their prevalence in ready-to-eat foods prepared under inadequate hygiene conditions (Wang *et al.,* 2019). The high incidences of bacterial contamination recorded in this study are mainly due to the unsanitary and largely unhygienic nature of the food preparations and services areas as foods are good indicators of the state of the environment in which they are prepared or served. For the microorganisms isolated from local vendors, the presence of *Staphylococcus aureus*, an organism implicated in food poisoning as the highest occurring organism and several other organisms can indicate faecal contamination of food and water, poor hygiene and poor protection of food from contaminants (Akpoka *et al.,* 2019). Although the total number of microorganisms isolated from local vendors was slightly higher than those obtained from eateries, there was no significant difference ($p \leq 0.05$) in all isolated organisms from eateries and local vendors. Therefore, there is a need for public health regulations and

implementation of food sanitation practices regarding the sale of cooked foods on the street by food vendors and in eateries. Furthermore, to minimize this trend, there should be training and educating the food vendors and eatery owners on safe and good hygiene practices especially hand washing and enforcement of legislation in food handling and processing as well as environmental sanitation.

Conclusion

The research report showed an unsatisfactory bacterial colony mean count for the freshly analyzed soup sample from local vendors and for the sample analyzed spoilt after 24 hours from eateries. The isolated and identified organisms were majorly Gram-positive organisms of medical importance highly implicated in foodborne infections. The results of the study also revealed that the consumption of food after 24 hours without appropriate heating can be unsafe and expose consumers to a high risk of infection from foodborne pathogens. However, the presence of these pathogens in ready-to-eat foods can pose a serious public health hazard to unsuspecting consumers as most of these bacterial pathogens have been implicated in food-borne illnesses and diarrheal diseases. Hence, to handle bacterial outbreaks from soup samples, affected individuals should be treated, and the source of infection should be investigated. Also, relevant agencies in public health and food safety should create awareness of food safety and hygiene for all food vendors especially compliance with hazard analysis and critical control points principles (HACCP) during the preparation, packaging and serving of these foods to consumers.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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