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Bacteriological Evaluation of Food Contact Surfaces of Food Canteens at the University of Abuja, FCT Nigeria

Bridget Maria Jessica Adah[1*], Samuel Mailafia[1], Agbo James Ameh[1], Hamza Olatunde Kazeem Olabode[1], Martha Echioda-Ogbole[1], Mercy Oluwaseun Aiyedero[1], Fatima Oyenike Oyelowo-Abdulraheem[2], Olamide Tawa Owolabi[3], Rabi Rebecca Mairabo[4], Casmir Ifeanyichukwu Cajetan Ifeanyi[5], Odey Ebenezer Odey[1]

[1]Department of Veterinary Microbiology, Faculty of Veterinary Medicine, University of Abuja, Abuja, Nigeria
[2]Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Abuja, Abuja, Nigeria
[3]Department of Animal Health and Production Technology, Rufus Giwa Polytechnic, Owo, Nigeria
[4]Department of Veterinary Microbiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria
[5]Department of Medical Laboratory Science, Faculty of Allied Health Science, University of Abuja, Abuja, Nigeria
Email: *bridget.adah@uniabuja.edu.ng

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Abstract

The contamination of food by pathogens occurs in canteens, restaurants, fast-food services and cafeterias as a result of failure to observe proper sanitation, improper cooling of foods, cross-contamination and long interval between preparation and consumption, a large number of people over a wide area might be affected. This research study reports the bacteriological evaluation of food contact surfaces of food canteens in Mini and Main campus, Gwagwalada, University of Abuja. A total of 390 samples were collected from 43 canteens for this study. Bacterial isolation was done using Nutrient Agar, Mannitol Salt Agar, Eosin Methylene Blue (EMB), and Mackonkey Agar, using the streak inoculation method and all the cultural morphology of the colonies was observed and recorded. The total number of growth observed on Eosin methylene blue was 85. 20 were from plates, 15 were from refrigerator handle (B) and 50 were from table tops (C). The total growth observed from Macconkey was 266. 102 were from plates, 65 were from refrigerator handle (B) and 99 were from table tops (C). The growth observed on mannitol salt agar was 37 from which 15 were from plates (A), 5 were from refrigerator handle (B) and 17 were from table tops (C). The growth observed on nutrient agar was 381 from which 129 were from plates (A), 82 were from refrigerator handles (B) and 170 were from table tops (C). The total number of isolates recovered from this research was 116 isolates. The percentage prevalence of bacteria isolates from this study, as determined by biochemical characterization, is *Staphylococcus* 30 (7.7%), *Streptococcus* 15 (3.8%),

Bacillus 27 (6.9%), *Klebsiella* 10 (2.6%), *Escherichia coli* 41 (10.5%) and *Proteus* 8 (2.1%) from both campuses. A chi-square test of independence showed no significant association between campus location and bacterial isolate distribution, $\chi^2(5) = 4.68$, $p = 0.46$. This study established that unhygienic food handling predisposes food consumers to various pathogens, which are harmful and therefore necessitates the need for improved hygienic practices.

Keywords

Hygiene, Contamination, Bacteriological, Vended Food, Food Pathogens

1. Introduction

A vital instrument for consistently satisfying the body's needs is food [1]. Since raising food safety and hygiene standards can help stop the spread of food-borne illnesses, everyone should be concerned about it. Any material intended for human consumption that is either raw, semi-processed, or processed is considered food, according to the World Health Organization (WHO) [2].

Musa *et al.* [3] adopt a similar perspective when defining food as any material that individuals prepare and consume in order to meet their physiological demands. Additionally, food is defined as any liquid or solid substance that can nourish the body when consumed and digested [4].

From the aforementioned criteria, it can be concluded that food includes any consumed item that can meet a person's nutritional needs and must be wholesome and secure. This is due to the fact that adequate and healthy food supports wellbeing, but subpar and tainted food components pose a risk to human health [5].

According to Rahman *et al.* [6], food adulteration is a serious public health issue that has an impact on people's quality of life, particularly community children. In poor nations, like Nigeria, food-borne illnesses are important sources of morbidity and mortality and pose serious health risks. According to War *et al.* [7], microorganisms like the *Norwalk* virus, *Campylobacter jejuni*, and *Salmonella* species are the main causes of outbreaks of food-borne illness. As an illustration, a microbiological evaluation of a variety of food products supplied by canteens in different regions of India revealed the presence of microorganisms [8].

Many urban residents, including construction workers, laborers, street people, market vendors, students, and local residents, rely on food vending for crucial services. Here, the term "food adulteration" refers to the mixing of food by canteens with other chemicals that could be detrimental to human consumption [9]. Food vending is a growing trend, probably as a result of several important functions it performs, such as offering rapid and affordable food services to the public and generating employment chances for women [10]. While acknowledging the crucial function that canteens play in the lives of city inhabitants, Bankal and Ray [11] point out that the lack of food hygiene measures on the part of the vendors makes these

foods potentially dangerous for people's health.

Canteens are small-scale business owners that typically operate out of stalls or facilities that are simply set up in public areas to serve the needs of the general public quickly and affordably [12]. Both urban and rural communities have canteens that are open to the public. They either set up shop next to the communities or conduct business under a nearby tree. They offer a variety of foods, including rice, beans, okpa, agidi, ice cream, and snacks. Customers of such items are more concerned with convenience than with cleanliness and safety [13] [14].

Hygiene is a science that is concerned with the members of an organization's or group's environmental cleanliness in order to preserve healthy living. In this study, hygiene is defined as any actions taken to ensure a healthy environment and ward off disease or other health risks. Thus, maintaining one's environment to prevent illness and sickness is a necessary part of hygiene for a healthy lifestyle in society [15].

Hygiene refers to the actions taken to uphold health and stop the spread of disease. Unhygienic behaviors have been found to expose people to intoxications and infections that include clinical symptoms such as vomiting, retching, dehydration, abdominal cramps, diarrhea, and other environmental health concerns [16].

The quality of food consumed is thought to have a significant impact on the state of society's health, hence institutional catering is receiving more attention. Nowadays, it is common for employees and students to have their primary meals away from their houses and do [10].

2. Statement of Problems

Food is a fundamental requirement for human survival and well-being, and its safety is therefore a major public health concern [1]. The World Health Organization defines food as any substance intended for human consumption, whether raw, semi-processed, or processed [2], while other scholars similarly describe it as any material consumed to meet physiological and nutritional needs [3] [4]. Despite its essential role in sustaining health, contaminated or poor-quality food poses serious risks, as unsafe food components can lead to disease and threaten overall well-being [5].

Food adulteration and microbial contamination remain significant global health challenges, particularly in developing countries such as Nigeria, where food-borne illnesses contribute substantially to morbidity and mortality [6]. Pathogens, including *Norwalk* virus, *Campylobacter jejuni*, and *Salmonella* species, have been identified as major causes of outbreaks [7], and studies of canteen foods in various regions have revealed the presence of harmful microorganisms [8]. These findings raise concerns about the microbiological safety of foods sold to the public.

The rapid growth of food vending services, driven by urbanization and demand for affordable and convenient meals, has increased public reliance on canteens for daily nutrition [10]. Although these establishments provide essential services and employment opportunities, inadequate hygiene practices among vendors may ren-

der such foods unsafe for consumption [11]. Many customers prioritize convenience over cleanliness and safety, thereby increasing their vulnerability to food-borne infections [13] [14]. Poor hygiene practices are known to expose individuals to illnesses characterized by symptoms such as vomiting, diarrhea, dehydration, and abdominal cramps [16].

Given the rising dependence on institutional and street-vended foods and the documented risks associated with inadequate food hygiene, there is a clear need to assess the sanitary conditions, handling practices, and microbial safety of foods sold in canteens. Without systematic evaluation and intervention, contaminated food from these sources may continue to pose serious health hazards to consumers, especially students and workers who frequently rely on such meals.

3. Materials and Methods

3.1. Study Area

The sampling was carried out from the main and mini campuses of the University of Abuja, Gwagwalada, in the Federal Capital Territory (FCT), Abuja. Abuja shares boundary with Kogi, Kaduna, Niger and Nassarawa and is made up of six area councils which include: Abuja municipal area council, Gwagwalada Area council, Kuje Area council, Kwali Area council, Bwari Area council and Abaji Area council and Abuja municipal area council, as shown in **Figure 1** below [17].

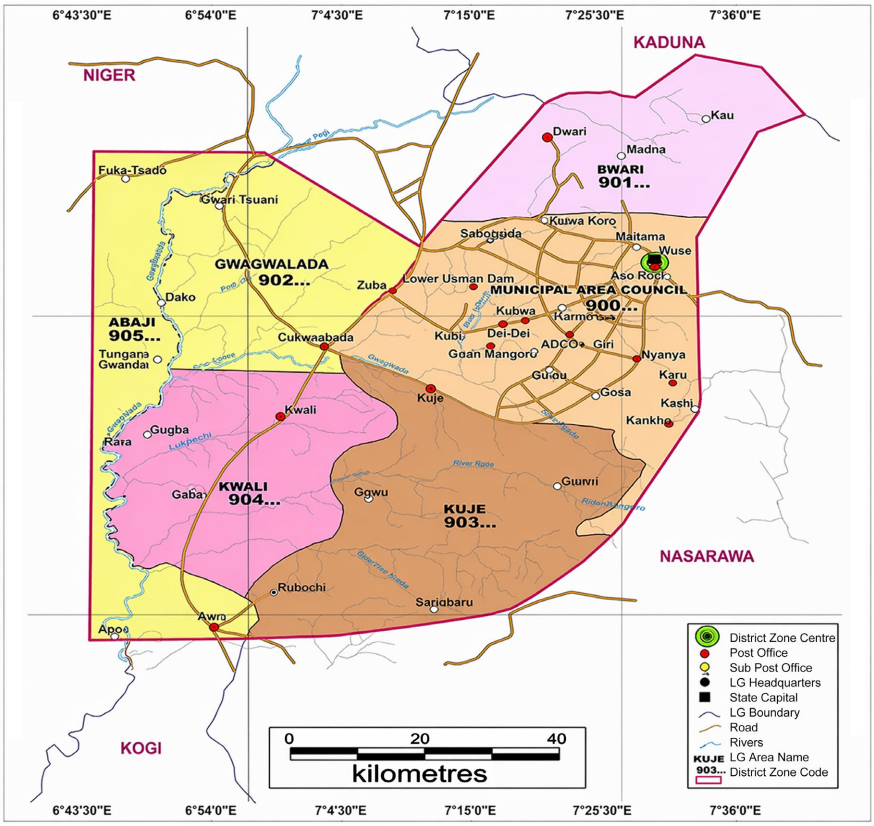

Figure 1. Map of Abuja showing the 6 area councils. Source: Odey *et al.* [17].

3.2. Study Design

This study is a cross-sectional study of the 43 canteens in the University of Abuja main and mini campuses using simple random sampling technique.

3.3. Sample Collection

The surface was sampled by swabbing a 10 cm × 10 cm area with sterile cotton swabs pre-moistened in peptone water. The area was rubbed horizontally, vertically, and diagonally while rotating the swab tip. Each swab was then placed into a 10 mL diluent tube, broken, capped, labeled, and transported chilled within two hours for analysis [18]. Three hundred and ninety (390) samples from table tops, plates and refrigerator handle were collected using commercial sterile swab sticks from 43 canteens/maishai stalls in Mini campus and Main campus at University of Abuja with 117 samples gotten from mini campus at different locations (Mini campus gate, boys' hostel, girls' hostel) and 273 samples from Main campus (Convocation ground, market, hotels, faculties) respectively for 4 consecutive weeks. During the process of collection, the sterile swab stick was used to swab the table surfaces, plates and refrigerator handle and it was transported pack on ice to the Microbiology laboratory of the Department of Veterinary Microbiology, University of Abuja for processing and bacteriological analysis.

3.4. Sample Size Determination

Sample size was determined using the formula ($N = Z^2pq/d^2$) as described by Thrusfield [19], using 50% prevalence, 384 was obtained but increased to 390 to increase precision.

3.5. Laboratory Analysis

Cultural Isolation and Microscopic Identification

The following media: Nutrient Agar (Oxoid, UK), Eosin Methylene Blue (EMB) (Oxoid, UK), MacConkey (Oxoid, UK), and Mannitol Salt Agar (MSA) (Oxoid, UK) were used for isolation of the bacterial organisms and all media were prepared following the manufacturer's instructions. All culture media were inoculated using the streak method and incubated at 37˚C for 18 to 24 hours for observation of colonial morphology. The resultant colonies were stained using Gram's technique and viewed under the microscope at 100× under oil immersion objective lens for identification of the isolates.

Characterization of the Isolates

Characterization of the isolates was carried out based on Colonial Morphology, Gram's Staining Technique and by the use of Conventional Biochemical Characterization Method as described by Odey *et al.* [17].

3.6. Statistical Analysis

The data obtained from this study were analyzed using Statistical Package for Social Science (SPSS) version 21.0 and the results obtained were presented in tables and

charts and percentages. Chi-square test was carried out using a p-value of 0.05.

4. Main Results

Table 1 shows the following biochemical tests carried out to aid characterization of the isolates: Catalase test, Oxidase test, Indole test, VP/MR, Urease test, Motility test, Citrate test, and Hydrogen Sulphide production (H_2S). Some of the results of the biochemical characterization reactions from this study are shown below in Plates 1-5 in **Appendix**.

Table 1. Biochemical characterization.

S/N	Biochemical reaction	Organisms					
		Staphylococcus spp.	*Streptococcus* spp.	*E. coli*	*Bacillus* spp.	*Proteus* spp.	*Klebsiella* spp.
1	Gram reaction	+	+	−	+	−	−
2	Catalase	+	−	+	+	+	+
3	Oxidase	−	−	−	Variable	−	−
4	Indole production	−	−	+	−	−	−
6	VP	+	−	−	+	−	+
7	MR	+	+	+	−	+	−
8	Urease	+	−	−	−	+	+
9	Motility	−	−	+	+	+	−
10	Citrate	+	+	−	+	+	+
12	Shape	Cocci	Cocci	Rod	Rod	Rod	Rod
13	Gas	−	−	+	−	+	+
14	H_2S	−	+	−	−	+	−

Key: VP: Vogues Proskauer; MR: Methyl Red; +: Positive, −: Negative.

Table 2 shows the various sources of samples and their location. A total of 390 samples were collected from both the main and mini campus. Table (C) had the highest number of samples, which was 179. Plate (A) was 129 while Refrigerator handle (B) was 82. The number of samples from plates in main campus was 93 while in mini campus was 36. Samples gotten from refrigerator handle (B) in main campus were 70 while in mini campus, they were 12. There were 107 samples from table tops (C), which were gotten from main campus and 72 from mini campus.

Table 2. Samples collected and location.

S/N	Source	Main campus	Mini campus	Total
1.0	Plate (A)	93	36	129
2.0	Refrigerator handle (B)	70	12	82
3.0	Table top (C)	107	72	179
4.0	**Total**	**270**	**120**	**390**

Table 3 shows the total number of growth observed on Eosin methylene blue was 85; 20 were from plates (A), 15 from refrigerator handle (B) and 50 from table tops (C). The total growth observed from Macconkey was 266. 102 were from plates, 65 were from refrigerator handle (B) and 99 were from table tops (C). The growth observed on manitol salt agar was 37 from which 15 were from plates (A), 5 from refrigerator handle (B) and 17 from table tops (C). Lastly, the growth observed on nutrient agar was 381 from which 129 were from plates (A), 82 were from refrigerator handles (B) and 170 were from table tops (C).

Table 3. Percentage growth of microorganisms on different media.

Source \ Media	Eosin Methylene blue	MacConckey	Mannitol salt agar	Nutrient agar
Plates (A)	20	102	15	129
Refrigerator handle (B)	15	65	5	82
Table top (C)	50	99	17	170
Total	**85**	**266**	**37**	**381**

From Table 4, it is observed that *Staphylococcus* species and *Streptococcus* species were present in plates (A), refrigerator handle (B) and table tops (C). *Bacillus* specie was present in refrigerator handle and table top (C) but absent in plates (A). *Klebsiella* specie was present in plates but absent in refrigerator handle (B) and table tops (C).

Table 4. Distribution of microorganisms from restaurants in University of Abuja main and mini campus.

Bacteria	Plates	Refrigerator handle	Table top
Staphylococcus spp.	+	+	+
Streptococcus spp.	+	+	+
Escherichia coli	+	+	+
Bacillus spp.	−	+	+
Proteus spp.	−	+	−
Klebsiella spp.	+	−	−

Key: +: present; −: Not present.

Table 5 shows the frequency of occurrence of isolates for the period of sampling in University of Abuja (main and mini campus). The result showed that *E. coli* was the highest, being 41, representing 10.5% of the isolate followed by *Staphylococcus* spp., which was 30, representing 7.7% of the isolates *Bacillus* spp. was 27, representing 6.9%, *Streptococcus* spp. 15 (3.8%). These was followed by *Klebsiella*, which was 10, representing 2.6 and. The organism with the lowest isolation frequency was *Proteus* spp., which was 8, representing 2.1%.

Table 5. Bacterial isolates and their percentage prevalence.

Bacterial isolate	Frequency	A	B	C	Percentage prevalence (%)
Staphylococcus spp.	**30**	**7**	**8**	**15**	**7.7**
Streptococcus spp.	**15**	**4**	**6**	**5**	**3.8**
E. coli	**41**	**10**	**22**	**9**	**10.5**
Bacillus spp.	**27**	**8**	**7**	**12**	**6.9**
Proteus spp.	**8**	**3**	**2**	**3**	**2.1**
Klebsiella spp.	**10**	**5**	**3**	**2**	**2.6**

Table 6 shows the bacterial isolates and their percentage frequency in main campus. The table reveals that the highest organism isolated from main campus were *E. coli* and *Staphylococcus* spp., which represented 5.4% each. This was followed by *Bacillus* spp., which was 15, representing 3.8%. *Klebsiella* was 7, representing 1.8%, *Streptococcus* spp. was 8, representing 2.1%. The organism with the lowest frequency of isolation was *Proteus* spp., which was 3, representing 0.8%.

Table 6. Bacterial isolates and their percentage prevalence in main campus.

Bacterial isolate	Frequency	A	B	C	Percentage prevalence (%)
Staphylococcus species	21	5	7	9	5.4
Streptococcus species	8	4	3	1	2.1
E. coli	21	9	8	4	5.4
Bacillus species	15	6	4	5	3.8
Proteus species	3	1	0	2	0.8
Klebsiella species	7	2	2	3	1.8

Table 7 shows the bacterial isolates and their frequency of isolation isolated in mini campus. The result showed that the organism with the highest frequency of isolation was *E. coli*, which was 20, representing 5.1% of the isolates. This was followed by *Bacillus* spp., which was 12, representing 3.0% of the isolates. *Staphylococcus* spp. and *Streptococcus* spp. were 9 and 7, representing 2.3% and 1.8%, respectively. *Proteus* spp. was 5, representing 1.3%. The organism with the lowest isolation frequency was *Klebsiella*, which was 3, representing 0.8% of the isolates.

Table 7. Bacterial isolates and their percentage prevalence in mini campus.

Bacterial isolate	Frequency	A	B	C	Percentage prevalence (%)
Staphylococcus species	9	4	2	3	2.3

Continued

Streptococcus species	7	2	2	3	1.8
E. coli	20	9	6	5	5.1
Bacillus species	12	5	3	4	3.0
Proteus species	5	2	0	3	1.3
Klebsiella species	3	2	1	0	0.8

Remark: The World Health Organization (WHO) has long been aware of the need to educate food handlers about their responsibilities for food safety [15]. In the early 1990s, WHO developed the Ten Golden Rules for Safe Food Preparation and introduced the Five Keys to Safer Food in 2001. Recognizing the importance of safe food in human and animal health is a key objective of ensuring safety of food from farm to plate [20].

Food hygiene is an essential matter of public health for protecting or preventing diseases caused by unsafe food due to lack of good quality from production to consumption [20]. There are thousands of different types of microorganisms everywhere in air, soil, and water, and consequently on foods, and in the digestive tract of animals and human. This study was aimed at ascertaining the hygienic condition of food canteens at the University of Abuja.

This study isolated and biochemically characterized 6 bacteria species namely *Staphylococcus*, *streptococcus*, *Escherichia coli*, *Bacillus*, *Proteus* and *Klebsiella* species as shown in **Table 1** and **Table 4**, from food contact surfaces sampled from various food canteens in the mini and main campuses of the University of Abuja, in the Federal Capital Territory, Nigeria, hence indicating the possible presence of pathogenic bacteria organisms on food contact surfaces of canteens and this finding is also in line with the report of Mahammed *et al.* (2022) [21], who reported the occurrence of harmful bacteria organisms from multiple food contact surface areas in cafeterias, and the presence of these organisms on food contact surfaces serves as a major source of infection to humans and hence of great public health significance worldwide.

The prevalence of microorganism was 33.1%. The prevalence of *Staphylococcus* spp. was 7.7%, *Streptococcus* spp. was 3.8%, *E. coli* was 10.5%, *Bacillus* spp. was 6.4%, *Proteus* spp. was 2.1% and *Klebsiella* spp. was 2.6%, as shown in **Tables 5-7**. All prevalences obtained in this present study were lower than the 31.1% for *Staphylococcus* species, 13.8% for *E coli*, 6.9% for *Bacillus* species, 6.9% for *Proteus* species and 20.7% for *Klebsiella* species reported by Mahammed *et al.* [21] from food contact surfaces of selected cafeterias in Ahmadu Bello University, Zaria, Kaduna state. The differences in prevalence obtained were attributed to the differences in sample location and sample size, as the previous study took samples from 9 different food contact surfaces like spoons, plates, forks, chopping board, work tops, tables, hands, washing water and plate rinsing water [21].

From the present study, *E. coli* had the highest prevalence in the study, which

might be as a result of high level of faecal contamination, which is in line with the report of Agbo *et al.* [22]. The prevalence of microorganisms in main campus was 18.7% with *E. coli* having the highest prevalence of 5.4% while the lowest prevalence was 0.8% from *Proteus* spp. The prevalence of microorganisms as shown in **Table 4**, in mini campus was 14.1% were *E. coli* had the highest prevalence of 5.1% and *Klebsiella* had the lowest prevalence of 0.8%, as shown in **Table 6** and **Table 7**, which is also in line with the report of Ameh *et al.* [23].

Staphylococcus reported might have originated mainly from human skin, hands, nasal passages, or wounds, and could be transferred through handling or contaminated utensils. *Klebsiella* spreads via dirty hands, water, food, soil, or unclean equipment. *E. coli* contamination is linked to fecal sources such as unwashed hands, raw foods, contaminated water, or cross-contaminated surfaces [24]. *Bacillus* is identified as an environmental contaminant entering through dust, soil, air, raw ingredients, or poorly stored foods. *Proteus* is associated with fecal matter, sewage, contaminated water, and poor hygiene during preparation [25]. *Streptococcus* reported might have spread through respiratory droplets, saliva, coughing, sneezing, talking over food, or contact with unclean hands [26].

The media used for the isolation of organism were Eosin Methylene Blue, MacConkey, Manitol salt agar and Nutrient agar. Nutrient agar had the highest number of growth 381, as shown in **Table 3**, because it is a non-selective medium which allows the growth of all organisms while Manitol Salt Agar had the lowest number of growth because it is a selective medium [21].

The presence of *Staphylococcus* spp., *Streptococcus* spp., and *E. coli* on plates, the refrigerator handle, and the table top as shown in **Table 2**, is indicative of fecal contamination [24] while *Klebsiella* and *Proteus* were not found on tabletops, *Bacillus* and *Proteus* were found on plates. Because these surfaces are contacted at varying rates and frequencies, the aforementioned pattern is the result.

Due to a lack of awareness about the effects of pollutants on people, cafeteria managers and employees have been unable to maintain adequate cleanliness to stop the potential spread of harmful organisms to students and personnel at the school and *Previous* studies have also noted this pattern, with a preponderance of female food vendors [3] [27]-[31] within the ages of 20 - 40 years old [3] [27]; and have either a secondary or tertiary level of education [6] [32]. On the contrary, some studies have observed that food vendors were predominantly male [33] with no education or primary education as the highest level of education attained [29] [31] [33].

A chi-square test of independence showed no significant association between campus location and bacterial isolate distribution, $\chi^2(5) = 4.68$, $p = 0.46$. This means that there is no statistically significant difference in bacterial isolate distribution between Main Campus and Mini Campus. The differences observed are statistically non-significant and likely due to sampling variation.

The results of this study have shown that certain bacteriologic agents of intoxication are prevalent, it is imperative that strategies be put in place to manage food

vending services in the university's public health. Additionally, the quality control analysis of food vending services in the school environment should include the need to deliver vending services in a sanitary and safe manner.

5. Conclusions and Suggestions

This study has shown the possibility of isolating and biochemically characterizing harmful bacteriological organisms with a prevalence of 7.7% for *Staphylococcus* specie, *Streptococcus* specie was 3.8%, *E. coli* was 10.5%, *Bacillus* spp. was 6.4%, *Proteus* spp. was 2.1% and *Klebsiella* spp. was 2.6%.

It is essential to continuously promote cleanliness messaging in the workplace if desired food handling behaviors are to be maintained. Enhancing food hygiene practices can also be achieved by establishing a social and physical environment that promotes the use of appropriate food handling techniques.

Training activities that are directly tied to such an environment would be more suited than food hygiene courses, which are taught in settings unrelated to the sector and strictly use knowledge-based assessment methods. In the interest of public health, planned, effective, integrated, and preventive measures for regulating food vendors, both stationary and mobile, should be developed, given that the majority of the microbial agents isolated from this investigation are zoonotic and pathogenic.

Regular personal and environmental cleanliness examinations, initial and continuing medical certification, formal hygienic practices training, and seller enrollment should all be prioritized in these measures. Assuming that knowledge by itself does not lead to advances in food handling practices, trustworthy methods for evaluating work sites should also be developed. Having reliable baseline data will be necessary in order to conduct comparisons.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Plate 1. TSI reaction of organisms.

Plate 2. Citrate utilization of orgaisms.

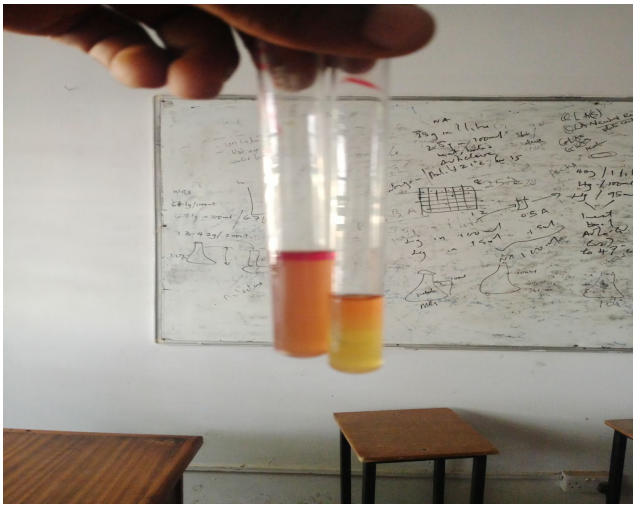

Plate 3. Indole ring test.

Plate 4. Growth of *E. coli* on EMB.

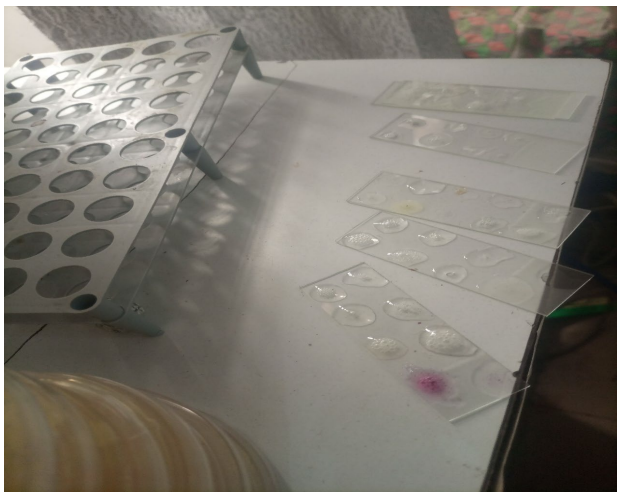

Plate 5. Catalase test of organisms.