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(Research Article)

The prevalence of pathogenic *E coli* in food sold at government primary schools in Kombo central district, the Gambia using biochemical tests

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Abstract

Background: Recently, pathogenic bacteria have evolved that can contaminate food and, when consumed by people, frequently result in life-threatening illnesses. The study aimed to detect and determine the prevalence of pathogenic *E coli* in food sold at government primary schools in the Kombo Central district using biochemical tests.

Methods: This was a cross-sectional study in which 104 food samples were collected using the aseptic method and laboratory analysis was done to determine the prevalence of pathogenic *E. coli* using the biochemical method.

Results: Out of the 104 analyzed food samples, 92.3% of food samples had microbial contamination, 43.3% of food samples had extremely high microbial count (≥ 10^7 cfu/g), and all food types showed microbial contamination with no significant difference. *E. coli* was detected in 34 samples (32.7 %). The "Gorong" soup sample type had the highest percentage of *E. coli* contamination (75 %), followed by the steamed fish food sample type (50 %). Ice (local beverage) had the least *E. coli* contamination (15.8 %). Of the 34 isolated *E. coli*, 73.5 % were found to be pathogenic and biofilm-producing while 26.5 % were non-pathogenic and non-biofilm-producing *E. coli.* Percentage wise "gorong" soup has the highest prevalence (75.0%) of pathogenic *E. coli* followed by steamed fish sauce (44.4%), Cake (33.3%), and Puff-puff 33%.

Conclusion: There was a considerably high prevalence of pathogenic *E. coli* therefore all food vendors should be trained/educated and certified on food hygiene and safety practices before he/she starts operating as food vendors to reduce this microbial contamination.

Keywords: Prevalence; Pathogenic *E. coli*; Food; Biochemical test; Government primary schools

1. Introduction

Microbiologically contaminated street food is considered a global problem, which is liable to be a significant contributor to the transmission of foodborne health risks (1). The presence of microorganisms in food is natural and is hard to avoid entry, but by cooking or heating to some extent it can be destroyed. The presence of microorganisms hazardous to human health is considered a health threat. In case of uncooked, processed ready to eat and partially cooked food can have pathogenic microorganisms which are a serious health risk (1). However, among infections caused by microorganisms' bacterial infection is one of the most important factors causing morbidity and mortality. The indicator organisms commonly associated with hygiene practices include, among others, total viable counts, total coliforms, *E. coli*, members of the family Enterobacteriaceae, and Staphylococcus aureus. The detection of coliforms is widely used

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as a means of measuring the effectiveness of sanitation programs and their presence could indicate a substantially increased risk of the presence of pathogens(2). *E. coli* is both a common commensal inhabitant of the gastrointestinal tract and one of the most important pathogens in humans. Thus, *E. coli* is the most frequent cause of bloodstream infection and urinary tract infections (UTIs) among gram-negative bacteria. *E. coli* isolates often possess specialized virulence factors such as adhesions, toxins, iron-acquisition systems, polysaccharide coats, and invasions that are not present in commensal and intestinal pathogenic strains (2). In addition, *E. coli* is the enteric gram-negative bacilli most frequently found in the genital tract of women, causing vaginal and/or endocervical colonization as well as different infections in pregnant women, such as intra-amniotic and puerperal infection, and neonatal infections, such as early and late neonatal sepsis (2).

Mokhtar and Karmi (3) screened for *E. coli* in different types of ready-to-eat meat in 120 Samples of sausage, hamburger, minced beef and fried chicken, 30 of each of them through culture and biochemical tests and confirmation isolates by polymerase chain reaction, the result of their study reveal that *E. coli* isolates were detected in 40% samples of sausage, 13% of hamburger, 27% of minced beef and 3% of fried chicken with prevalence of all isolates were confirmed in 20.83%. A similar study by (4) showed that *E. coli* was isolated in 51 out of 90 beef samples and identification of the isolates was based on their colonial morphology comprising of bluish-green colonies with a metallic sheen and biochemical testing and when the isolates were cultured on Congo-red media, to test for their pathogenicity all isolates (100%) were positive to the Congo-red binding assay, producing an intense orange/brick-red color on Congo-red media, thus showing their potential pathogenicity. Another study by Suryani et al., (5) using selective culture and biochemical tests (indole and Triple Sugar Iron agar) shows that among 630 samples examined, 78 were positive for *E. coli*. The result of a study by Ali et al., (6) shows that *E. coli* was present in 35 food samples out of 100 samples, they further highlighted that the elevated level of microbes such as *E. coli* in food samples might be due to inappropriate food handling practices and inadequate washing of utensils.

A study in Windhoek, Namibia by Shiningeni, et al (7) that examined the prevalence of pathogenic bacteria in street ready-to-eat food unveiled the presence of *E. coli* in 42% out of the 96 samples. They emphasized that the high levels of microorganisms and the predominance of dangerous bacteria, such as *E. coli* in the study's food samples demonstrate that the participants did not follow the fundamental food safety precautions that are required to lessen contamination. A similar result was shown by the study of (8) on traditional cheeses in Marand, Iran out of the 150 samples tested, 40% of the samples were positive for *E. coli.* According to the result of a study in Jeddah, Saudi Arabia by Iyer et al, (9), the distribution of *E. coli* in meat homogenates samples from different sources gives a high incidence (65%) in open butcher shops, (40%) groceries and (20%) hypermarkets.

E. coli is a food-borne pathogen that causes recurrent outbreaks every year. Therefore, determination of the prevalence of pathogenic *E. coli* in the food can help responsible bodies to prevent and control the occurrence of contamination in foods before reaching the consumers which can ultimately reduce the number of foodborne illnesses. According to (10), accurate detection of *E. coli* in food is critical because this bacterium is considered a primary fecal indicator. Considering that ready-to-eat foods are commonly consumed by primary school children in The Gambia during school hours, there is a need to screen the food for pathogenic organisms like *E. coli*. Therefore, this study aimed to determine the prevalence of pathogenic *E. coli* in the foods via biochemical technique. The data generated in this study can provide information for planning and determination of further approaches to be taken to improve food hygiene and safety in the country and also it can serve as a source of information for future researchers on this topic..

2. Material and Methods

2.1. Study Design

A cross-sectional mix-method study design was conducted in the government's primary schools in Kombo central district. The study was done from November 2022 to September 2023.

2.2. Study Setting

The study was conducted in nineteen government primary schools in Kombo central district. Kombo Central is a district in West Coast Region Two in The Gambia. It is located at latitude 13° 15 '00.0"N (13.2500000°) and longitude 16° 40' 00.0" W (-16.6666700°) with a total population of 142 831 (11). Kombo Central has a total of 25 primary schools among which 19 were government schools, 5 private, and 1 grant aid school. The district was divided into three clusters namely; Brikama, Jamisa, and Bakary Smbouya. Each cluster was headed by a cluster monitor who was responsible for helping the schools achieve the best possible teaching and learning and the highest possible standards for pupils. Each of the schools was headed by a headmaster/mistress.

2.3. Data Collection Methods

The food samples collection form was adopted from (12), and it was used during sample collection and laboratory analysis. Information such as the sample number, the sample name, the place where the samples were collected from, the date, the time it was collected, and the time it arrived in the laboratory was recorded on it. Each Sample had its form.

2.4. Reliability and Validity of Instruments

. Training on collection was done with data collectors which was coordinated by my supervisor and the lecturer who did the laboratory analysis. Ten food samples were also collected and analyzed at the laboratory. The result of the pre-test was excluded in the final analysis and those 10 food vendors were also excluded from the study. The aseptic technique was used throughout all sampling, handling, and analysis procedures by using sterile materials, and flaming. Samples were kept in a cool box containing ice packs and transported to the University of the Gambia biology laboratory within one to three hours. Microbial analysis was conducted within one to three hours after the sample collection to avoid unpredictable changes. The microbial analysis involved negative controls for the reliability of the results. Culture Media was prepared aseptically based on the manufacturer's instructions.

2.5. Data Collection Procedure

The data collection technique was laboratory analysis. Approximately 30-50g of food samples were aseptically collected from the vendors who consented for their food to be collected. The food samples were put into sterile containers, the containers were labeled with identifier codes kept in a cool box containing ice packs, and transported within 1-3 hours to the University of the Gambia Biology Laboratory for analysis. A food sample collection form was filled out for each sample.

2.6. Laboratory analysis (Isolation and identification of *E. coli*)

2.6.1. Sample preparation and culturing

The food samples were prepared and cultured within 1-3 hours when they arrived in the laboratory. Five grams (5 g) of food samples were suspended in 45 mL of distilled water. The homogenized mixture was diluted to a dilution factor of 10^{-3}. This was followed by adding 0.1 mL of sample to prepared Luria-Bertani (LB) Miller agar, for culturing following the spread plate technique and it was incubated at 37 °C overnight (13). Samples were analyzed in duplicate. The number of colonies was counted and the colony forming unit in gram (cfu/g) was determined using the below (*eq3*) as described from the Bacteriological Analytical Manual of the US FDA (14). The isolated colonies were used for further analysis.

$$cfu/g = \frac{(\text{Average no.of colonies} \times \text{total dilution factor})}{(\text{Volume plated})} \quad \text{……………….. } eq3$$

2.6.2. Microscopic identification by Gram's staining method

Gram staining was performed as per procedures described by (15) to determine the size, shape, and arrangement of bacteria. The organisms that revealed gram-negative, pink color with rod-shaped appearance and arrangement in single or in pairs were suspected as *E. coli.*

2.6.3. Biochemical Characterization

Four biochemical tests were done to confirm whether the isolated organisms were *E coli*. These biochemical tests were the Catalase test, Methyl Red, Voges-Proskauer, and citrate utilization test**.** Eosin Methylene Blue Agar (EMB agar) was used to further confirm the presence of *E. coli*.

The Catalase test was done using the hydrogen peroxide slide (drop) method as described by Reiner (16) for the American Society for Microbiology.

The Methyl Red Test and the Voges-Proskauer test were done using the procedures described by(17) for the American Society for Microbiology**.**

The citrate utilization test was done using a citrate agar with Sodium citrate and Bromothymol blue as described by(18) for the American Society for Microbiology.

EMB agar plate test was done as described by Lal and Cheeptham (19) for the American Society for Microbiology. Samples that formed a metallic sheen with a dark center on EMB agar were confirmed to be E coli.

NB: Only samples confirmed by EMB test to be *E coli* were further analyzed for pathogenicity and antibiotic susceptibility test

2.7. Pathogenic test for *E. coli*

The pathogenicity of isolated *E. coli* was tested with Congo-red agar (CRA) as described by (20). The colonies with rough and black color represented pathogenic and biofilm-producing *E coli* while colonies exhibiting an orange appearance were recorded as non-pathogenic). Based on the intensity of the black color of CRA after inoculation, the *E. coli* were classified as highly pathogenic/biofilm producers, moderate pathogenic/biofilm producers, and weak pathogenic/biofilm producers.

2.8. Data Management

The food samples were collected in a sterile container, labeled, and kept in a cool box containing ice packs. When the samples arrived at the laboratory they were prepared and cultured and a warning label was pasted on the incubator and cool box so that no one opened it without permission.

2.9. Data Analysis

The laboratory analysis was done as described in 3.8.1-3.8.5. The results from the food samples analysis were used to determine the prevalence of *E coli*.

2.10. Ethical Procedures

Ethical approval was obtained from The University of the Gambia Department of Public and Environmental Health Research Committee. Before the data collection, permission was obtained from the regional education director of West Coast Region Two to conduct the research in Kombo Central District primary schools. The director was verbally informed and issued a supportive letter obtained from the Department of Public and Environmental Health research committee. The director then gave the researcher a permission letter (19 copies) which the researcher took to the headmaster/mistress of each school within the study area before the date of data to solicit support and cooperation. Before the commencement of the study, the food vendors were informed that a sample of their food would be collected for analysis.

3. Results

3.1. Types of the food samples collected for laboratory analysis

The result of different types of food samples collected in the study is shown in Table 1. These samples were, bean sauce (18.3%), seam fish sauce (17.3%), "gorong soup" (3.8%), fish ball (6.7%), "ebbe" (cassava porridge) (12.5%), puff-puff (11.5%), fish pie (5.8 %%), cakes (2.9%), local beverage (ice) (18.3%), and "Acheke" (cassava couscous) (2.9%). The images are shown in figure 1.

Table 1 The types of food samples collected (n= 104)

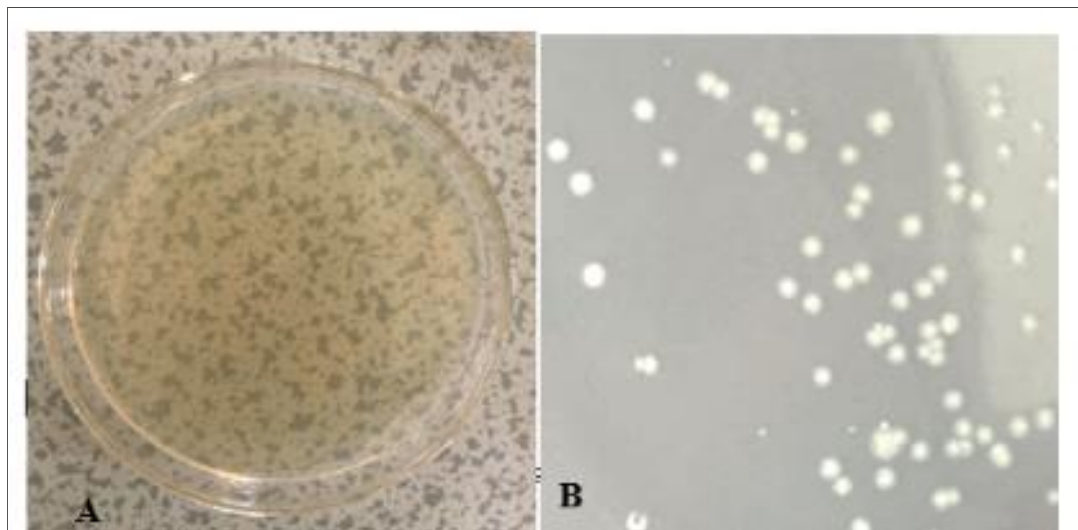
Name of sample	Description	Cooking/preparing method	Frequency (n)	Percentages (%)
Bean sauce	Its beans are cooked with water and oil and other ingredients such as onion, jumbo etc. are also added. It is often served with bread and it's a common dish that is normally sold in schools and streets in the Gambia	Cooked	19	18.3
Seam fish sauce	It is a combination of ground fish, spaghetti, and other ingredients, it is cooked with water and oil and it is normally served with bread.	Cooked	18	17.3

“Gorong soup”	It's prepared with smoked fish, lemon, onion, pepper and other vegetable ingredients. It's normally served with bread.	Prepare by mixing the ingredients (uncooked)	4	3.8
Fish ball	It combination of grind fish with groundnut powder/ groundnut paste another ingredients It is normally roll into ball shape and some serve it with bread and other vendors sell in a plastic bags without bread	Cooked(by boiling/ fried and cooked)	7	6.7
“Ebbe” (cassava porridge)	Its main ingredients are cassava, palm oil, smoked fish, lemon and other ingredients such as sea foods (shrimps, crabs), it is normally sold in plastic bags or disposable cups	Cooked by boiling	13	12.5
“Acheke” (cassava couscous)	It is made from fermented cassava pulp that has been grated or granulated (“garri’’) and other ingredients and it is sometimes served with fish or chicken. The vendors normally kept it in a pan and put it in plastics when selling	Cooked by steaming the grated cassava (“garri”)	3	2.9
Local beverage (ice)	This is normally prepared with local fruits or artificial juices powdered and normally tied in small plastic	Prepare by mixing the ingredients in water and put into the fridge	19	18.3
Puff-puff	It is made of two types of puff-puff sugar which is prepared with flour and sugar as the main ingredients and the other type is puff-puff sauce that is prepared by mixing the flour and rolled in a round shape and served with sauce.	Cooked by frying	12	11.5
Fish pie	It is usually made with flour, smoked fish or fresh fish as the main ingredients. Other ingredients also are normally added.	Cooked by frying	6	5.8
Cake	It normally made from flour, sugar, and other ingredient such as milk	Bake	3	2.9
Total			104	100

Figure 1 Types of food samples collected in this study

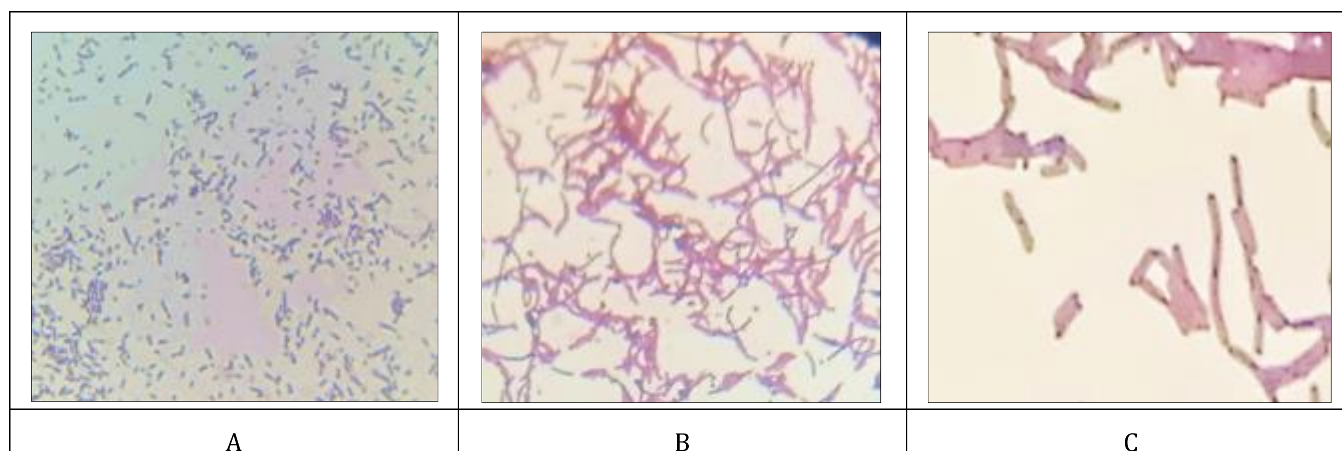
3.2. Microbial colony count and gram staining analysis

Table 2 shows the result of the microbial colony count and the gram staining analysis. Only 104 vendors agreed for their food to be collected out of the 209 interviewed vendors, therefore only104 food samples were analyzed. Out of the 104 analyzed food samples, 96 (92.3%) food samples had microbial contamination (figure 2: B). 45(43.3%) food samples had extremely high microbial counts (≥ 10^7 cfu/g), and all food types showed microbial contamination with no significant difference. 50 (48.1%) of the microbial positive sample were gram-negative bacteria (figure 3: B and C), the prevalence of gram negative bacteria in the food samples are as follows; gorong samples (100%), cake (66.7%), bean sauce (52.6%), seam fish sauce (50%) and ice has the lowest number of gram negative bacteria (31.6%).



A is the negative control, showing no microbial contamination after 24 hours; **B** is one of the tested sample showing microbial growth after culturing with a food sample for 24 hours

Figure 2 Luria-Bertani (LB) Miller agar



A is a gram-positive bacteria as indicated by the purple/blue colour of the microorganism; **B** is a gram negative bacteria as indicated by the pink/red colour of the microorganism; **C** is also a gram negative bacteria with a characteristic pink colour and rod-shaped appearance, arranged in single or in pairs which is indicative of *E. coli*

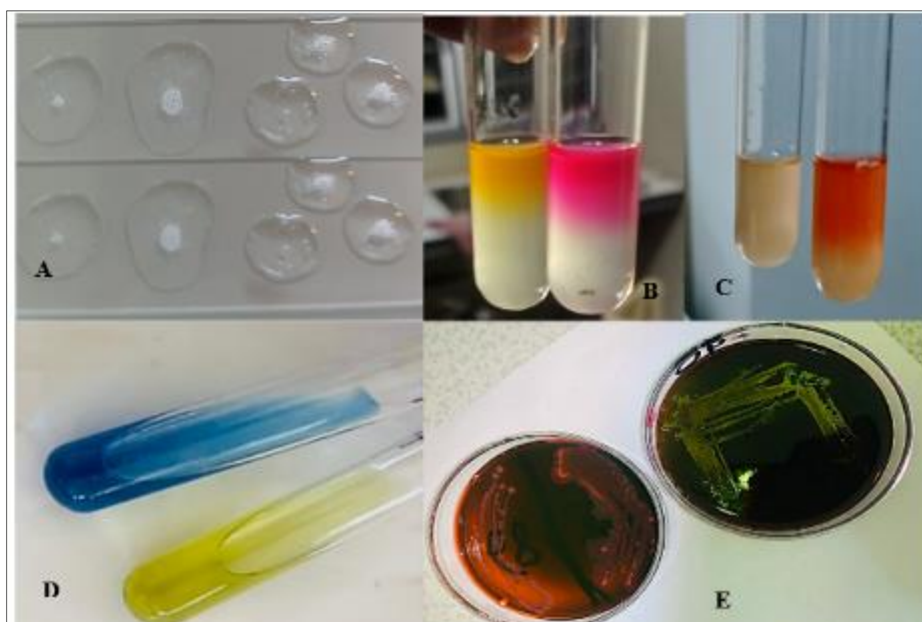
Figure 3 Gram staining analysis

Table 2 Summary of microbial contamination and gram straining analysis

Sample Type	**Microbial infection n (%)**	**Bacterial Count (cfu/g) [n (%)]**		**Gram Negative n (%)**	**Gram Positive n (%)**
		< 10^7	**≥ 10^7**		
Bean sauce (n=19)	17 (89.4)	9 (47.4)	8 (42.1)	10 (52.6)	7 (36.8)
Steam fish sauce (n=18)	16 (89)	5 (27.8)	11 (61.1)	9 (50.0)	7 (38.9)
"Gorong" soup (n=4)	4 (100)	1 (25.0)	3 (75.0)	4 (100.0)	0 (0 .0)
Fish ball (n=7)	7 (100)	4 (57.1)	3 (42.9)	3 (42.9 .0)	4 (57.1.0)
"Ebbe" (n=13)	13 (100)	10 (76.9)	3 (23.1)	6 (46.2 .0)	7 (53.8 .0)
Puff-puff (n=12)	11 (91.7)	2 (16.7)	9 (75.5)	6 (50 .0)	5 (41.7)
Fish pie (n=6)	6 (100)	3 (50 .0)	3 (50 .0)	3 (50.0)	3 (50 .0)
"Acheke" (n=3)	3 (100)	3 (100 .0)	0 (0 .0)	1 (33.3)	2 (66.7)
Cake (n=3)	3 (100)	3 (100 .0)	0 (0 .0)	2 (66.7)	1 (33.3)
Local beverage (ice) (n=19)	16 (84.2)	11 (57.9)	5 (26.3)	6 (31.6)	10 (52.6)
Total	96 (92.3)	51(49.0)	45 (43.3)	50 (48.1)	46 (44.2)

3.3. Biochemical detection of *E. coli*

Among the 104 samples collected, *E. coli* was detected in 34 samples (32.7 %). "Gorong" soup sample type had the highest percentage of *E. coli* contamination (75 %), followed by the steamed fish food sample type (50 %). Ice (local beverage) had the least *E. coli* contamination (15.8 %) (Table 2). Gram-negative samples that are catalase test positive, methyl red test positive, Voges Proskauer test negative, citrate test negative, and produce shiny metallic green on EMB agar are recorded as *E. coli*-positive samples (figure 4).



A is a catalase test using the slide (drop) method. Appear of air bubble/foam indicate the microorganism is a catalase test-positive bacteria like *E. coli*; **B** is methyl red test analysis. The red/pinkish color shows methyl red-positive organisms like *E. coli*, while the yellow color shows methyl red-negative microorganisms; **C** is Voges Proskauer test analysis. No color change indicates Voges Proskauer test negative bacteria like *E. coli* while the reddish color mean present of Voges Proskauer tests positive bacteria; **D** is the citrate utilization test analysis. The green color means the presence of citrate-test-negative bacteria such as *E. coli* while the blue color is indicative of a citrate-test-positive bacteria; **E** is the Eosin Methylene Blue Agar (EMB agar) test analysis. The appearance of shiny metallic green color means and confirms the bacteria is *E. coli*, while the plate with non-shiny metallic green color means the bacteria is not *E. coli*.

Figure 4 Biochemical analysis for identification of *E. coli*

Figure 5 Pathogenic/biofilm detection test for *E. coli* showing positive result on Congo red agar medium

Displayed dark black–rounded colonies indicate pathogenic and biofilm-producing *E. coli* whilst orange is indicative of non-pathogenic *E. coli*. The intensity of the dark black indicates a level of pathogenic and biofilm-producing ability

3.4. Pathogenic *E. coli* detection

From the 34 isolated *E. coli*, 25 (73.5 %) were found to be pathogenic and biofilm-producing while 9 (26.5 %) were non-pathogenic and non-biofilm-producing *E. coli*. Out of the 25 pathogenic *E. coli* isolates, 8 (32.0% %) were found to be highly pathogenic/strong biofilm producers, 11 (44%) were intermediate pathogenic/biofilm producers and 6 (24%) were low/weak pathogenic/biofilm producers (Table 3) (Figure 5). Percentage-wise wise "gorong" soup has the highest prevalence (75.0%) of pathogenic *E. coli* followed by steamed fish sauce (44.4%), Cake (33.3%), and Puff-puff 33%. Fish balls and "Acheke" were not contaminated with pathogenic *E. coli*. However, all the 3 *E. coli* isolates from Ice were highly pathogenic. The overall prevalence of pathogenic *E. coli* in the foods was 24 % (25/104).

Table 3 Summary of biochemical detection of *E. coli* and analysis of pathogenic and biofilm-producing *E. coli*

Sample Type	*E. coli* positive n (%)	Pathogenic/biofilm producing *E. coli*			Non-pathogenic/biofilm producing
		High	Moderate	Low	
Bean sauce (n=19)	6 (31.6)	0 (0.0)	2 (10.5)	0 (0.0)	4 (21.1)
Steam fish sauce (n=18)	9 (50.0)	1 (5.6)	3 (16.7)	4 (22.2)	1 (5.6)
Gorong soup (n=4)	3 (75.0)	1(25.0)	2 (50.0)	0 (0.0)	0 (0.0)
Fish ball (n=7)	2 (28.6)	0 (0.0)	0 (0.0)	0 (0.0)	2 (28.6)
Ebbe (n=13)	4 (30.8)	1 (7.7)	1 (7.7)	1 (7.7)	1 (7.7)
Puff-puff (n=12)	4 (33.3)	1 (8.3)	2 (16.7)	1 (8.3)	0 (0.0)
Fish pie (n=6)	1 (16.7)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)
Cakes (n=3)	1 (33.3)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)
Acheke (n=3)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)
Local beverage (ice) (n=19)	3 (15.8)	3 (15.8)	0 (0.0)	0 (0.0)	0 (0.0)
Total	34 (32.7)	8 (7.7)	11 (10.6)	6 (5.8)	9 (8.7)

4. Discussion

Interestingly, a high prevalence of microbial contamination was observed in the analyzed food. A similar prevalence of microbial contamination (77.5%) was also reported by (21) in a work done in India. This high prevalence of microbial contamination is not surprising, as the majority of the food vendors were observed not to wash their hands before handling food. The significance of food handlers' hands as a source of microbial food contamination is highlighted by (22) who reported a high prevalence (74 %) of pathogenic microbes on food vendors' hands. Worryingly from this study is the observation on microbial colony count (MCC). All the microbial-infected samples had MCC levels above the acceptable level of 10^5 cfu/g FDA (23). Out of which 43.3 % of samples had an MCC value of $\geq 10^7$. According to (24), such a high bacterial count may result in sensorial detectable spoilage. The high bacterial count in this study could point to that most of the food was prepared in the night or very early morning, enabling the bacteria to multiply before the time of selling to the primary school children.

More than half of the microbial-positive samples in this study were gram-negative. Gram-negative bacteria are known to pose high antibiotic resistance ability and as such post significant public health problems (25). The high prevalence of gram-negative bacteria means that primary school children in Kombo Central are at serious risk of infection from drug-resistant bacteria. In a review in the American Society of Microbiologists journal, Osei Sekyere and Reta (26) noted that gram-negative bacteria cause some of the most fatal and common infections and diseases known to humankind such as typhoid, pneumonia, cholera, meningitis etc. According to (27), Gram-negative bacteria are responsible for 69 % of all bacterial food-borne diseases. One such gram-negative bacterium is *E. coli*. The prevalence of *E. coli* in this study was 32.7%. This is in line with the prevalence of *E. coli* (33.3%) detected in beef burgers as reported by. (28). The result is also similar to the finding of a study in Mecca City, Saudi Arabia by (29), where the prevalence of *E coli* in the tested food samples was 33.3 %. (30), recorded 46 % *E. coli* prevalence in poultry markets in Bangladesh which is higher than that of the current study. However, the prevalence in this study is higher than those reported by Tan et al. (22) (9.41-14.12 %). Considering, *E. coli* is a major cause of food-borne disease with numerous outbreaks leading to death in some cases, the current high prevalence of *E. coli* in this study is a public health concern. Furthermore, the presence of *E. coli* in food means that the food had fecal contamination, thus a sign that other disease pathogens are present in the food (24). A much greater concern is that 73.5 % (25/34) of the *E. coli* isolates in this study are pathogenic with biofilm-producing ability. The overall prevalence of pathogenic *E. coli* in the present study is 24 % (25/104). This high presence of pathogenic *E. coli* in this study means that there is a greater risk of an outbreak of *E. coli*-borne diseases such as diarrhoeal disease, as there is a link between pathogenic *E. coli* and disease outbreak (2). Children are one of the most vulnerable groups *to E. coli* infection. Therefore, with the observed high prevalence of pathogenic *E. coli*, there is a public health concern in Governments' Primary schools at Kombo Central. The pathogenic *E. coli* was classified into high, moderate, and low with 23.5 % of the *E. coli* being highly pathogenic (i.e. 7.7 % of the analyzed food samples. High

pathogenic *E. coli* are strong biofilm producers (31). According to (32), biofilm-producing *E. coli* are intrinsically resistant to many antibiotics with resistance up to 1000 folds. A similar prevalence of highly pathogenic and strong biofilm producers was reported by Neupane et al. (33).

Limitations

The limitation of this study was the lack of a molecular confirmatory test to establish the pathotypes and serotypes of isolated *E. coli* from the food samples. Also, no statistical analysis was done to establish the hygienic practices of the respondents and the presence of *E. coli* in food. Another strength of the study is that the result cannot be generalized as the sample size is too small also it was done in the urban Gambia and cannot be representative of the study population

5. Conclusion

The present study evidenced the presence of a high prevalence of *E. coli* in food sold at a Primary school in Kombo Central, the Gambia. The majority of the *E. coli* isolates were pathogenic with multidrug resistance ability. Most of the *E. coli* strains in this study were resistant to beta-lactam antibiotics and therefore, extended-spectrum beta-lactamase (ESBL) producing *E. coli*. Food safety and quality authority should ensure that all food vendors are trained/educated and certified in food hygiene and safety practices before he/she starts operating as food vendors. Also, they should collect food samples randomly from food vendors routinely and analyze the food at the laboratory for detection of pathogenic organisms such as *E. coli.*

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no competing interests

References

[1] Akbar, A., & Anal, A. K. (2011). Food safety concerns and food-borne pathogens, Salmonella, Escherichia coli and Campylobacter. *FUUAST journal of Biology, 1*(1 June), 5-17.

[2] Vila, J., Sáez-López, E., Johnson, J. R., Römling, U., Dobrindt, U., Cantón, R., . . . Martínez-Medina, M. (2016). Escherichia coli: an old friend with new tidings. *FEMS microbiology reviews, 40*(4), 437-463

[3] Mokhtar, A., & Karmi, M. (2021). Surveillance of food poisoning Escherichia coli (STEC) in ready-to-eat meat products in Aswan, Egypt. *Egyptian Journal of Veterinary Sciences, 52*(The 9th International Conference of Veterinary Research Division National Research Centre, Giza, Egypt 27th-29th September 2021), 41-50.

[4] Ikimi, C. G., Omeje, F. I., & Anumudu, C. K. (2020). Identification and Biochemical Characterization of Pathogenic Escherichia coli in Raw Beef Sold in Otuoke Market, Bayelsa State, Nigeria. *European Journal of Nutrition & Food Safety*, *12*(1), 39-43.

[5] Suryani, D., Sutomo, A. H., & Aman, A. T. (2019). The factors associated with food safety practices on food handlers in primary school canteens. Unnes Journal of Public Health, 8(1), 1-9

[6] Ali, S. W., Ahmad, M., Asif, M., Amir, R. M., & Ali, A. (2022). Assessment of food safety knowledge, attitude, practices of food handlers and microbial contamination in foods at the canteens of a University in Pakistan. Italian Journal of Food Safety, 11(3).

[7] Shiningeni, D., Chimwamurombe, P., Shilangale, R., & Misihairabgwi, J. (2019). Prevalence of pathogenic bacteria in street vended ready-to-eat meats in Windhoek, Namibia. Meat Science, 148, 223-228

[8] Jafari-Sales, A., Hosein-Nezhad, P., & Shahniani, A. (2020). Antibiotic susceptibility assessment of Escherichia coli isolated from traditional cheeses in Marand, Iran. International Journal of Advanced Biological and Biomedical Research, 8(3), 236-241.

[9] Iyer, A., Kumosani, T., Yaghmoor, S., Barbour, E., Azhar, E., & Harakeh, S. (2013). Escherichia coli and Salmonella spp. in meat in Jeddah, Saudi Arabia. The Journal of Infection in Developing Countries, 7(11), 812-818

[10] Assefa, A., & Bihon, A. (2018). A systematic review and meta-analysis of prevalence of Escherichia coli in foods of animal origin in Ethiopia. Heliyon, 4(8), e00716

[11] Gbos. (2013). The Gambia 2013 Population and Housing Census Preliminary Results. The Gambia Bureau of Statistics, 23. Retrieved from www.gbos.gov.gm

[12] Gilbert, R., De Louvois, J., Donovan, T., Little, C., Nye, K., Ribeiro, C., . . . Bolton, F. (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. PHLS Advisory Committee for Food and Dairy Products. Communicable disease and public health, 3(3), 163-167

[13] England, P. H. (2014). Preparation of samples and dilutions, plating and sub-culture (pp. 12-13): Public Health England London

[14] Maturin, L. and Peeler, J. T. (2001). Aerobic Plate Count. Bacteriological Analytical Manual, Edition 8, Revision A, 1998. Chapter 3. U.S Food and Drug Administration. Last update 06/16/2021.

[15] Goldman, E., & Green, L. H. (2015). Practical handbook of microbiology: CRC press.

[16] Reiner, K. (2010). Catalase Test Protocol. American Society for Microbiology, 8..

[17] McDevitt, S. (2009). Methyl red and voges-proskauer test protocols. American Society for Microbiology, 8.

[18] MacWilliams, M. P. (2009). Citrate test protocol. American Society for Microbiology

[19] Lal, A. and Cheeptham, N. (2007). Eosin-Methylene Blue Agar Plates Protocol. American Society for Microbiology

[20] Kowalska, J., Maćkiw, E., Stasiak, M., Kucharek, K., & Postupolski, J. (2020). Biofilm-forming ability of pathogenic bacteria isolated from retail food in Poland. Journal of Food Protection, 83(12), 2032-2040

[21] Ghimire, P., Khand, S., Chaulagain, B., Siwakoti, A., Dhakal, D., & Shrestha, U. T. (2021). Microbial Quality Analysis of Panipuri Samples Collected from Different Parts of Bhaktapur. Tribhuvan University Journal of Microbiology, 38-45.

[22] Tan, S. L., Lee, H. Y., & Mahyudin, N. A. (2014). Antimicrobial resistance of Escherichia coli and Staphylococcus aureus isolated from food handler's hands. Food Control, 44, 203–207. doi:10.1016/j. foodcont.2014.04.008

[23] Maturin, L. and Peeler, J. T. (2001). Aerobic Plate Count. Bacteriological Analytical Manual, Edition 8, Revision A, 1998. Chapter 3. U.S Food and Drug Administration. Last update 06/16/2021.

[24] Luu-Thi, H., & Michiels, C. W. (2021). Microbiological Safety of Ready-to-Eat Foods in Hospital and University Canteens in Hanoi, Vietnam. Journal of food protection, 84(11), 1915–1921. https://doi.org/10.4315/JFP-20-324

[25] Oliveira J, and Reygaert WC. Gram-Negative Bacteria. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: Osei Sekyere, J., & Reta, M. A. (2020). Genomic and Resistance Epidemiology of Gram-Negative Bacteria in Africa: a Systematic Review and Phylogenomic Analyses from a One Health Perspective. mSystems, 5(6), e00897-20

[26] Osei Sekyere, J., & Reta, M. A. (2020). Genomic and resistance epidemiology of Gram-negative bacteria in Africa: a systematic review and phylogenomic analyses from a one health perspective. Msystems, 5(6), 10-1128

[27] Greig, J. D., & Ravel, A. (2009). Analysis of foodborne outbreak data reported internationally for source attribution. International journal of food microbiology, 130(2), 77–87. https://doi.org/10.1016/j.ijfoodmicro.2008.12.031

[28] Sofy, A.R., Sharaf, A.E., Karim, A., Hmed, A.A., & Moharam, K.M. (2017). Prevalence of the Harmful Gram-Negative Bacteria in Ready-to-Eat Foods in Egypt. Food and Public Health, 7, 59-68

[29] Hariri S. (2022). Detection of Escherichia coli in Food Samples Using Culture and Polymerase Chain Reaction Methods. Cureus, 14(12).

[30] Akond, M. A., Alam, S., Hassan, S. M. R., & Shirin, M. (2009). Antibiotic resistance of Escherichia coli isolated from poultry and poultry environment of Bangladesh. Internet Journal of food safety, 11, 19-23.

[31] Thien-fah UK, George PA (2001). Mechanism of biofilm resistance to antimicrobial agents. Trends Microbiol.; 9: 34–39. http://dx.doi.org/ org.10.1071/AN17729

[32] Stewart, P. S., & Costerton, J. W. (2001). Antibiotic resistance of bacteria in biofilms. The lancet, 358(9276), 135-138.

[33] Neupane, S., Pant, N. D., Khatiwada, S., Chaudhary, R., & Banjara, M. R. (2016). Correlation between biofilm formation and resistance toward different commonly used antibiotics along with extended spectrum beta lactamase production in uropathogenic Escherichia coli isolated from the patients suspected of urinary tract infections visiting Shree Birendra Hospital, Chhauni, Kathmandu, Nepal. *Antimicrobial resistance and infection control*, *5*, 1-5.