

Microbiological Assessment of Foods and Hygienic Practices of Food Vendors in Federal University of Technology, Ikot Abasi-Nigeria

Ioryue Ijah Silas¹

¹Department of Biochemistry, Federal University of Technology, Ikot Abasi, Nigeria

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Abstract

This study aimed to assess Nigerian currency notes, food contact utensils, washing water, and vended fried foods as potential vehicles or reservoirs of pathogenic microorganisms in Federal University of Technology, Ikot Abasi environments. It specifically determined the prevalence, types, and microbial loads of bacterial and fungal contaminants associated with these materials. A cross-sectional microbiological study was conducted using 200 each of Nigerian currency notes, fried food samples, utensils and washing/rinsing water. Samples were examined using standard culture, microscopy, Gram staining, and biochemical identification techniques on appropriate microbiological media. Bacterial contamination occurred in 77% (154/200) of currency notes, with *Staphylococcus aureus* (36%) predominating, followed by *Pseudomonas aeruginosa* (13.5%) and *Escherichia coli* (11.5%). Fungal contamination occurred in 73.5% (147/200), with *Aspergillus niger* (30.5%) most prevalent. Polymer notes were slightly more contaminated than paper notes, although the difference was not significant ($p > 0.05$). Among fried foods, 91.5% (183/200) were contaminated, yielding 191 bacterial isolates, predominantly *S. aureus* (46.6%), *E. coli* (23.6%), and *P. aeruginosa* (19.9%). Utensils and washing water also showed high microbial loads, with total aerobic counts reaching TNTC and spoon coliform counts up to 7.6×10^3 CFU/mL. Currency, utensils, washing water, and fried foods may serve as important vehicles for pathogenic microorganisms. Improved hygiene, sanitation, food-handler education, and regular microbiological monitoring are recommended.

Keywords: Dishwater, Currency, Note, Fried, Food, Bacteria, Fungi.

I. INTRODUCTION

Food vendors frequently act as conduits for the spread of foodborne infections, which is a sign of a serious worldwide health issue. Food vendors increase the risk of food-borne illnesses by spreading germs to food through their thumbs, dishes, water used to rinse plates, utensils, currency, and the fried food they sell to employees and university students.

Through hands, cutlery, dishwashing water, and coins, microorganisms can spread from one location to another and from person to person. The hand is rarely completely microbe-free; harmful microorganisms can cause acute or chronic sickness. Human hands frequently include bacteria that are a normal component of the body's flora as well as transient germs that are picked up from the environment.

Because human skin is their natural environment, microorganisms like *Staphylococcus* can transmit from person to person. Numerous foodborne illnesses and dangerous bacteria can be spread by contaminated hands and dishes [1].

Food handlers are directly involved in the food preparation, cooking, packaging, and delivery processes. As a result, their hands may be a significant source of food contamination [2]. Their skin, nasal secretions, and faeces, as well as infected utensils and meals they prepare or serve by hand touch, could all directly or indirectly transfer bacteria to the food [2]. One of the main causes of both occasional and epidemic food-borne illness is cross-contamination in homes and food service establishments [3]. It has been shown that workers in the ready-to-eat food service industry are carriers of foodborne infections, mostly as a result of poor hand hygiene [4]. Approximately 97% of food-borne illnesses have been linked to improper food handler procedures in the food industry [4–5].

Restaurants, workplace canteens, school canteens, and other catering service facilities are the most common sites of food-borne epidemics [6–9]. *Escherichia coli* and *Staphylococcus aureus* are two bacteria that have been known to colonise food handlers' hands [10].

Food safety is one of the most important parts of food service operations [5]. Food handlers must possess the required knowledge and training in personal and general hygiene in order to safeguard the health and safety of consumers [11]. In order to ensure food cleanliness and ensure that the food is safe and uncontaminated, food handlers must also adhere to food safety regulations. Food-borne illness risks are greatly increased by inadequate food handling procedures, poor hygiene, and a lack of regulation. Customers' health is at risk due to the unclear microbiological quality of food sold on campus.

Uncontaminated food is essential to many human processes and activities, because contaminated food can result in foodborne illnesses that are harmful to health; it poses a major risk to both staff and students. This research investigation was inspired by students' and staff members' persistent complaints about food-related illnesses within the university community. Additionally, the kind of food that employees and students eat affects their wellbeing and effectiveness. The purpose of this study was to determine whether food were contaminated by bacteria and fungi by the handlers at the Federal University of Technology, Ikot Abasi (FUTIA), Akwa Ibom State. The main purpose of this research is to evaluate bacteria in washing and rinsing water (soapy washing water and utensils rinsing waters), Investigate bacteria and fungi in pieces of money (200, 500 and 1000 Naira notes) during vending, Investigate bacteria on utensils (plates, spoons, knives and dining plates), Investigate bacteria on fried food sold within the school and provide solutions for the difficult situation that the institution's staff and students are facing with the degree of bacterial and fungal food contamination.

II. LITERATURE REVIEW

The local government of Ikot Abasi and Nigeria as a whole both heavily rely on the street food trade, yet little is known about the diseases associated with it.

Women make up over 75% of merchants, and 56% of them lack literacy [12]. They are largely ignorant of the causes of diarrhoea illnesses and proper hygiene procedures [12–13], which raises the possibility of contaminated street food [14–15]. As a result, the conditions under which street food is prepared and sold present numerous health risks for customers. Hands and dishes are typically washed in one or more buckets, sometimes without soap, because running water is typically unavailable at vending locations. Garbage and waste water are dumped close by, giving rodents and insects food. Certain foods are not effectively shielded from flies, which can spread food-borne illnesses. Street food is rarely stored at safe temperatures. Furthermore, food contamination by pathogenic bacteria and fungus, as well as subsequent contamination by vendors during preparation, post-cooking handling, and cross-contamination, might pose health hazards. The goal of this study is to determine how hygienic vendor hands, dish washing solutions, utensils, and cash are, as well as how this affects the health of Federal University of Technology Ikot Abasi employees and students.

III. MATERIALS AND METHODS

➤ Study Area

This study was conducted within the school environment of Federal University of Technology, Ikot Abasi (FUTIA), Akwa Ibom State, Nigeria in 2025. FUTIA is located at the back of Secondary commercial school, Ikot Abasi along Onna Road in a village called Ntuen ibok close to Lifegate power ministries at latitude $4^{\circ}36'26''\text{N}$ and longitude $7^{\circ}39'21''\text{E}$ as shown in Figure 1. The food handlers have no prior knowledge of the sampling activity, and the sampling was carried out during working hours.

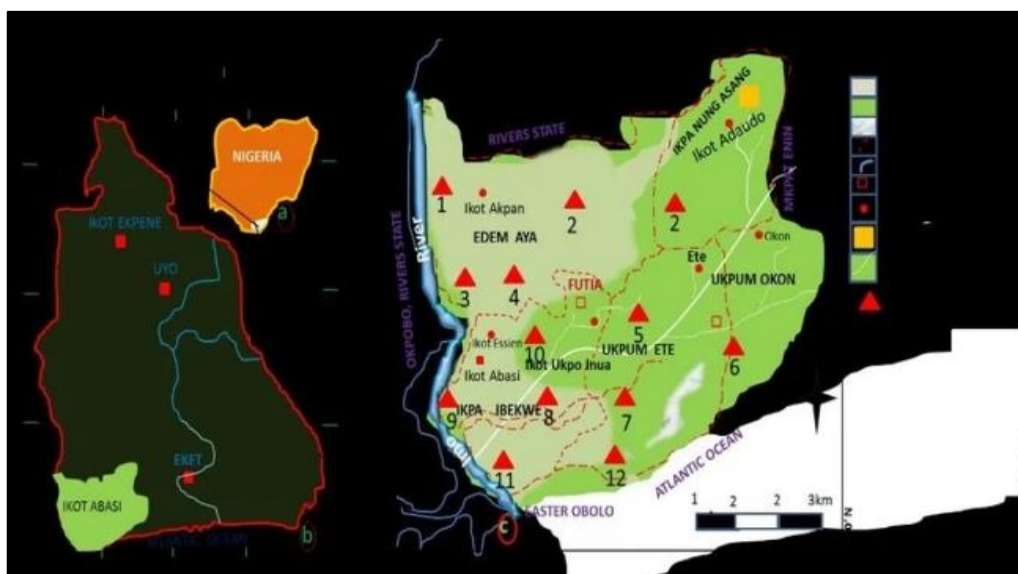


Fig 1 Map of Ikot Abasi Showing FUTIA and the Sampling Points

➤ *Fried Foods Analysis*

A total of 200 samples comprising of 50 different fried food types each, that is Yam, sweet potato, beans ball (Akara), and fried plantain was collected using random sampling technique [16]. The fried foods were collected at different occasions in the school within the period of this study in FUTIA campus. Fifty (50) samples of each food type was purchased in sterile brown bag envelopes directly from sellers and immediately send to the laboratory for analysis.

➤ *Investigations on Dish Waters*

Three types of dish washing water was used for utensils analysis. Washing water was collected from twenty food vendors. The first dish washing (W_1) water was soapy and used for washing. The second and third dish washing (Rinsing) water (W_2 and W_3) was used for utensils' rinsing according to the vendors. Volumes of 100 ml of dish washing water was taken in sterile jar for bacteriological and fungi analysis within two hours of collection.

➤ *Sampling Technique and Sample Collection for Money*

A random sampling technique was employed to obtain the various denominations of the Naira notes of the polymer and paper currency form. A total of 200 currency note samples were collected through the process of buying products and obtaining balance from food sellers at the various restaurants and food vendors within the university community. All samples were swabbed with pre-labelled, sterile swab sticks pre-soaked in sterile peptone water; the samples were then transported to the University of Uyo Teaching Hospital laboratory for microbial analysis.

➤ *Bacteriological Analysis of Samples of Money*

Each sample swab was soaked in 3-5 mL of sterile peptone water in a test tube and incubated at 37°C for 3-5 hours. The stock suspension for each sample was then cultured onto blood agar (BA), chocolate agar (CHOC) and MacConkey agar (MAC) plates and also enriched in Selenite F broth; all cultures were incubated at 37°C for 18-24 hours. The enriched culture in Selenite F broth was then sub-cultured onto Salmonella-Shigella agar (SSA) after incubation at 37°C for 18 hours. The bacterial colonies on the agar plates were identified using Gram reaction, colonial and morphological appearance, and standard biochemical tests (oxidase, indole, coagulase, DNase, urease, lysine and ornithine decarboxylase, beta-galactosidase, hydrogen sulphide production, methyl red, citrate and carbohydrate fermentation) (Franco-Duarte *et al.*, 2019).

➤ *Mycological Analysis of Samples of Money*

Each sample swab was soaked in 3-5 mL of sterile peptone water in a test tube and incubated at 37°C for 3-5 hours. The stock suspension for each sample was then cultured onto Sabouraud Dextrose agar (SDA) and incubated at 37°C for 24-48 hours. Fungal colonies were morphologically identified by viewing the slide smears of the colonies, stained with lactophenol blue (Sangeetha and Thangadurai, 2013) and confirmed with standard fungal

biochemical tests such as carbon and nitrogen utilization, carbon fermentation and enzyme activity (caseinase, cellulase, gelatinase, glucosidase, fatty acid esterase, lipase, urease) (Paterson and Bridge, 1994).

➤ *Utensils Surface Sampling Procedure*

Utensils comprised of five spoons, five dinner plates of 25 cm diameter made of aluminum or plastic and five knives. After their washing by vendor, utensils will be taken for surface sampling procedure. Surface will be rinsed with 100 ml of sterile buffered peptone water. The rinsing water of each utensil was collected in a sterile jar. Samples were kept at 4°C on ice and transported to laboratory for microbiological analysis the same day.

➤ *Bacteria Identification and Counting*

All samples were collected and processed in the laboratory for microbiological analysis. Ten (10) ml of each dish washing water and utensil surface rinsing water were diluted 1:10 with 90 ml of sterile buffered peptone water. Pieces of money was placed in 100 ml of sterile peptone water and shaken vigorously to remove bacteria which might have adhered. Further tenfold serial dilution was made with the sterile buffered peptone water. A volume of 0.1 ml of each dilution was spread over the specific growth media in petri dishes. Bacteria isolation and counts was done according to microbiological analysis standard methods. Mesophilic aerobic bacteria were isolated on plate count agar. The specific bacteria examined were coliforms indicative of hygiene and recent faecal contamination. For the detection of faecal coliforms, the production of acid and gas will be taken as positive indication. The *Enterobacteriaceae* was isolated on the violet red bile lactose agar medium (Fluka BioChemica 70189) incubated aerobically for 24 h at 44°C. Staphylococci was counted on Chapman mannited medium (Difco) and incubated aerobically for 24 h at 37°C. The detection of bacteria belonging to *Salmonella* and *Shigella* genera was done on the SS medium (Fluka BioChemica 85640). Inoculated media were incubated aerobically at appropriate conditions according to [13] method. After these appropriate incubation, suspected colonies were identified based on their morphological, physiological and biochemical features using microscope and standard biochemical methods.

➤ *Identification of Isolated Bacteria*

The conventional isolation method was adopted. All the bacterial isolated were identified using Gram staining, morphology and biochemical tests following Bergey's manual of determinative bacteriology [17].

➤ *Media Preparation for Fungi:*

Two media were used, Potato Dextrose Agar (PDA) and Sabouraud Dextrose Agar (SDA). They were prepared according to the manufacturer's instructions, 39gm (PDA) powder in 1 L of distilled water for PDA medium and 62gm (SDA) powder in 1L distilled water for SDA medium, then sterilized and used for fungal cultivations.

➤ Collection of Samples and Isolation of Fungi

A total of 20 samples each from vendors, water and different foods were obtained from the university community. The food samples were taken in sterile plastic bags according to [18] direct plate used for culturing the individual yeast and mold species. The samples were transferred with sterile forceps into Petri dish contain sterilized SDA Saboured dextrose agar and PDA Potato Dextrose Agar and incubated at 25°C for 5-7 days [19].

➤ Identification of Fungi

Fungal isolated was transferred to sterilized plates for purification and identification [20]. The grown fungi was placed on a slide, stained with gram stain for yeast identification and lacto phenol cotton blue to detect fungal structures covered with a cover slip, examined under microscope and identified on the basis of their colony morphology and spore characteristics.

Macroscopic and microscopic observations were carried out on the cultures. The physical characteristics of the mycelia such as the colour and structure were noted as well as the microscopic characteristics.

➤ Data Handling and Analysis

The number of colony forming unit per fingers (cfu/f), per milliliter (cfu/ml), per utensil (cfu/ut) or per piece of money (cfu/mo) was calculated by standard methods. The significance of any observed differences was determined using X^2 test. Statistical significance was set at $P \leq 0.05$. The data was analyzed using Statistical Package for Social Sciences (SPSS).

IV. RESULTS AND DISCUSSIONS

➤ Microbiological Quality of Dish Washing Waters

Table 1 summarizes determination of the number of dish washing waters used by vendors and their microbiological quality assessment.

Table 1 Indicator and Enterotoxigenic Bacteria Count in Dishwaters (cfu/ml)

Type of sellers	Dish waters	MAB	Coliforms	S. aureus	Salmonella Shigella
First Resturant(R1)	W1(soapy water)	1.7×10^7	4.4×10^5	2.2×10^4	<10
N=30 ; n =15 (50%)	W2(first rinsing)	7.1×10^6	2.1×10^4	1.4×10^3	0
m = 15 (50%)	W3(second rinsing)	8.2×10^5	4.1×10^3	5.0×10^1	0
Second Resturant(R2)	W1	9×10^7	6.8×10^4	1.2×10^4	<10
N = 21 ; n =10 (47.61%)	W2	4.3×10^7	2.3×10^4	0.6×10^3	0
m = 11 (52.39%)	W3	2.7×10^6	1.3×10^3	0.4×10^2	0
Third Resturant(R3)	W1	1.3×10^8	7.8×10^4	3.0×10^5	1.2×10^1
N=19 ; m=17 (89.48%)	W2	4.2×10^6	8.5×10^3	2.4×10^3	0
n = 2 (10.52%)	W3	4.0×10^6	8.4×10^3	2.4×10^3	0
Average	W1	7.9×10^7	1.9×10^5	2.1×10^2	< 10
NT=70 ; nT = 27 (38.57%)	W2	18.1×10^6	1.7×10^4	1.4×10^2	0
mT = 43 (61.43%)	W3	17.6×10^6	2.7×10^3	4.5×10^1	0

MAB = mesophilic aerobic bacteria, cfu = colony-forming unit, N = number of sellers, n = number of sellers using three dishwaters, W1, W2 and W3 = 1st, 2nd and 3rd dishwaters, m = number of sellers using two dishwaters, W1 and W2, in parentheses = percentage of sellers using 2 or 3 dishwaters, NT; nT; mT := totals.

It seems that 38.57% of vendors used the three types of dishwashing water-soapy water, first rinsing water, and second rinsing water, respectively in compliance with the Food Hygiene Office's guidelines alone (W1, W2, and W3). Two types of dishwashing water (W1 and W2) were used by the others (61.43%). About half of the sellers in restaurants and kiosks used all three types of dishwashing water, but 89.48% of vendors selling roasted or fried meat used only two types (W1 and W2). In the initial dishwashing fluids (W1), the average number of mesophilic aerobic bacteria was 7.9×10^7 cfu/ml, while the average number of total coliforms was 1.9×10^5 cfu/ml. Few bacteria from the genera Shigella and Salmonella have been found in E1. Coliform levels in rinse waters W2

and W3 were 1.7×10^4 and 2.7×10^3 cfu/ml, respectively. The classification of dish washing fluids based on the total coliform load is depicted in Figure 1. The first dishwashing water samples (W1) were deemed to be of extremely poor quality due to their high levels of contamination. Just 11% of the second dishwashing fluids (W2) were of acceptable grade, while the percentages of impure and highly impure values were equal (44.5%). Finally, 45.45% of the third dishwashing fluids (W3) were of acceptable quality, whereas 27.27% of the waters were unclean or extremely impure. The majority of sellers utilised dishwashing water in floor-mounted buckets. Rarely were the utensil washing and rinsing waters replaced, and they were generally found to be unclean ($P < 0.05$). Small puddles, insects, and animals were present in several other dishwashing locations[21]. The low bacterial quality of dishwashing fluids can be explained by their lack of renewal[22-24].

➤ Utensils Microbiological Quality

Table 2 shows microbiological analysis of utensils surface.

Table 2 Number of Bacteria Count Per Utensil

Utensils	MAB	Tot C	Th C.	S. aureus	Salmonella Shigella
Spoons (n = 25)	2.8×10^4	2.8×10^2 (68)	1.2×10^1 (28)	2.5×10^2 (60)	0
Dinner plates (n = 30)	4.1×10^4	3.2×10^2 (36.6)	1.3×10^1 (40)	2.3×10^2 (33.3)	0
Knives (n = 25)	8.6×10^5	5.1×10^4 (100)	1.4×10^2 (100)	3.4×10^3 (100)	1.7×10^2 (85)

ut = Utensils, Th C. = Thermotolerant coliforms, Tot C. = Total coliforms ; MAB = mesophilic aerobic bacteria ; cfu/ut = colony-forming unit per utensil, n= number of sample; in parentheses are percentage of contaminated utensils. *S. aureus* and coliforms were found on all blades. Butcher knives generally had high levels of *Shigella* and *Salmonella*. In general, pathogen germs were found on utensils utilised in school food selling locations ($P < 0.05$).

According to a number of authors ([25-26]; [23]; [27]), bacteria from unclean dish washing waters and other sources can stick to utensil surfaces and pose a risk of contamination during food vending. In certain instances, raw meat, gravy, and salad ingredients were sliced and

diced with the same knife during meat preparation and vending without being cleaned in between. The knives were frequently infested with flies and were not cleaned at all [22]. Since leftovers were typically kept in the original cooking pots, our results support earlier findings that contamination from utensils could occur during serving but not from storage containers ([22]; [25]; [27]).

➤ Vended Fried Food

The mean bacterial count per gram of food sample according to the sample is presented in table 3. Fried yam has the highest mean bacterial count of 1.6×10^3 while fried potato has the least mean bacterial count of 1.0×10^2 as shown below:

Table 3 Mean Bacterial Count, Type and the Isolated Bacteria per Gram of Food Sample According to Food Type.

Food item	Mean Bacterial Count (cfu)	Types of bacteria isolated	Bacteria isolated
Fried yam	1.6×10^3	4	<i>S. aureus</i> , <i>E. coli</i> , <i>P. aeruginosa</i> and <i>Klebsiella</i>
Fried potatoes	1.0×10^2	2	<i>S. aureus</i> and <i>P. aeruginosa</i>
Fried beans ball (Akara)	1.5×10^3	4	<i>S. aureus</i> , <i>E. coli</i> , <i>P. aeruginosa</i> and <i>Klebsiella</i>
Fried plantain	1.06×10^3	3	<i>S. aureus</i> , <i>E. coli</i> and <i>P. aeruginosa</i>

A total of 200 vended fried food samples were gathered in batches (10 samples per batch), 40 samples per sampling site across five sites and a total of 50 samples for each type of food offered on FUTIA school grounds (fried yam, fried sweet potato, Akara, and Masa). Four distinct bacterial genera—*Staphylococcus*, *Escherichia*, *Pseudomonas*, and *Klebsiella*—were isolated, according to the findings. Fried yam had the greatest mean total bacterial load (1.6×10^3), followed by fried bean balls (akara) with a mean total bacterial load of 1.5×10^3 , and fried potatoes with the lowest mean total bacterial count (1.0×10^2). This outcome was consistent with research by Maduake *et al.* [17] and Ochei *et al.* [16], as well as with the work of Ochei *et al.* [16]. The mean count reveals bacterial contamination in the food samples, which is likely due to incorrect handling/serving, preparation, or consumption as well as being sold in extremely unclean environments [5,6]. Among all the samples analysed, the low moisture content of potatoes may be the cause of the low bacterial load in fried potatoes.

According to the study's findings, four bacterial isolates were found in 200 samples of various fried food varieties. 183 of the 200 samples that were examined showed bacterial growth, whereas 17 showed no discernible growth. Some of the 183 samples that produced notable growth were pure culture samples, while others produced mixed culture samples. *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* were the bacterial species. *Staphylococcus aureus* demonstrates the high frequency of bacterial isolates from the 200 samples of the four chosen street-vended fried food types examined in Ikot Abasi,

Nigeria [15]. The presence of *Staphylococcus aureus* in the samples is indicative of human contamination after production; this could be from direct human contact, such as fingers, or indirectly through additives or utensils. As a result, hawked food sales are highly contentious from a health perspective [1]. The bacteria is linked to endotoxins that cause severe nausea, vomiting, diarrhoea, and a brief incubation period (1–8 hours) [18]. Although members of Enterobacteriaceae found in the study, such as *Escherichia coli* and *Klebsiella pneumoniae*, can be linked to environmental contamination by unwholesome materials like faeces, the subsequent bacterial prevalence was *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. These organisms may be of faecal origin. This result corroborated the findings of Bukar *et al.* [19], who found that approximately 5 (10.0%) of 50 food handlers in three small-scale food companies in Kano city had *E. coli* on their hands.

Site B (School clinic side) had the highest bacterial contamination among the sample sites, with a total of 50 isolates (26.2%). This could be due to the clinic's frequent attendance of patients (students) with various illnesses, both communicable and non-communicable, and the high bacterial growth found in all food types sampled. Site D yielded 35 isolates (18.3%), whereas Site C had 47 isolates (24.6%). The majority of the sellers are ignorant of inappropriate food handling practices and their part in the spread of diseases since they either have no formal education or only a few years of schooling [7]. Site A had a slightly lower bacterial contamination of 29 isolates (15.2%) and Site E had 30 isolates (15.7%). These two vending sites had low bacterial contamination because

they were frequented by nearly identical literate individuals (students), and a large number of covered food samples were collected from both locations. According to Table 4.6 of this study, food samples that were purchased from uncovered sources had a total of 140 isolates, or 76.5% of the total, whereas food samples that were purchased from covered sources had a total of 43 isolates, or 23.5%. This suggests that foods that are not covered are more polluted. Foods made in our area may be polluted, particularly if they are not affected by airborne microbes,

mostly at the point of sale. Coughing and sneezing can introduce certain bacteria from the vendors' mouths, noses, and skin surfaces into the food [20, 21].

➤ Occurrence of Microbes on Currency Notes

The bacteria and fungi pathogens distribution on Nigerian currency notes is presented in Table 4. Results from microbial analysis of currency notes established a higher prevalence of bacteria (51.0%; 154/301) than fungi (49.0%; 147/301) (Table 4).

Table 4 Distribution of Bacterial and Fungal Pathogens on Used Nigerian Currency Notes in Relation to Note Texture

Currency note texture	No. examined	No. (%) positive for Bacteria Fungi		Chi-square Value Significance	
Polymer	128	104 (81.30)	99(77.30)	X ² = 3.626, <i>p</i> >0.05	NS
Paper	72	50(69.40)	48(66.70)	X ² = 2.697, <i>p</i> >0.05	NS
Total	200	154(77.60)	147(73.50)		

NS – not significant

Polymer-type notes, compared with paper (104/128; 81.3% and 50/72; 69.4 respectively) and fungi (99/128;

77.3% and 48/72; 66.7% respectively) (Table 1). These differences were not statistically significant (*X* *p*>0.05 and X² = 2.697, *p*>0.05 respectively)

Table 5 Distribution of Potential Bacterial Pathogens on Used Nigerian Currency Notes Based on Denominations

Currency denomination	Number Examined	No (%) +ve for bacterial pathogen					Total
		<i>S.aureus</i>	<i>Proteus mirabilis</i>	<i>Klebsiella aerogenes</i>	<i>E. coli</i>	<i>P. aeruginosa</i>	
N5	12	3(25.00)	1 (8.33)	2(16.67)	2(16.67)	1(8.33)	9 (75.00)
N10	22	12(54.54)	1 (4.55)	1 (4.55)	2 (9.09)	1(4.55)	17 (77.27)
N20	26	9 (34.61)	2 (7.70)	3(11.53)	4 (15.38)	2(7.69)	20 (76.92)
N50	68	31 (45.59)	4 (5.88)	5 (7.35)	6 (8.82)	12(17.64)	58 (85.29)
N100	28	7 (25.00)	1 (3.57)	3(10.71)	4 (14.29)	6(21.42)	21 (75.00)
N200	24	6 (25.00)	2 (8.33)	2 (8.33)	3 (12.50)	3(12.50)	16 (66.67)
N500	10	3 (30.00)	1 (10.00)	1(10.00)	1 (10.00)	1(10.00)	7 (70.00)
N1000	10	1 (10.00)	1 (10.00)	2(20.00)	1 (10.00)	1(10.00)	6 (60.00)
Total	200	72 (36.00)	13 (6.50)	19(9.50)	23(11.50)	27(13.50)	154(77.00)
		X ² =3.626, <i>p</i> >0.05					

➤ Distribution of Bacterial and Fungal Pathogens on Used Nigerian Currency Notes in Relation to Note Texture.

Numerous authors have reported bacterial and fungal contamination of currency notes in Nigeria [28-33] and other countries [34-38]. These results are supported by this study. More bacteria than fungus were isolated from banknotes in the current investigation. On human skin, bacteria are known to be more common than fungus [39]. The higher number of bacterial isolates compared to fungal isolates may have been explained by this fact. The majority of the bacteria found in this investigation are typical skin flora. According to [29] and [40], the notes may have been colonised when placed in areas where they come into direct contact with the skin, which harbours a complex ecosystem of transient and/or resident microorganisms. This suggests that humans are the primary source of bacteria found on Naira notes. According to Skowron *et al.* [40], the amount of bacteria on a skin surface varies from 103 cfu/cm² in dry areas to more than 107 cfu/cm² in moist areas. Furthermore, unclean notes are typically damp, which makes them an ideal surface for bacterial development [41].

According to reports from Saudi Arabia [35] and other African countries like Libya, Ghana, and Sudan ([34]; [37]; [38]), banknotes offer a large surface area for the growth of pathogenic microbes that can cause human diseases like meningitis, tuberculosis, diarrhoea, septicaemia, and urinary tract and gastrointestinal infections[33]. In the current study, compared to paper-type currency notes, polymer-based currency notes had higher levels of bacteria and fungi. According to some research, polymer-type currency notes frequently have fewer bacteria than cotton-based, paper-type currency notes [42]. This could be due to different physicochemical characteristics of polymers[42-43]. Since plastic polymer-made currency is stronger and likely to remain longer in circulation, numerous countries have recently adopted it [41-42]. Due to longer circulation times and higher handling rates during cash transactions, the polymer notes in this study may have accumulated a higher bacterial and fungal burden. Additionally, petty traders who are less concerned with the hygienic handling of currency notes handle the smaller polymer-type denominations far more frequently than the bigger paper-type denominations [34]; [41] noted this pattern in reviewed academic papers.

On the currency notes examined in this study, Enterobacteriaceae bacteria were more widely distributed; yet, *Staphylococcus aureus* was the most common of all the isolated bacteria. *S. aureus* are typically harmless, normal bacteria that live on human skin. However, once they penetrate deeper bodily tissues or damaged skin, they can frequently cause pyogenic infections, ranging from mild conditions like carbuncles, impetigo, and exfoliation to more serious conditions like food intoxication and deep-seated systemic infections [29]. Currency notes may unintentionally become contaminated if people rub their noses, cough or sneeze on their hands while exchanging money [33]; [35], or put them in or near knickers or knickers, which are near damp skin areas[44]. Although *S. aureus* infections often cause serious issues in hospitals, the prevalence of community-acquired *S. aureus* infections has significantly increased over the last several decades [35].

Recently, it has been discovered that paper money can spread community-acquired *S. aureus*. The spread of antibiotic-resistant strains through paper money is nearly certain because staphylococci have become resistant to numerous drugs [35]; [45]. *Pseudomonas aeruginosa* was shown to be more common in this investigation than *S. aureus*. One of the three *Pseudomonas* species that cause opportunistic infections in immunocompromised people, it is a free-living bacterium [46]. It may result in external otitis and infections of the skin and eyes [29]. Approximately half of all the fungus isolated from currency notes in this investigation were *Aspergillus* and

Candida species. Compared to currency notes made on paper, both creatures were more prevalent in lower denomination, polymer-based notes.

This might be due to the lower denomination currency notes' increased circulation, which are mostly handled by small-time dealers that don't give proper handling and storage of currency notes much thought [34]; [41].

Additionally, polymer notes retain more surface moisture that can encourage the growth of fungus because they absorb moisture poorly. Numerous studies [30]; [34]; [47], reported *Rhizopus*, *Penicillium*, *Aspergillus* species, and yeasts, including *Fusarium* [47]; [49], *Trichoderma* species [31]; [47]. Sani *et al.* [32] found *Rhizopus* species to be the most predominant fungi in their study, whereas [29] reported the least predominant fungi. Old paper notes and even recently minted notes frequently contain *Aspergillus* species; *Aspergillus niger* appears to be the most common fungus. Although it is less likely to cause illness in humans, inhaling a large number of spores typically leads in aspergillosis and severe pneumonia [48-49].

In addition to invading every region of the body and colonising lung cavities, the fungus nearly usually causes immunocompromised patients to die. In addition to otomycosis, it can result in severe pulmonary conditions [50-51]. Serious endocarditis can result from an infection with *Candida* species[52-53].

Table 6 Distribution of Pathogenic Fungi from the Nigerian Currency Notes Based on Denominations

Currency denomination	Number Examined	No (%) +ve for Fungi pathogen					Total
		<i>Aspergillus niger</i>	<i>Aspergillus fumigatus</i>	<i>Candida albicans</i>	<i>Blastomyces dermatitidis</i>	<i>Penicillium spp</i>	
N5	12	2(16.67)	1 (8.33)	1(8.33)	1(8.33)	1(8.33)	6(50.00)
N10	22	11(540.00)	2(9.09)	1 (4.54)	1(4.54)	1(4.54)	16(72.73)
N20	26	8(30.77)	4 (15.38)	3(11.53)	2(7.70)	1(3.85)	18(69.23)
N50	68	24(35.29)	19(27.94)	6 (8.82)	6 (8.82)	4(5.88)	59(86.76)
N100	28	8(28.57)	7(25.00)	3(10.71)	2 (7.14)	1(3.57)	21(75.00)
N200	24	5(20.83)	4(16.67)	4(16.67)	1(4.17)	2(8.33)	16 (66.67)
N500	10	2(20.00)	1(10.00)	1(10.00)	1(10.00)	1(10.00)	5(50.00)
N1000	10	1 (10.00)	1 (10.00)	1(10.00)	1 (10.00)	1(10.00)	5(50.00)
Total	200	61(30.50)	39 (19.50)	20(10.00)	16(7.50)	12(6.00)	147(73.50)
		$X^2 = 2.697, p > 0.05$					

Aspergillus niger (61/200; 30.5%), *Aspergillus fumigatus* (39/200; 19.50%), *Candida albicans* (20/200; 10%), *Blastomyces dermatitidis* (16/200; 7.5%), and *Penicillium spp.* (12/200; 6.0%) were among the fungal pathogens found in 147 (73.5%) of the 200 used Nigerian banknotes. The 50 Naira notes had the highest percentage of fungal contamination among the denominations studied (86.8%; 59/68), followed by the 100 Naira notes (75.0%; 21/28) and the 20 Naira notes (69.2%; 18/26) (Table 3). There was no statistically significant difference in the distribution of fungal pathogens by denominations on used Nigerian currency notes ($X^2 = 2.697, p > 0.05$).

V. CONCLUSION

The study demonstrated high bacterial and fungal contamination of Nigerian currency notes, food-contact utensils, washing water, and fried foods, indicating their potential role in transmitting pathogenic microorganisms. The findings highlight inadequate personal hygiene, utensil sanitation, food handling, and environmental hygiene practices. Therefore, improved hand washing, safe handling of currency and fried foods, proper cleaning and disinfection of utensils, and regular hygiene education for food handlers and consumers are recommended. Strengthening cashless payment systems and periodically removing dirty or mutilated notes from circulation may

further reduce the risk of pathogen transmission and foodborne infections.

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