Journal of Advances in Microbiology

14(2): 1-11, 2019; Article no.JAMB.45662
ISSN: 2456-7116

Microbial Assessment of Foods and Currencies from Street Food Vendors and Antibiotic Resistance Profile of Isolates

O. A. Ajayi[1*] and D. O. Oladele[1]

[1]Department of Food Science and Technology, Faculty of Agriculture, Bowen University, P. M. B. 284, Iwo, Osun State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author OAA designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Author DOO performed analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMB/2019/45662
Editor(s):
(1) Dr. Luciana Furlaneto-Maia, Technological Federal University of Paraná, Brazil.
(2) Dr. Charu Gupta, AIHRS, Amity University, UP, India.
(3) Dr. Arun Karnwal, Professor, Microbiology, School of Bioengineering & Biosciences, Lovely Professional University, India.
Reviewers:
(1) Pinar Sanlibaba, Ankara University, Turkey.
(2) Mariana Tavares Dias, Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro, Brasil.
Complete Peer review History: http://www.sdiarticle3.com/review-history/45662

Original Research Article

Received 04 October 2018
Accepted 26 December 2018
Published 16 January 2019

ABSTRACT

Aims: Street food vendors handle money and food simultaneously, creating possibilities of cross contamination. This study focused on determining the microbial loads of street vended foods and currency denominations received as change; identify and determine the antibiotics resistance profile of the isolates.
Materials and Methods: Four Street vended food samples and currency (10 - 500 Naira) notes from four vendors (FV) were collected. Microbial loads of food and money, biochemical analyses for identification of isolates and antibiotic resistance profile of the isolates were performed using standard methods.
Results: Total viable count (TVC) value ranged from (1.0×10^7 to 1.7×10^8 CFU/g); Staphylococcal (5.8×10^6 to 1.6×10^7 CFU/g), *Salmonella-Shigella* (NG to 1.2×10^7 CFU/g) and Coliform (no growth) from FV1. TVC ranged from (4.2×10^6 to 2.0×10^7 CFU/g); Staphylococcal (1.2×10^6 to 2.0×10^7

**Corresponding author: E-mail: sunmbo.ajayi@gmail.com, olasunmbo.ajayi@bowenuniversity.edu.ng;*

CFU/g), *Salmonella-Shigella* ($1.6×10^6$ to $1.1×10^7$ CFU/g) and Coliform (NG to $1.5×10^5$ CFU/g) from FV2. From FV3 TVC ranged from ($9.3×10^6$ to $4.6×10^7$ CFU/g); Staphylococcal ($1.9×10^6$ to $5.1×10^6$ CFU/g), *Salmonella-Shigella* ($1.3×10^6$ to $5.9×10^6$ CFU/g) and Coliform ($5.0×10^3$ to $1.0×10^6$ CFU/g). FV4 load ranged from ($2.8×10^6$ to $1.3×10^8$ CFU/g); Staphylococcal ($1.7×10^6$ CFU/g to TNTC), *Salmonella-Shigella* (NG to $5.7×10^7$ CFU/g) and Coliform ($6.5×10^4$ to $6.8×10^5$ CFU/g). Eleven genera were identified from food and currencies including: *Staphylococcus, Klebsiella, Escherichia coli* and *Enterobacter.* Organisms showed varied resistance patterns to the different antibiotics screened. The percent resistance for Ampicillin and Ciprofloxacin were (87.5%), Ofloxacin (61.5%), Ceftazidime, Gentamicin and Amoxycillin/Clavulanate were (53.8%).

Conclusion: In conclusion, there are possibilities of cross contamination between food and currencies making the safety of consuming the foods a public health concern.

Keywords: Street foods; food; money; simultaneous handling; safety.

1. INTRODUCTION

Street foods are ready–to-eat foods and beverages prepared and/or sold by vendors on streets and other public places [1]. Street foods are sources of nutrition for many, at affordable prices. Some of the popular street foods sold in Nigeria include: rice, beans, akara (fried bean cake), boli (roasted plantain), roasted corn, amala (yam flour meal), garri, fufu (cassava meal), fried fish, stick or peppered meat, suya (peppered stick meat), fruits, salads and more. The street food industry plays an important role in developing countries in meeting the food demands of the urban dwellers [2]. There is a noticeable increase of food vendors in Nigeria as a result of dwindling economy and unemployment [2]. Types of vending sites encompass stalls, a variety of push-carts, roadside stands, and hawkers depending upon the ingenuity of the individual, resources available and type of food sold [3].

Trading has been part of mankind from time immemorial. Items passed from hand to hand are likely to be contaminated with disease causing microorganism especially if handled with unclean hands or kept in dirty surroundings [4]. Paper and polymer currency notes may habour various deadly pathogenic microorganisms, and this could represent a universal medium of transmission of bacteria in the environment and among humans [5].

Many of the street food vendors serve foods and collect money for the foods simultaneously and do not wash or sanitize their hands between tasks [6,7,8]. In spite of numerous advantages offered by street foods, there are several health hazards associated with this sector of the economy. There is a possibility that currency notes might act as vehicles for the transmission of potential pathogenic microorganisms from human and environment into foods especially during simultaneous handling of food and money by street food vendors. Money on which pathogenic microorganisms might survive represents an often over looked reservoir for enteric disease [9,10,11].

Vendors often lack formal education and untrained in food hygiene; work under crude and unsanitary conditions and have very little knowledge about the causes of foodborne diseases [3]. Evidently, since street vended foods have been shown to have epidemiological links with illness [12,13,14,15], it further suggests that street foods contribute immensely to food poisoning outbreaks.

Furthermore, the rise of street food vending and simultaneous handling of money by same vendors has created opportunities for contaminations, resulting in public health problems [16,17]. Unsafe food is becoming an increasingly serious threat to public health in Nigeria.

Perpetual and indiscriminate administration of antimicrobial agents and antibiotics in developing countries coupled with poor hygiene habits has led to the development of multiple drug resistant microorganisms. Furthermore, the prevalence of antibiotic resistance among food borne pathogens has increased in recent times [18]. Failure of food service workers to adequately wash and or sanitize hands between handling of money and serving of food could put consumers at risk of diarrheal diseases. Therefore, the aim of this study was to assess the microbial quality of food and currency denominations from street food vendors for possibility of cross contaminations and determine the antibiotic resistance profile of isolates.

2. MATERIALS AND METHODS

2.1 Sample Collection

Four types of food samples namely: Ekuru, jollof rice, pounded yam with sauce and suya were procured from food (stationary and mobile) vendors in Iwo, Osun State. Two food samples type making a total of eight were collected in sterile polyethylene bags and kept in an ice pack inside food flasks for transportation to Bowen University Food Science laboratory and isolation of microorganisms from samples were carried out within 24 hours of purchase. Table 1 describes the food categories. Also, the currency notes returned as change after purchase were placed in separate Ziploc bags. Both food items and the currency notes were used for analyses.

Table 1. Description of food samples obtained during research

Food categories	Composition of food in the category
Ekuru	Uncoated bean paste, pepper sauce, oil and meat
Jollof rice	Rice, pepper sauce, oil and meat
Pounded Yam	Yam, vegetable stew, pepper sauce and meat
Suya	Steak meat, ground pepper, oil and seasoning

2.2 Microbial Analysis of Food

About 10 g of the food samples was homogenized in 90 mL peptone water and mixed properly. Then, 1 mL of sample was serially diluted in 0.85% saline solution up to 10^{-5}. Using the pour plate method, 1 mL of the last dilution was plated according to Pollack et al. [19], into plate count agar; Eosin methylene blue agar (Coliform); *Salmonella- Shigella* agar (SSA); Baird Parker agar; and Sabouraud dextrose agar (SDA) (Park Scientific Limited, Finland) in duplicates and incubated at 37°C overnight while SDA plates were incubated at 28°C for 72-96 h. All plates with less than 300 colonies were enumerated after incubation.

2.2.1 Microbial analysis of paper currencies

Collected currency notes from each vendor were analyzed separately. A total of 40 Notes were separated into denominations of polymer (10, 20, 50 Naira), (22) in all; (9) 100 Naira; (6) 200 Naira; and (3) 500 Naira. Each denomination was aseptically placed into a new Ziploc bag. About 100 mL of peptone water was added and the samples were shaken vigorously for 10 mins in order to dislodge adhering microorganisms. Further serial dilution up to 10^{-4} was performed, plating, incubation and enumeration were as previously described.

2.3 Identification of Isolated Microorganisms

After enumeration, colonies with distinct morphological differences like color, size and shape were randomly selected for further biochemical analyses. Isolates were purified by repeated plating and preserved on Nutrient agar slants and stored at 4°C until characterization was carried out. Isolates were characterized using Gram reaction, motility, sugar fermentation test, MR VP test, citrate utilization test, starch hydrolysis test and catalase test [19].

2.4 Antibiotic Resistance Testing

A total of 13 (5 Gram positive and 8 Gram negative) isolates from food and currency samples were randomly selected and tested for antimicrobial resistance profile. About 5 mL of nutrient broth was inoculated with a loopful of the organism and incubated at 37°C overnight to an inoculum density equivalent to a 0.5 McFarland turbidity standard. Sterile cotton swab was moistened with each isolate and used to swab Muller-Hinton (Biomark, India) agar plates in duplicates. Then, the plates were left to dry for about 5 mins before placing the antibiotics discs (Rapid Labs, UK) on each of the plates as described by [20]. Antibiotic discs and concentrations used were: Ceftazidime (CAZ) – 30 µg; Cefuroxime (CRX) – 30 µg; Gentamicin (GEN) – 10 µg; Cefriaxone (CTR) – 30 µg; Erythromycin (ERY) – 5 µg; Cloxicillin (CXC) -5 µg; Ofloxacin (OFL) – 5 µg; Amoxycillin/ Clavulanate (AUG) -30 µg; Ciprofloxacin (CPR) – 5 µg; Nitrofurantoin (NIT) – 300 µg; and Ampicillin (AMP) – 10 µg. Zoning diameter was taken as the mean zone along the two directions on perpendicular lines using a ruler on the reverse side of the plates and measured in millimeters. In addition, zone size was expressed as susceptible/resistant based on the recommendation of European Committee on Antimicrobial Susceptibility Testing (EUCAST) [21].

2.5 Statistical Analysis

Data collected from microbial load were analyzed using Statistical Package for the Social Sciences

(SPSS) (2011) [22]. Analysis of Variance (ANOVA) was used to evaluate significant differences and separation of the mean values was carried out using Duncan Multiple Range Test at ($p<0.05$).

3. RESULTS AND DISCUSSION

3.1 Microbial Loads of Food and Currency Denomination from Food Vendors

The results of microbial loads of the food samples and currency denominations (Naira) received as change after purchase are presented in Table 2. Overall, all of the samples analyzed in this study had microbial contamination. Ekuru had (1.7×10^8 CFU/g); (1.3×10^7 CFU/g); (1.2×10^7 CFU/g) and (1.9×10^7 CFU/g) for total viable (TVC), Staphylococcal, *Salmonella-Shigella* and fungal counts respectively. While Naira denominations from same vendor ranged from (1.0×10^7 to 1.7×10^7 CFU/g); (5.8×10^6 to 1.6×10^7 CFU/g) and (1.0×10^6 to 1.4×10^6 CFU/g) for TVC, Staphylococcal and Fungal counts respectively. There were no observable enterobacteriaceae growths on the currency denominations.

Food vendor 2, jollof rice sample, TVC was (2.0×10^7 CFU/g), Staphylococcal count was (2.0×10^7 CFU/g), *Salmonella-Shigella* was (1.1×10^7 CFU/g) and fungal count was (9.3×10^6 CFU/g) as shown in Table 2. While for the currency denominations obtained from the vendor, TVC ranged from (4.2 to 5.0×10^6 CFU/g); Staphylococcal count ranged from (1.2 to 2.0×10^6 CFU/g); *Salmonella-Shigella* count ranged between (1.6×10^6 to 3.2×10^6 CFU/g).

There were no observable coliform growth in currency denominations except 200Naira notes which had an average of (1.5×10^5 CFU/g). However, fungal counts ranged between (5.7 and 7.3×10^5 CFU/g). Total viable count from pounded yam sample from food vendor 3 was (4.6×10^7 CFU/g), the total Staphylococcal count was (5.1×10^6 CFU/g) the total *Salmonella-Shigella* count was (5.9×10^6 CFU/g), coliform count was (1.0×10^6 CFU/g) while the total fungi count was (8.5×10^5 CFU/g).

Table 2. Microbial load (CFU/g) of food and currency samples from food vendors

Sample	TVC*	Staph	SS[1]	Coliforms	Fungi
FV1					
Ekuru	$1.7{\pm}0.6^a{\times}10^8$	$1.3{\pm}0.7^a{\times}10^7$	$1.2{\pm}0.2^a{\times}10^7$	NG	$1.9{\pm}0.2^a{\times}10^7$
Currency					
Polymer	$1.7{\pm}0.5^b{\times}10^7$	$1.4{\pm}0.9^a{\times}10^7$	NG	NG	$1.1{\pm}0.4^b{\times}10^6$
200Naira	$1.0{\pm}0.5^b{\times}10^7$	$5.8{\pm}0.4^a{\times}10^6$	NG	NG	$1.0{\pm}0.3^b{\times}10^6$
500Naira	$1.2{\pm}0.8^b{\times}10^7$	$1.6{\pm}0.2^a{\times}10^7$	NG	NG	$1.4{\pm}0.1^b{\times}10^6$
FV2					
Jollof rice	$2.0{\pm}0.3^a{\times}10^7$	$2.0{\pm}0.2^a{\times}10^7$	$1.1{\pm}0.2^a{\times}10^7$	NG	$9.3{\pm}0.2^a{\times}10^6$
Currency					
Polymer	$4.5{\pm}1.2^b{\times}10^6$	$1.2{\pm}0.2^b{\times}10^6$	$3.0{\pm}0.3^b{\times}10^6$	NG	$5.7{\pm}0.6^b{\times}10^5$
200Naira	$4.2{\pm}0.8^b{\times}10^6$	$2.0{\pm}0.3^b{\times}10^6$	$1.6{\pm}0.1^b{\times}10^6$	$1.5{\pm}0.3^b{\times}10^5$	$7.4{\pm}0.3^b{\times}10^5$
500Naira	$5.0{\pm}0.9^b{\times}10^6$	$1.7{\pm}0.5^b{\times}10^6$	$1.6{\pm}0.4^b{\times}10^6$	NG	$6.2{\pm}0.3^b{\times}10^5$
FV3					
Pounded yam	$4.6{\pm}0.5^a{\times}10^7$	$5.1{\pm}0.4^a{\times}10^6$	$5.9{\pm}0.1^a{\times}10^6$	$1.0{\pm}0.8^a{\times}10^6$	$8.5{\pm}0.0^a{\times}10^5$
Currency					
100Naira	$9.3{\pm}0.4^a{\times}10^6$	$2.8{\pm}0.8^b{\times}10^6$	$1.7{\pm}0.8^b{\times}10^6$	$1.0{\pm}0.0^b{\times}10^4$	$1.4{\pm}0.1^c{\times}10^5$
200Naira	$3.2{\pm}0.2^a{\times}10^7$	$2.1{\pm}0.2^b{\times}10^6$	$5.6{\pm}0.8^b{\times}10^5$	$9.0{\pm}0.1^b{\times}10^4$	$2.5{\pm}0.4^b{\times}10^5$
500Naira	$2.4{\pm}0.1^a{\times}10^7$	$1.9{\pm}0.3^b{\times}10^6$	$1.3{\pm}0.8^b{\times}10^6$	$5.0{\pm}0.0^b{\times}10^3$	$1.3{\pm}0.0^c{\times}10^5$
FV4					
Suya	$1.3{\pm}0.4^a{\times}10^8$	TNTC	$5.7{\pm}0.6^a{\times}10^7$	$3.1{\pm}0.6^a{\times}10^5$	NG
Currency					
Polymer	$2.8{\pm}0.6^b{\times}10^6$	$1.7{\pm}0.1{\times}10^6$	NG	$3.7{\pm}0.2^b{\times}10^5$	ND
100Naira	$6.0{\pm}0.6^b{\times}10^6$	TNTC	NG	$6.5{\pm}0.8^b{\times}10^4$	ND
200Naira	$3.0{\pm}0.4^b{\times}10^6$	$1.2{\pm}0.8{\times}10^7$	$4.9{\pm}0.1^b{\times}10^5$	$6.8{\pm}0.6^b{\times}10^5$	ND

FV= Food vendor; TVC= Total viable count; SS= Salmonella –Shigella; NG= No growth; ND= not determined; TNTC= Too numerous to count; Polymer notes included: 10, 20 and 50 Naira notes. Values are mean ± SD of duplicate; Duncan separation of means with same alphabets are not different (P =< .05) in each column*

For the change obtained from the vendor after purchase, the counts ranged from (9.3×10^6 to 2.4×10^7 CFU/g); (1.9 to 2.8×10^6 CFU/g); (5.6×10^5 to 1.7×10^6 CFU/g); (5.0×10^3 to 9.0×10^4 CFU/g) and (1.4×10^5 to 2.5×10^5 CFU/g) for TVC, Staphylococcal, *Salmonella*-*Shigella*, Coliform and fungal counts respectively. From food vendor 4, suya sample had total viable count of (1.3×10^8 CFU/g), staphylococcal count was too numerous to count (TNTC), *Salmonella-Shigella* count was (5.7×10^7 CFU/g) and total coliform count of (3.1×10^5 CFU/g) while there was no observable fungal growth For the currency notes obtained, the counts ranged from (2.8 to 6.0×10^6 CFU/g) for total viable count; (1.7×10^6 CFU/g to TNTC) for Staphylococcal count; (6.5×10^4 CFU/g to 6.8×10^5 CFU/g) for coliform count. Previous studies conducted on Ethiopian and Ghana currencies by Girma et al. [23] Amankwah Kuffour et al. [24] who collected from food vendors selling various foods indicated that currencies are contaminated with various pathogenic microorganisms. Both authors concluded that paper currencies are sources of contaminants into street vended foods. Furthermore, the species of microorganisms reported included *Salmonella, E. coli, Coliforms and Staphylococci.* However, the different food items were not analyzed, while this study collected food and currencies from the various vendors and the results concur with other works.

Food handling personnel play important roles in ensuring food safety throughout the food chain of production, processing, storage and distribution. Mishandling and wanton disregard of hygienic measures on the part of the food vendors have been reported to introduce contaminants and pathogens that survive and multiply in sufficient numbers to cause illness in the consumers [25, 26,27,28]. The proper preparation of foods in advance of consumption, exposure to unclean environment, holding at ambient temperature conducive for microbial multiplication coupled with the rich nutrient medium of these foods are factors that increase microbial loads of the samples [29]. Microbial guideline for cooked foods stipulates that "plate counts must be less than 1.0×10^7CFU/g for meat; 1.0×10^4 for plant products [30]. The microbial loads of the food samples were higher than the stipulated, hence, consumption of the foods constitute health risk to consumers. It can be adjudged that the street foods obtained in this study are not bacteriologically fit for consumption. Thus, it calls for improvement in awareness at all levels, especially among personnel working in food establishments, on the possible health risks associated with poor handling of paper currencies while serving/preparing foods. Consequently, the combination of the widespread use of paper currencies and their constant exchange make them a likely agent for various disease transmissions since communicable diseases can spread through contact with fomites [23]. Furthermore, a study revealed that paper currencies can serve as an ideal breeding ground for microorganisms [31]. Pieces of money are in continuous circulation, passing in all environments that constitute a reservoir of various bacteria some of which can survive. Paper currency absorb moisture which encourages the growth of microorganisms on them. Fungi get into money especially from air, soil and where it is kept (for instance, sacks pockets and socks). Money is contaminated as it circulates from hand to hand [32]. Besides reducing the life span of the notes, some of these fungi have the potential to cause skin, eye and gastrointestinal infections [33,34], infections of internal organs [35,36] as well as serious diseases of the respiratory tract [37] in man. In Nigeria, currency notes are often manhandled and mutilated by different categories of people, including traders, churches, beggars and commuter bus conductors [38].

3.2 Identification of Microorganisms

A total of 50 isolates were recovered from all the street food and currency denominations.

3.2.1 Isolates from food samples

Five genera of bacteria were isolated and identified from food sample from food vendor 1 while 4 genera were found on the various currency denominations (Figs. 1a and 1b).The genera included: *Staphylococcus, Klebsiella, Bacillus, Proteus, Yersinia, Enterobacter and Salmonella.* At least 3 bacteria genera were found in common from food vendor 1.

From the second food vendor selling jollof rice, 5 and 7 bacterial genera were identified from food and currency denominations respectively. Pounded yam (FV3) and suya (FV4) vendors had more diversed contaminants of 7 genera in the foods. The organisms isolated were observed to be similar to those isolated by Adamu et al. [39]. *Shigella*, *Klebsiella* spp*. E. coli*, *Staphylococcus aureus* and *Staphylococcus* spp. were isolated in the food samples. According to Asogwa et al. [40], during preparation and vending, food items

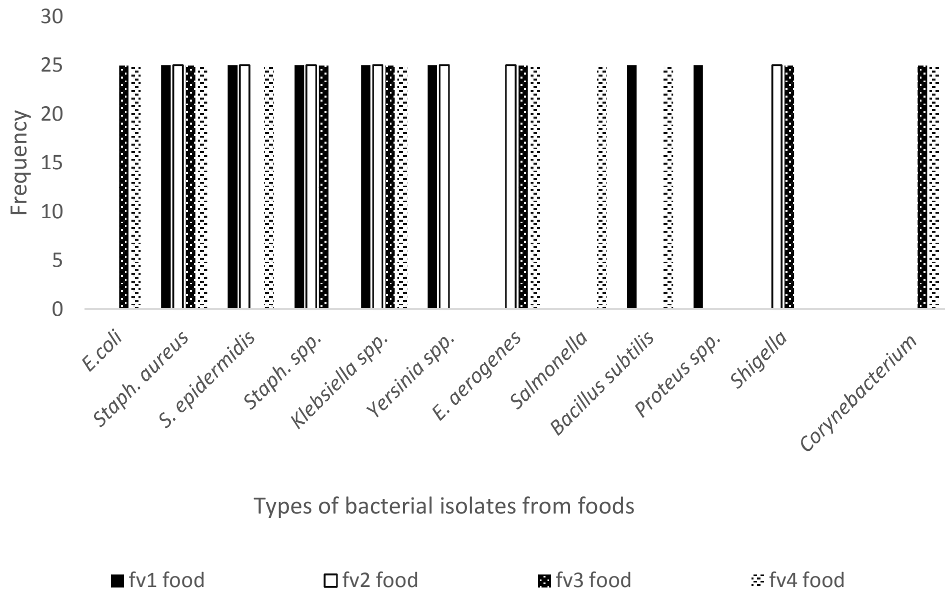

Fig. 1a. Types and frequency of isolation of bacteria from foods (ekuru from food vendor 1; jollof rice from food vendor 2; pounded yam from food vendor 3; and suya from food vendor 4)

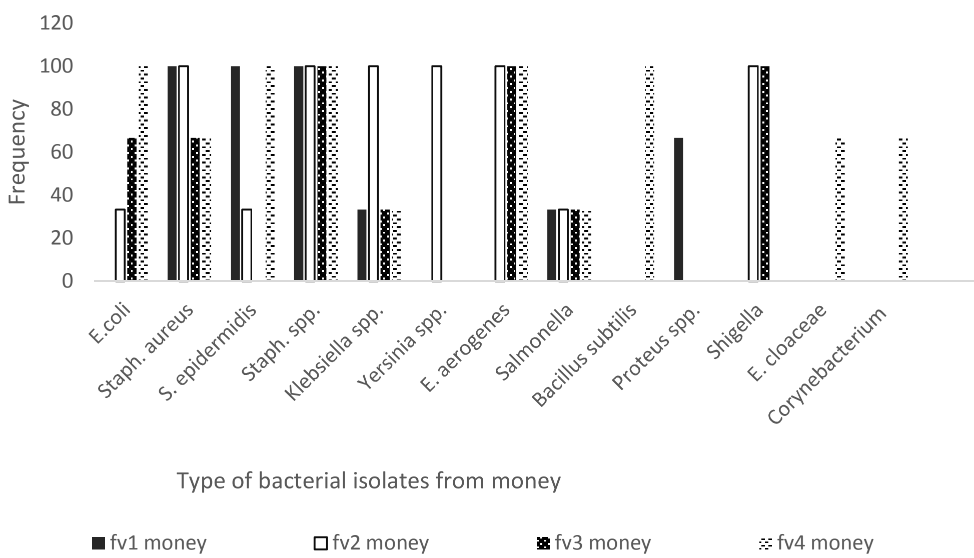

Fig. 1b. Types and frequency of isolation of bacteria from currency denominations received as change from food vendors

like raw meat for 'suya' (roasted pieces of meat attached to a stick) and salad raw materials were prepared using the same knife without in-between washing. After cooking or roasting, foods are continuously exposed to open environment for quick sale and are often invaded by flies [40], and this was also observed in this study.

Table 3. Antibiotics resistance profile of selected foodborne and currency denomination isolates

Antibiotics	*S. epidermidis* (+)		*Coryne bact.* (+)		*B. subtilis* (+)		*S. aureus* (+)		*Staph.* spp. (+)		*P. aeruginosa* (-)		*Klebsiella* spp. (-)		*E. coli* (-)		*E. aerogenes* (-)		*E. cloacae* (-)		*Salmonella* spp. (-)		*Yersinia* (-)		*Proteus* spp.(-)	
	MIC*[1]	**I***	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**	**MIC**	**I**
CAZ	NBP		NBP		-		NBP		NBP		>8	R	>4	R	>4	R	>4	R	>4	R	>4	R	>4	I	>4	R
CRX	NBP		NBP		-		NBP		NBP		NBP		>8	S	>8	S	>8	R	>8	R	>8	S	>8	S	>8	R
GEN	>1	S	>1	R	-		>1	R	>1	R	>4	R	>4	S	>4	R	>4	R	>4	S	>4	S	>4	R	>4	S
CTR	NBP		NBP		-		NBP		NBP		NT		NT		NT		NT		NT		NT		NT		NT	
ERY	>2	S	NBP		-		>2	R	>2	R	NT		NT		NT		NT		NT		NT		NT		NT	
CXC	NBP		≤1	R	-		NBP		NBP		NT		NT		NT		NT		NT		NT		NT		NT	
OFL	>1	R	NBP		-		>1	R	>1	S	NBP		>0.5	R	>0.5	R	>0.5	R	>0.5	R	>0.5	S	>0.5	R	>0.5	R
AUG	NBP		>1	R	-		NBP		NBP		NBP		>8	R	>8	R	>8	R	>8	R	>8	S	>8	R	>8	R
AMP	NT		NT		NT		NT		NT		NBP		>8	R	>8	R	>8	R	>8	R	>8	R	>8	R	>8	R
NIT	NT		NT		NT		NT		NT		NBP		>64	S	>64	S	>64	S	>64	S	>64	S	>64	R	>64	S
CPR	NT		NT		NT		NT		NT		>0.5	R	>0.5	R	>0.5	R	>0.5	R	>0.5	R	≤0.06	S	>0.5	R	>0.5	R

MIC[1] = Minimum inhibition concentration; I* = Interpretation; CAZ= Ceftazidime; CRX= Cefuroxime; GEN= Gentamicin; CTR= Cefriaxone; ERY= Erythromycin; CXC= Cloxicillin; OFL= Ofloxacin; AUG= Amoxycillin/ Clavulanate; CPR= Ciprofloxacin; NIT= Nitrofurantoin; and AMP= Ampicillin; R=Resistant; S= Susceptible; NT = Not tested; NBP = No Breakpoint*

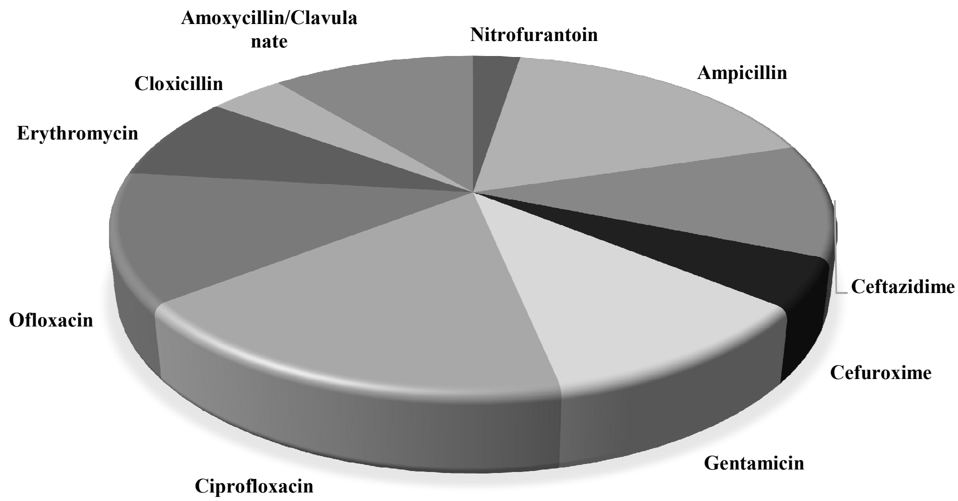

Fig. 2. Antibiotic resistance profile of bacterial isolates from Street vended foods and money

3.3 Antibiotics Resistance Profile of Isolates

Microbial strains showed varied resistance patterns to the different antibiotics screened. C*orynebacterium, S. aureus, E. coli, E. aerogenes, E. cloaceae, Yersinia and Proteus* were multidrug resistant, since multidrug resistance was defined as resistance to ≥3 of the antimicrobial agents tested. It was further observed that Five Gram positive and 8 Gram negative bacteria were randomly selected for antimicrobial resistance profile from foods and currency denominations received as change from Street food vendors. Results presented in Table 3 indicate that out of the Gram positive bacteria, *Corynebacterium* spp. and *Staphylococcus aureus* were resistant to 3 of antibiotics. Corynebacterium was resistant to gentamicin (GEN), cefuroxime (CRX) and Amoxicillin/Clavulanate (AUG). While *S. aureus* was resistant to Gentamicin (GEN), Erythromycin (ERY) and Ofloxacin. For the Gram negative bacteria, all of the isolates except *Salmonella* spp. were multi-drug resistant, ranging from 3 to 7 antibiotics. E. aerogenes was resistant to seven antibiotics. The majority of Gram negative bacteria were resistant to Ceftazidime (CAZ), Ofloxacin (OFL), Amoxicillin/Clavulanate (AUG), ampicillin (AMP), Ciprofloxacin (CPR), but susceptible to Nitrofurantoin (NIT). The percent resistance for Ampicillin and Ciprofloxacin were (87.5%), Ofloxacin (61.5%), Ceftazidime, Gentamicin and Amoxycillin/Clavulanate were (53.8%) (Fig. 2).

Studies have shown that different genera show varied resistance patterns to different compounds found in antibiotics. For example, *Corynebacterium* though could be considered as opportunistic bacteria has antibiotic resistant genes on large plasmid and could therefore show resistance to Tetracycline, Chloramphenicols, Erythromycin, Fluoroquinolones and more [41]. *Enterobacter* species are resistant to Ampicillin, Amoxicillin-Clavulanic acid and Cephalothin because of production of Cephalosporinase [42]. Furthermore, enzymatic resistance to Fluoroquinolones (ciprofloxacin) was elucidated recently by Huang et al. [43], and the isolates from this study also show resistance.

4. CONCLUSION

The microbial load of all the foods in this study exceed the stipulated limit for ready-to-eat foods, thereby making consumption of these foods of safety and public health concern. Suya and ekuru food samples had higher microbial loads, followed by pounded yam and jollof rice samples. Some of the organisms isolated from the money samples were also found in the food samples, this could be an indication of cross contamination between money and food. Gram negative isolates were found to have higher drug resistance than the Gram positive isolates. Also, some of the organisms were found to be multidrug resistant. Most of the isolated organisms in this study were resistant to Ceftazidime (30 µg) while *Yersinia* was resistant to most of the drugs. Proper washing of hands with running water in between food activities; use of antimicrobial agents such as hand sanitizers, antiseptics and cleaning agents should be encouraged to prevent cross contamination during food handling. Basic training in food and personal hygienic and environmental management is recommended to ensure that food vendors follow the required rules for proper hygiene and sanitation. Policies should be enforced to improve food safety, while customers/ consumers are also encouraged to wash hands frequently and in between food handling activities and after handling money in order to reduce the prevalence of foodborne diseases.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Muleta D, Ashenafi M. *Salmonella, Shigella* and growth potential of other foodborne pathogens in Ethiopian street vended foods. East African Medical Journal. 2001;78:576-580.
2. Chukuezi CO. Food safety and hygienic practices of street food vendors in Owerri, Nigeria. Studies in Sociology of Science. 2010;1:50-57.
3. FAO. Street foods: Report of FAO expert consultation. Jogjakarta, Indonesia. FAO Nutrition. 1990;46:3-30.
4. Umeh EU, Juluku JU, Ichor T. Microbial contamination of Naira (Nigerian Currency) notes in circulation. Research Journal of Environmental Sciences. 2007;1:336-339.
5. Xu J, Moore JE, Millar BC. Ribosomal DNA (rDNA) identification of the culturable bacterial flora on monetary coinage from 17 currencies. Journal of Environmental Health. 2005;67:1-7.
6. Barro N, Ouattara CAT, Nikiéma P, Ouattara AS, Traoré AS. Evaluation de la qualité microbiologique de quelques aliments de rue dans la ville de Ouagadougou au Burkina Faso. Cah. Santé. 2002a;12:369-374.
7. Barro N, Nikiéma P, Ouattara CAT, Traoré AS. Evaluation de l'hygiène et de la qualité microbiologique de quelques aliments rue et les caractéristiques des consommateurs dans les villes de Ouagadougou et de Bobo-Dioulasso (Burkina Faso). Revue Scientifique et Technique Sci. Santé. 2002b;25:7-21.
8. Prasai T, Yami KD, Joshi DR. Microbial load on paper/polymer currency and coins. Nepal Journal of Science Technology. 2008;9:105-109.
9. Bryan FL, Teufel P, Riaz S, Roohi S, Qadar F, Malik Z. Hazards and critical control points of street-vending operations in a mountain resort town in Pakistan. Journal of Food Protection. 1992;55:701–707.
10. Ashenafi M. Bacteriological profile and holding temperature of ready-to-serve food items in an open market in Awassa, Ethiopia. Tropical Geographical Medicine. 1995;47:1-4.
11. WHO. The role of food safety in health and development: Report of a joint FAO/WHO Expert Committee on Food Safety. Technical Report Series. 1984;705.
12. El-Sherbeeny MR, Saddik MF, Bryan FZ. Microbiological profiles of food served by street vendors in Egypt. Internatonal Journal of Food Microbiology. 1985;2:355-362.
13. Saddik MF, El-Sherbeeny MR, Mousa BM, El-Akkad A, Bryan FL. Microbiological profile and storage temperatures of Egyptian fish and other sea foods. Journal of Food Protection. 1985;48:403-406.
14. Abdussalam M, Kaferstein FK. Safety of street foods. World Health Forum. 1993;14:191-194.
15. FAO. Street foods. FAO report, Rome. 1997;1-4.
16. Uraku AJ, Obaji PI, Nworie A. Potential risk of handling Nigerian currency notes. International Journal of Advanced Biological Research. 2012;2:228-233.
17. Ajayi OA, Oluwoye JO. Sustainable street vended foods and food safety: A conceptual framework. International Journal of Food Safety, Nutrition and Public Health. 2015;5:195-216.
18. Davis MA, Hancock DD, Besser TE, Rice DH, Gay JM, Gay C. Changes in antimicrobial resistance among *Salmonella enterica* serovar. Infectious Disease. 1999;5:802-806.
19. Pollack RA, Findlay L, Mondschein W, Modesto RR. Laboratory exercises in microbiology, 2nd Edition. USA. John Wiley and Sons Inc.; 2002.
20. Bauer AW, Kirby WMM, Sherris JC, Turk M. Antibiotic susceptibility testing by a

standardized single disk method. American Journal of Clinical Pathology. 1996;45: 493–496.

21. European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 7.1, valid from; 2017.
22. SPSS Inc. IBM SPSS Statistic 20.0. Chicago, IL, USA; 2011.
23. Girma G, Bacha K, Ketema T. Microbial load and safety of paper currencies from some food vendors in Jimma Town, Southwest Ethiopia. Biomedcentral Research Notes. 2014;7:843.
24. AmankwahKuffour R, Dwumfour-Asare B, Kuffour C. Currency notes as pathogenic risk sources for street foods in Ghana: A study at a suburb of Kumasi City. International Journal of Health Sciences and Research. 2015;5:336-345.
25. WHO. Health surveillance and management procedures for food handling personnel. WHO Technical Report Series. 1989;785:52.
26. Greig JD, Todd ECD, Bartleson CA, Micheals BS. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 1. Description of the problem, methods and agents involved. Journal of Food Protection. 2007;70:1752-1761.
27. Todd ECD, Greig JD, Bartleson CA, Micheals BS. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 2- Description of outbreaks by size, severity, and settings. Journal of Food Protection. 2007a;70:1975-.
28. Todd ECD, Greig JD, Bartleson CA, Micheals BS. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 3- Factors contributing to the outbreaks and description of outbreak categories. Journal of Food Protection. 2007b;70:2199-2217.
29. Food Safety Research Information Office A focus on hazard anaysis and critical control points; 2003.
30. Gilbert RJ, de Louvois J, Donovan T, Little K, Nye C, Ribeiro CD, Richards J, Roberts D, Bolton FJ. Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. Communicable Disease and Public Health. 2000;3:163-167.
31. Ayandele AA, Adeniyi SA. Prevalence and antimicrobial resistance pattern of microorganisms isolated from Naira notes in Nigeria. Nigerian Journal of Research Biology. 2011;8:587–593.
32. Okungbowa FI, Dede APO. Fungal flora of Nigerian currency notes in circulation in Benin City, Nigeria. Indian Journal of Microbiology. 2010;50:139–141.
33. Michaels B. Handling money and serving ready-to-eat food. Food Service Technology. 2002;2:1–3.
34. Basavarajappa KG, Rao PN, Suresh K. Study of bacterial, fungal and parasitic contamination of currency notes in circulation. Indian Journal of Pathology Microbiology. 2005;48:278–279.
35. Yildiran ST, Mutlu FM, Saracli MA, Uysal Y, Gonlum A, Sobaci G, Sutton DA. Fungal endophthalmitis caused by *Aspergillus* ustus in a patient following cataract surgery. Medical Mycology. 2006;44:665–669.
36. Singh N, Limaye AP, Forrest G, Safdar N, Munoz P, Pursell K, Houston S, Rosso F, Montoya JG, Patton PR, Busto RD, Aguado JM, Wagener MM, Husain S. Late – onset invasive aspegillosis in organs transplant recipients in the current era. Medical Mycology. 2006;44:445–449.
37. Denning DW. *Aspergillus* and aspergillosis – Progress on many fronts. Medical Mycology. 2006;44:Supplement 1.
38. Olasupo NA, Olukoya DK, Niemogha MT, Olatunde OO. Bacterial flora of dirty naira notes. The Nigeria Medical Practices. 1992;38:4–8.
39. Adamu JY, Ameh JY, Agbo J. Bacterial contaminants of nigerian currency notes and associated risk factors. Research Journal of Medical Sciences. 2012;6:1-6.
40. Asogwa FC, UgwuOkechukwu PC, Alum EU, EgwuChinedu O, Edwin N. Hygienic and sanitary assessment of street food vendors in selected towns of Enugu North District of Nigeria. American-Eurasian Journal of Scientific Research. 2015; 10:22-26.
41. Oliveira A, Oliveira LC, Aburjaile F, Silva A, Figueiredo HCP, Ghosh P, Portela RW, Azevedo VAD, Wattam AR. Insight of genus Corynebacterium: Ascertaning the role of pathogenic and non-pathogenic species. Frontiers Microbiology. 2017; 8:1937.

42. Davin-Regli A, Pagès JM. *Enterobacter aerogenes* and *Enterobacter cloacae*; Versatile bacterial pathogens confronting antibiotic treatment. Frontier Microbiology. 2015;6:392.
43. Huang S, Dai W, Sun S, Zhang X, Zhang L. Prevalence of plasmid-mediated quinolone resistance and aminoglycoside resistance determinants among carbapeneme non-susceptible *Enterobacter cloacae*. Plos One. 2012; 7(10):e47636.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/45662