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Microbial Contamination and Antibiotic Resistance in Enteric Pathogens Isolated from Cooked Foods Sold in Eateries in Ado-Ekiti, Nigeria

O. A. Oluyege[1*] and O. Famurewa[1]

[1]*Department of Microbiology, Ekiti State University, P.M.B. 5363, Ado-Ekiti, 360001, Nigeria.*

Authors' contributions

Authors OAO and OF designed the study, author OAO performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author OAO managed the analyses of the study. Authors OAO and OF managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: There are indications that some ready-to-eat or street vended foods are of low microbial quality with varying degree of contaminations. The contaminants may include antibiotic-resistant bacteria that may further be spread through consumption of such foods which has epidemiological and public health implications. This study therefore, was aimed at investigating the microbial quality of ready-to-eat cooked foods sold in eateries in Ado-Ekiti, Nigeria and to determine the susceptibility of the isolates to antibiotics.
Methods: We evaluated bacterial contamination of ready-to-eat cooked foods using total bacteria plate counts (TPC) and total coliform counts (TCC). Susceptibility of isolates to antibiotics was tested using the disc diffusion method.
Results: The overall mean TPC and TCC of cooked food samples ranged from 4.96±1.01 $\log_{10}$ cfu/g to 5.34±0.06 $\log_{10}$ cfu/g for both. There was no significant difference (≤ 0.05) in the overall mean TPC and TCC of the various cooked food samples from the three categories of sampling sites. The cooked foods examined were contaminated with a total of 129 enteric bacterial species

**Corresponding author: Email: aooluyege@yahoo.com;*

belonging to 7 genera with *E. coli* (31.8%) being the most prevalent, followed by *Klebsiella* sp. (19.4%), *Proteus* sp. (17.1%), *Salmonella* (14.0%), *Pseudomonas* sp. (12.4%), *Shigella* sp. (3.8%) and *Enterobacter* sp. (1.6%) in that order. Resistance to antibiotics was very high (94.0%) and resistance to amoxicillin (89.1%) was the highest, and least to nalidixic acid (23.1%) while none of the isolates was resistant to ofloxacin. More than 50% of these isolates were resistant to six of the eight antibiotics tested and 26 different antibiotic resistance phenotypes were obtained. The most common phenotype observed was AMX/GEN/AUG. The results suggest that contaminated ready-to-eat (RTE) food sold in eateries can be a major source of antibiotic-resistant organisms in the study area.

Conclusion: Most of the food samples investigated was contaminated in varying degrees with pathogenic, opportunistic pathogenic bacteria and other bacterial indicators of contamination. There was an overall high rate of resistance to antibiotics with equally high rate of multiple antibiotic resistance (MAR) among the bacterial contaminants. This portent high risks of further spread of antibiotic resistance in the community and environment. Further study will hopefully help to determine the presence of resistance genes and or mode of resistance among the MAR organisms.

Keywords: Microbial contamination; ready-to-eat foods; antibiotic resistance; enteric bacteria; food canteens; street-vended foods; food safety.

1. INTRODUCTION

Food contamination with antibiotic-resistant bacteria can be a major threat to public health, as the antibiotic resistance determinants can be transferred to other pathogenic bacteria, potentially compromising the treatment of severe bacterial infections [1,2]. Antimicrobial-resistant bacteria have been recovered from a wide variety of foods, which included vegetables [3], meat and meat products [4,5,6]. The prevalence of antimicrobial resistance among food-borne pathogens has been on the increase [7-11] and is emerging as a major public health concern [12,13].

Contamination of ready-to-eat (RTE) food with high numbers of such organisms even where they are non-pathogenic is of serious concern since such foods are consumed without further heat treatment to destroy the contaminants. Furthermore, food bought from street vendors has been associated with diarrhoea and other illnesses in Nigeria [14-19].

Street vended or RTE foods are good sources of nourishment and a major source of income and livelihood for a vast number of individuals globally, and particularly among women [20]. They provide opportunity for self-employment as well and development of business skills with low capital investment. In contrast to these potential benefits, it is also recognized that street vended or RTE foods are a major public health risk [21-24]. Majority of those who eat out are only concerned with satisfying hunger and some time, pleasure, and do not give due consideration to the safety of the food in terms of microbial quality and or it is assumed that such foods are safe. Although RTE cooked foods have received some form of heat treatment, the organisms found are mainly those that gained entry during further manipulation of the food or as a result of post-processing contamination [24]. Nesbitt et al. [25] opined that demographics, lifestyles and eating habit as well as food choices and food preparation influence or affect food-borne illnesses.

Several investigations have been carried out on the microbial quality of RTE foods retailed in low income restaurants. However, there is paucity of information on the antimicrobial resistance and the potential risks associated with the consumption of foods contaminated with antibiotic-resistant bacteria particularly in the present study area. This study therefore examined the microbial quality of RTE from eateries and food outlets in Ado-Ekiti, Nigeria. Resistance to antibiotic among the bacteria recovered was also determined.

2. MATERIALS AND METHODS

2.1 Collection and Processing of Food Samples

Samples of various ready-to-eat food items were purchased from different eateries, and low income restaurants were processed as described by Famurewa and Moro [26]. Total aerobic and coliform counts were determined on Standard plate count agar and Violet Red Bile, respectively using the spreading technique. After incubation for 24 hours at 37ºC, the colonies were counted. The mean count was estimated as the bacterial population of the specimen, and was expressed as the colony-forming unit per gram (cfu/g) of food. Isolation of enteric bacterial pathogens was carried out on MacConkey agar (MCA) and *Salmonella*-*Shigella* agar (S-S agar), (Oxoid, Basingstoke, Hampshire, UK). All isolates were identified according to Barrow and Felthan [27].

2.2 Antibiotic Sensitivity Test

The disk diffusion method was used for susceptibility testing on Müller-Hinton (Fluka, UK) agar plates as recommended by Clinical and Laboratory Standard Institute [28]. The commercially prepared antibiotic disks (Abtek Biologicals Limited) used and their concentrations (g) are as follows: amoxicillin (25), gentamicin (10), cotrimoxazole (25), nitrofurantoin (30), nalidixic acid (acid), ofloxacin (5), augmentin (30) and tetracycline (30). The antibiotic from the discs was allowed to diffuse into the agar medium for about 30 minutes at room temperature after which the plates were incubated at 37°C for 18 hours. The plates were subsequently examined for zones of inhibition and evaluated according to CLSI [28].

2.3 Statistical Analysis

The mean values of data obtained were analyzed statistically using analysis of variance (ANOVA) at 5% level of significance with the aid the Statistical Package for Social Sciences (SPSS) version 17.0.

3. RESULTS

3.1 Types of Foods and Food Outlets

A total of 168 types of cooked food samples made up of solid indigenous food including *iyan* (pounded yam), *eba* (fermented grated cassava meal dumplings), *amala* (yam powder dumplings) and *fufu* (cassava dough dumplings), legumes and cereals (white rice, fried rice, rice and beans) sold in 55 public eating places were examined in this study. Ninety seven food samples were obtained from *bukaterias* (local eating centres), 39 from canteens and 32 from restaurants (Table 1).

3.2 Total Plate Count (TPC) and Total Coliform Count (TCC) of Cooked Food Samples

The mean TPC and TCC of the various foods examined are shown in Table 2. Overall mean by source showed that Canteen (5.21±0.17 $\log_{10}$ cfu/g) and Restaurant (4.99 ±0.65 $\log_{10}$ cfu/g) had the highest and lowest TPC respectively while overall mean by food type indicated that *Amala* (5.34±0.06 $\log_{10}$ cfu/g) and *Iyan* (4.96±1.01 $\log_{10}$ cfu/g) had the highest and lowest TPC respectively in the *buketarias* and canteens examined. It shows that *amala* had the highest mean TPC value of 5.34±0.006 and 5.39±0.04 $\log_{10}$ cfu/g respectively. Among the restaurant samples, *eba* had the highest mean TPC value of 5.35±0.34 $\log_{10}$ cfu/g while. On the basis of the source of samples, the highest overall mean of 5.21±0.17 $\log_{10}$ cfu/g was obtained among the canteen samples. Furthermore, in all the three sites examined, *amala*, had the highest mean TCC in each site with an overall mean of 5.34±0.06 $\log_{10}$ cfu/g. On the basis of source, samples from the *buketarias* had the highest overall mean TCC of 3.81±1.25 $\log_{10}$ cfu/g while those from the restaurants had the lowest overall mean 3.36±1.43 $\log_{10}$ cfu/g (Table 3). Multiple comparison of the mean TPC and TCC of the various samples showed that there was no statistically significant difference in the overall mean count of food items based on the source of purchase of the food samples.

Table 1. Distribution of the food samples and public eating places examined in Ado-Ekiti

Category of eating places (n)	Indigenous foods				Common food			Total
	Eba	Fufu	Amala	Iyan	Rice	Fried Rice	Rice and Beans	
Bukateria (30)	27	23	17	16	8	-	6	97
Canteen (12)	10	8	4	5	6	3	3	39
Restaurant (13)	7	5	2	6	6	4	2	32
Total (55)	44	36	23	27	20	7	11	168
%age of total sample	26.2	21.4	13.7	16.1	11.9	4.2	6.5	100

(n) Number of food outlets

However, multiple comparisons of food types and source showed statistically significant difference in *eba* versus *iyan*, *fufu* versus *amala*, *amala* versus *iyan*, white rice and beans versus *iyan* (≤ 0.05).

3.3 Distribution of Enteric Bacteria Isolated from Cooked Food Samples

A total of 129 bacterial species belonging to 7 genera were identified as enteric organisms in the ready-to-eat food samples from 55 different public eating places in Ado-Ekiti. In all the different categories of food examined, *E. coli* had the highest occurrence of 41 (24.4%) followed by *Klebsiella* sp. 25 (14.9%) and *Proteus* sp. 22 (13.1%). *Pseudomonas* sp. occurred in 16 (9.5%), *Salmonella* sp. 18 (10.7%), *Shigella* sp. and *Enterobacter* sp. were recovered from 5 (3.0%) and 2 (1.2%) of the samples, respectively (Table 3). *Eba* was the most commonly contaminated food with a total number of 34 (77.3%) bacterial species, followed by *fufu* and *iyan* with a total of 30 (23.3%) and 19 (14.7%) enteric bacterial species respectively, while rice, fried rice and rice and beans had 11.6, 3.8 and 7.0% contamination rate respectively (Table 3).

Escherichia coli was detected in all the different types of foods except fried rice and white rice and beans while *Salmonella* sp. was detected in all the food types except fried rice. *Shigella* sp. was also recovered from all except the food samples containing rice. *Enterobacter* spp. on the other hand was found only in *fufu* and fried rice samples in very low numbers (Table 3).

3.4 Antibiotic Susceptibility of Enteric Bacteria Isolated

Out of the 78 bacterial isolates examined for susceptibility to 8 antibiotics, 73 (94.0%) were resistant to at least one antibiotic. Resistance to amoxicillin (89.1%) was the highest, followed by augmentin (76.8%), gentamicin (71.8%), tetracycline (67.9%), nitrofurantoin (55.1%), otrimoxazole (53.9%) and nalidixic acid (23.1%) while none of the isolates was resistant to ofloxacin (Table 4).

Multiple antibiotic resistance (MAR) was recorded in 85.0% of the isolates; of the eight antibiotics tested 16 (21.0%) were resistant to 3 antibiotics, 8 (10.0%) to 4, 17 (22.0%) to 5, 9 (12.0%) to 6 and 16 (22.0%) to 7 with 26 different antibiotic resistance phenotypes recorded (Table 5). The commonest phenotype observed was AMX/GEN/AUG, which occurred in 10 strains of *E. coli*.

4. DISCUSSION

Microbial contamination is an indicator of the degree of safe handling of food which is a globally recognized vehicle for transmission of pathogens [15,29-32]. Food hygiene has been largely neglected in the study area despite the fact that it is the most important component, essential to health and productivity of individuals and the community at large [16,33]. In this study, bacterial load was adopted as a measure of the microbial quality of food vended or served to the general populace.

All the food items examined in this study were contaminated in varying degrees (Table 2) and can be categorized as *not satisfactory* in terms of microbial quality. This agrees with reports of several investigators that street vended foods in some African and low resources countries contained enteric pathogens in significant proportion [12,19,31,34-36].

The high bacterial counts observed in the foods sold generally in eateries and other various food centers examined in this study is of serious public health concern. The presence of coliform bacteria in almost all food samples may be an indication of unhygienic handling of the food after cooking and or lack of good manufacturing practices which may account for post-processing contamination recorded in this study. It is also an indication of post-processing fecal contamination due to poor handling. Food handlers are normally directly responsible for contamination of foods with enteric pathogens in particular, during preparation, post-processing handling and cross-contamination owing also to attitude of the food handler/vendors [16,17,19,36,37]. Food handlers who are carriers of some pathogens, and those with poor personal hygiene have been associated with post-processing contamination of foods with various etiologic agents [26,31,36,38-41]. This highlights the epidemiological significance of the role of food handlers or vendors in food-borne illnesses worldwide.

Table 2. Total plate counts and total coliform counts (log_{10}cfu/g) of cooked food from different sources in Ado-Ekiti

Food samples	Source of samples						Overall mean	
	Bukateria		Canteen		Restaurant			
	TPC	TCC	TPC	TCC	TPC	TCC	TPC	TCC
Eba	5.07±1.02	3.72±1.36	5.26±0.18	4.19±0.15	5.35±0.34	3.27±1.54	5.13±0.82	5.13±0.82
Fufu	5.26±0.12	3.70±1.23	5.18±0.14	2.90±1.84	3.75 ±0.81	2.09±1.95	5.03±0.60	5.03±0.60
Amala	5.34±0.06	4.35 ±0.07	5.39±0.04	4.49±0.08	5.30±0.02	4.36± 0.01	5.34±0.06	5.34±0.06
Iyan	4.85±1.30	3.08±1.86	5.06±0.17	2.68±1.59	5.19±0.27	3.56±1.01	4.96±1.01	4.96±1.01
Rice	5.27±0.08	4.26±0.14	5.15±0.16	2.45±1.97	5.09±0.24	3.24±1.66	5.18±0.17	5.18±0.17
Rice and beans	5.22±0.12	4.27±0.08	5.30±0.10	4.17±0.15	5.20 ±0.06	4.22±0.14	5.24±0.10	5.24±0.10
Fried rice	NA	NA	5.21±0.09	4.28±0.15	5.22±0.11	4.14±0.08	5.22±0.09	5.22±0.09
Overall Mean	5.16±0.76	3.18 ±1.25	5.21±0.17	3.48±1.44	4.99 ±0.65	3.36±1.43	5.13±0.65	5.13±0.65

cfu/g colony forming unit per gram; TPC Total Plate Count; TCC Total; Coliform Count;
±SD Standard deviation; NA not available

Table 3. Distribution of enteric organisms isolated from cooked food samples in Ado-Ekiti

Bacteria	Type of food							Total n=168
	Eba n=44	***Fufu*** n=36	***Amala*** n=23	***Iyan*** n=27	**White rice** n=20	**Fried rice** n=7	**White rice and beans** n=11	
Escherichia coli	11 (25.0)	11 (30.6)	6 (26.1)	7 (25.9)	6 (30.0)	0	0	41 (24.4)
Klebsiella sp.	7 (15.9)	4 (11.1)	1 (4.3)	4 (16.7)	3 (1.5)	1 (14.3)	5 (45.5)	25 (14.9)
Proteus sp.	5 (11.4)	5 (13.9)	4 (17.4)	1 (3.7)	3 (1.5)	2 (28.6)	2 (18.2)	22 (13.1)
Pseudomonas sp.	4 (9.1)	2 (5.6)	3 (13.0)	4 (14.8)	1 (5.0)	1 (14.3)	1 (9.1)	16 (9.5)
Salmonellas sp.	6 (13.6)	6 (16.7)	1 (4.3)	2 (7.4)	2 (10.0)	0	1 (9.1)	18 (10.7)
Shigella sp.	1 (2.7)	1 (2.8)	2 (8.7)	1 (3.7)	0	0	0	5 (3.0)
Enterobacter sp.	0	1 (2.8)	0	0	0	1 (14.3)	0	2 (1.2)
Total	34 (77.3)	30 (23.3)	17 (13.2)	19 (14.7)	15 (11.6)	5 (3.8)	9 (7.0)	129 (76.8)

N number of samples examined, Values in parenthesis are percentage of bacterial isolates

Table 4. Percentage antibiotic resistance of enteric bacteria recovered from cooked foods in Ado-Ekiti

Bacteria (n)	Antibiotics							
	AMX	COT	NIT	GEN	NAL	OFL	AUG	TET
E. coli (23)	100.0	30.4	26.1	19.3	8.7	0	95.7	34.8
Klebsiella sp. (20)	60.0	55.0	20.0	25.0	5.0	0	20.0	55.0
Proteus sp. (14)	100.0	71.0	92.9	71.4	21.4	0	100.0	92.9
Pseudomonas sp. (9)	100.0	100.0	100.0	88.9	88.9	0	88.9	100.0
Salmonella sp.(10)	100.0	50.0	100.0	100.0	40.0	0	100.0	100.0
Enterobacter sp. (2)	100.0	0	0	100.0	0	0	100.0	100.0
Total (78)	89.1	53.9	55.1	71.8	23.1	0	76.9	67.9

(n) Number of isolates; AMX Amoxycillin; COT Cotrimoxazole; NIT Nitrofuratoin; GEN Gentamicin; NAL Nalidixic acid; OFL Ofloxacin; AUG Augmentin; TET Tetracycline

Table 5. Multiple antibiotic resistance phenotypes in bacteria isolated from cooked foods in Ado-Ekiti

No of antibiotics	Resistance phenotypes	Bacteria	No of isolates
3	AMX/COT/TET	*E. coli*	1
3	AMX/GEN/AUG	*E. coli*	10
4	AMX/GEN/AUG/TET	*E. coli*	3
4	AMX/COT/GEN/AUG	*E. coli*	2
5	AMX/NIT/GEN/AUG/TET	*E. coli*	2
5	AMX/COT/NIT/GEN/AUG	*E. coli*	2
7	AMX/COT/NIT/GEN/AUG/TET	*E. coli*	2
3	AMX/COT/TET	*Klebsiella* sp.	4
3	COT/GEN/TET	*Klebsiella* sp.	1
6	AMX/COT/NIT/GEN/AUG/TET	*Klebsiella* sp.	3
6	AMX/COT/NIT/GEN/AUG/TET	*Klebsiella* sp.	1
4	AMX/NIT/GEN/AUG	*Proteus* sp.	1
4	AMX/NIT/AUG/TET	*Proteus* sp.	1
5	AMX/NIT/GEN/AUG/TET	*Proteus* sp.	2
5	AMX/COT/GEN/AUG/TET	*Proteus* sp.	1
5	AMX/COT/NIT/AUG/TET	*Proteus* sp.	3
6	AMX/COT/NIT/GEN/AUG/TET	*Proteus* sp.	3
7	AMX/COT/NIT/GEN/NAL/AUG/TET	*Proteus* sp.	3
4	AMX/GEN/AUG/TET	*Enterobacter* sp.	1
5	AMX/NIT/GEN/AUG/TET	*Enterobacter* sp	1
5	AMX/NIT/GEN/AUG/TET	*Salmonella* sp.	5
6	AMX/COT/NIT/GEN/AUG/TET	*Salmonella* sp.	1
7	AMX/COT/NIT/GEN/NAL/AUGTET	*Salmonella* sp.	4
5	AMX/COT/NIT/NAL/TET	*Pseudomonas* sp.	1
6	AMX/COT/NIT/GEN/AUG/TET	*Pseudomonas* sp.	1
7	AMX/COT/NIT/GEN/NAL/AUG/TET	*Pseudomonas* sp.	7

AMX Amoxycillin, COT Cotrimoxazole, NIT Nitrofuration, GEN Gentamicin, NAL Nalidixic acid, AUG Augmentin, TET Tetracycline

Furthermore, the result obtained revealed that foods sold in canteens had the highest total bacterial count, while foods sold in *bukaterias* had the highest coliform count (Table 2). However, there is no significant difference (P<0.05) in the total plate and total coliform counts in the different categories of eating places or food outlets. The major differences with these eating places in Nigerian context probably appear to be the environment, the level of sanitation and probably the level of awareness or education of the employees. Most often, the personnel employed in the cooking, handling and eventual sale of foods in these categories of eating centers, who come in direct contact with the foods, are usually illiterates, low income earners with little or no formal education, and lack the basic training in the hygienic handling of food. Thus, it is common knowledge that hygiene and good manufacturing practices (GMP) are essential ingredients of food safety [29,30,42].

The findings in this study are a likely reflection of the risk of exposure to bacterial pathogens that can be transmitted through RTE foods sold in eating centers Ado-Ekiti. Eating out is gradually becoming more popular in this fast emerging metropolis; probably out of necessity and the category of eating places reflect the socio-economic status or social stratification of consumers [26,31].

The ability of African indigenous fermented foods to transmit pathogens such as *Salmonella*, *Campylobacter* among others has been documented [11,43]. The most commonly encountered pathogens in Africa fermented foods include *Bacillus cereus*, *E. coli*, *Salmonella* sp., *Staphylococcus aureus*, *Vibrio cholera*, *Aeromonas*, *Klebsiella*, *Campylobacter* and *Shigella* spp. [17-19,36,39-41,43,44]. Four (*eba*, *amala*, *fufu*, and *iyan*) out of the 7 types of food examined in this study were African fermented food products. The findings in this study further suggest that local Nigerian diets may also play a significant role if and when they become contaminated by such organisms. Foods are frequently cooked well in advance of consumption in most African settings and thereafter it is held at ambient temperature. Frequent opening of the containers where the foods are stored for subsequent sale to customers also make the foods liable to post-processing contamination. Aside from the food handlers, source of contamination may as well include the packaging materials used which are in most cases not sterile in any way.

One of the aims of this study was to determine the level of the microbial contamination of RTE cooked food samples, which can serve as sources of infection to consumers of such foods. The results showed that *E. coli* was the most common coliform recovered with an occurrence rate of 24.4% in the food items (Table 3). *Escherichia coli* was isolated from all cooked food samples with the exception of fried rice and white rice and beans (Table 3).

Escherichia coli is an ecologically versatile bacterium, known to adapt to a variety of ecological conditions encountered in both animal hosts and the external environments [45]. This attribute may therefore have been responsible for the presence of the organism in the RTE foods examined in this study, which are thought to be less liable to contamination due to the fermentation processes they have undergone. On the other hand, the organism being part of the natural gastrointestinal flora of human may have contaminated the food through the food vendors. Other bacteria detected include the pathogens *Salmonella* and *Shigella* spp. whereas *Pseudomonas* and *Klebsiella* spp. are opportunistic pathogens. However, pathogens have been detected in fermented foods, or have been known to survive and grow in such foods [11,46-48]. The other bacterial isolates such as *Enterobacter* are good indicators of severe contaminations.

Reports from both developing and the developed nations suggest that the majority of food-borne gastrointestinal illnesses occur as a result of unhygienic handling and or unsanitary environment during and after the food preparation. Humans are chiefly exposed to gastrointestinal pathogens through direct or indirect contact with human and animal fecal wastes, or contamination of food. Evidence indicates that the incidence of diarrhoeal diseases can be reduced by preventing or controlling exposure to enteropathogens that are frequently present in foods [2,11,49]. In order to control enteric infections and gastrointestinal diseases, particularly in low resources nations, an understanding of the incidence of the organisms responsible for these illnesses and their survival in food is very crucial.

Antibiotic resistance among the enteric bacteria recovered from cooked food to amoxicillin (89%) was the highest, followed by augmentin (76.9%) and gentamincin (71.8%). These three antibiotics are commonly used to treat and cure infections both in human and veterinary medicine. Other reports have highlighted the existence of unacceptable high antibiotic residues in meat in Kenya and Nigeria [50,51] indicating that the use of antimicrobials for animal husbandry in Africa is not a rare occurrence [52,53] and may suggest serious abuse. The high antibiotic resistance and multiple antibiotic resistance (MAR) observed among the bacteria recovered from food samples in the study area is therefore a cause for serious concern. However, Teuber [29], Teuber et al. [30]

and Verraes et al. [11] reviewed the significant role of food and food-borne pathogens in food chain in the epidemiology of antibiotic-resistant bacteria, thus highlighting the need for urgent attention, particularly in low resources countries that may not possess the wherewithal to curtail any major outbreak by such MAR organisms.

The occurrence of antibiotic-resistant commensals and antibiotic resistance genes in RTE retailed foods have been reported [8,11]. In their study, Van et al. [8] reported that more than 90% of foods sampled were contaminated with *E. coli* and 83.3% of the *E. coli* was resistant to at least one antibiotic. Fifty-seven percent of the *E. coli* that contained integrons and plasmids were detected in 76% of the *E. coli* isolates. Furthermore, the role of commensals, especially food-borne microbes in transmitting antibiotic resistance genes through horizontal transfer has been enumerated [11,29,30]. The present study emphasizes the importance of surveillance of bacterial isolates throughout the food production continuum to detect emerging antimicrobial resistance phenotypes in developing countries including Nigeria and correlate virulence properties with antibiotic resistance for obvious consequences. These may include but not limited to increased number of hospitalization, increased risk of invasive infections, failures in medical treatment, increased health costs and mortality.

5. CONCLUSION

Most of the food samples investigated was contaminated in varying degrees. There was an overall high rate of resistance to antibiotics with equally high rate of MAR among the bacterial contaminants. This portent high risks of further spread of antibiotic resistance and resistance genes, among others, in the community and environment. Further molecular study of antibiotic resistance among isolates, therefore, will hopefully help to determine the presence of antibiotic resistance genes and or the type of resistance among the MAR organisms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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