



Research Article

Microbial Assessment of Food Contact Surfaces in Restaurants/Food Canteens at Ahmadu Bello University Main Campus, Samaru, Zaria, Kaduna State, Nigeria

Umaru, G. A.<sup>1,2\*</sup>, Okolocha, E. C.<sup>3</sup>, Maitala, Y. S.<sup>3</sup>, Adamu, S. G.<sup>4</sup>, Sunkani, J. B.<sup>2</sup>, Daudu, B. B.<sup>5</sup>, Jibrin, M. S.<sup>6</sup> and Joshua, I. A.<sup>7</sup>

<sup>1</sup>Department of Veterinary Pathobiology, Faculty of Veterinary Medicine, Bayero University, P.M.B., 3011, Kano, Kano State

<sup>2</sup>Department of Animal Health, College of Agriculture, P.M.B., 1025, Jalingo-660242, Taraba State, Nigeria

<sup>3</sup>Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, P. M. B. 1045, Zaria- 810271

<sup>4</sup>Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno State

<sup>5</sup>Department of Veterinary Services, Ministry of Agriculture and Natural Resources, Jalingo, Taraba State

<sup>6</sup>Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto-840212, Sokoto State, Nigeria

<sup>7</sup>Department of Community Medicine, College of Medicine, Kaduna State University, Kaduna, Nigeria

\*Corresponding author: [drghaliumaru@yahoo.com](mailto:drghaliumaru@yahoo.com), [doi.org/10.55639/607.1928](https://doi.org/10.55639/607.1928)

ARTICLE INFO:

Keywords:

Microbial assessment,  
Food,  
Contact surfaces,  
TAPC,  
TCC

ABSTRACT

Food contact surface is any surface with which food; especially unpackaged food normally comes in contact. These surfaces can harbour harmful micro-organisms and other substances which can contaminate food. This study was aimed at assessing the microbial quality of food contact surfaces from restaurants/food canteens in Ahmadu Bello University Main Campus, Samaru, Zaria, Kaduna State, Nigeria. Ninety nine swab samples were collected from hands, plates, pots, spoons and tables, and analyzed for total aerobic plate count (TAPC), total coliform counts (TCC), *Escherichia coli* and *Staphylococcus aureus*. The overall results showed that the mean TAPC obtained from pots ( $2.3 \times 10^7$  cfu/cm<sup>2</sup>) was significantly higher ( $P < 0.05$ ) than those obtained from plates, hands, spoons and tables, while the mean TCC obtained from hands ( $4.5 \times 10^6$  cfu/cm<sup>2</sup>) was higher than those obtained from tables, plates, spoons and pots respectively. The prevalence of *E. coli* was significantly higher than that of *S. aureus* (36.6% vs 27.3%), but all occurred at a significant rate ( $P < 0.05$ ). *E. coli* isolates showed resistance to ampicillin (30.6%), amoxicillin (27.8%) and tetracycline (25.0%), while that of *S. aureus* isolates showed high resistance to penicillin (100%), amoxicillin (88.9%), ampicillin (88.9%) and tetracycline (85.5%). Both *E. coli* and *S. aureus* isolates showed multidrug resistance nature with greater percentage (38.9%) of the *E. coli* and *S. aureus* (29.6%) isolates having MARI of 0.3 and 0.4 respectively. The high value of both TACP and TCC coupled with the isolation of *E. coli* and *S. aureus* may indicate faecal and sewage contaminations associated with unhygienic and unsanitary practices. The study recommends proper personal hygiene especially of the hands, washing and rinsing the food contact surfaces with warm soapy water and sanitizers; and proper disposal of sewage and garbage materials to reduce or eliminate hazards.

Corresponding author: Umaru, G. A, Email: [drghaliumaru@yahoo.com](mailto:drghaliumaru@yahoo.com)

Department of Veterinary Pathobiology, Faculty of Veterinary Medicine, Bayero University, Kano State

## INTRODUCTION

A food contact surface is any surface of equipment or a utensil with which food normally comes into contact (Baghapour *et al.*, 2015). It is also a surface of equipment or a utensil from which food may drain, drip, or splash into a food or onto a surface normally in contact with food. These can be things that are quite obvious like a glass, a can for soft drinks, machinery in a food factory, conveyor belts, table tops, saw blades, abattoir surfaces, hands of food handlers, spoons, dishes, pots, augers, stuffers, knives, stockpots, and cutting boards (Omoruyi *et al.*, 2011; Oranusi *et al.*, 2013; Orogu *et al.*, 2017). During contact with the food, molecules can migrate from the food contact material to the food, for example via blooming. Because of this, regulations are made to ensure food safety in many countries (Mazni *et al.*, 2013).

The cooking process is intended to obliterate harmful microorganisms and ensure the prepared food is microbiologically safe for human consumption (Saad *et al.*, 2013; Adekolurejo *et al.*, 2016). However, activities such as adding garnishes, cutting or slicing of cooked food can potentially reintroduce harmful organisms into the food (Adekolurejo *et al.*, 2016). Therefore, such activities require the use of clean hands and utensils to prevent the spread of potential harmful microorganisms to humans via food chain (Saad *et al.*, 2013; Mazni *et al.*, 2013). The preparations should be performed in a clean environment and also on clean food contact surfaces as the final product will not be subjected to the heating process. Therefore, poor hygienic practices can act as a source of contamination which may result in food spoilage and the spread of diseases and infections such as food poisoning to humans (Saad *et al.*, 2013; Mazni *et al.*, 2013; Adekolurejo *et al.*, 2016).

Foodborne diseases due to contaminated foods are of global concern with hazards leading to approximately 1.5 billion cases of diarrhea in children worldwide and greater than 3 million deaths annually (Alebouyeh *et al.*, 2014; Biranjia-Hurdoyal and Latouche, 2016). The major causes of outbreaks of

foodborne diseases and infections are improper personnel hygiene, improper handling of food materials and unhygienic kitchen utensils and surfaces. Therefore, the role of the kitchen cannot be overemphasized as far as food contamination and the spread of foodborne pathogens are concerned. Food borne pathogens such as *Staphylococcus aureus*, *Escherichia coli* O157:H7, *Salmonella typhi* and *paratyphi*, *Shigella spp.*, *Vibrio cholerae* 01, *Streptococcus pyogenes*, *Entamoeba histolytica*, *Yersinias enterocolitica*, *Giardia lamblia*, *Campylobacter jejuni*, *Cryptosporidium parvum*, *Caliciviruses* (*norovirus*, *Hepatitis A virus* and host of others have been associated with food poisoning outbreaks (FDA, 2014; Ayalew *et al.*, 2015).

Although food contact surfaces has been an interest for many studies in Nigeria and other parts of the world, little information on their safety and microbial status is available in the study area (Oranusi *et al.*, 2013; Lani *et al.*, 2014; Ayalew *et al.*, 2015; Zailani *et al.*, 2015; Zulfakar *et al.*, 2018). This necessitated the present study to assess the microbial quality of food contact surfaces, to isolate and identify *Escherichia coli* and *Staphylococcus aureus* and to determine the antibiogram of the *E. coli* and *S. aureus* isolated from food contact surfaces in restaurants and food canteens in Ahmadu Bello University Main Campus, Samaru, Zaria, Kaduna State.

## MATERIALS AND METHODS

### Collection of samples

The study was conducted in Ahmadu Bello University Main Campus Samaru, Zaria and covered restaurants and food canteens that consented to our request. The restaurants and food canteens were visited during operation time and the food contact surfaces namely; tables, pots, spoons, plates, dishes and handler's hands were identified. Then their swab samples were collected using sterile swab stick by swabbing a delimited area (100 cm<sup>2</sup>) (Christison *et al.*, 2008; Baghapour *et al.*, 2015). Swab head was rubbed slowly and thoroughly over a total area of 100 cm<sup>2</sup> of sampled area. A 4 × 5 cm<sup>2</sup> dimension of cart was used to measure the area. Five times swabbed

was taken five times to achieve a 100 cm<sup>2</sup>. Then the swab was broken and the tube covered. Then, the swabs were then placed into 5ml of Maximum Recovery Diluents (Cheesbrough, 2010).

All swab samples were placed in an ice-cooled box and transported to the Bacterial Zoonoses Laboratory, Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria for microbial analysis.

## MICROBIAL ANALYSES

### Serial dilution

Each tube containing the swab was vortexed for 10 seconds to ensure mixture of the sample. A 100 fold dilution method was used by serially diluting 0.1 ml of each sample in 9.9 ml of physiological saline to achieve a dilution factor of 10<sup>2</sup>, 10<sup>4</sup> and 10<sup>6</sup> respectively.

### Total aerobic plate count (TAPC) assay

For counting aerobic bacteria, 0.1ml aliquot homogenate sample was inoculated and spread onto duplicate plates of Nutrient agar plates (Oxoid, CM0325), and incubated at 37°C for 24 hours. Recovery colonies from plates containing between 30 and 300 colonies were visually enumerated (A.P.H.A., 2015; ISO, 2013), and expressed as CFU/cm<sup>2</sup> as indicated below.

$$N_c = \frac{\text{Plate 1} + \text{Plate 2}}{2}$$

$$\text{TAPC} = \frac{N_c \times V \times 10^n}{100\text{cm}^2}$$

Where

N<sub>c</sub> = Number of colonies counted/cm<sup>2</sup>

V = Volume of the diluents

10<sup>n</sup> = Inverse of dilution factor inoculated

100 = Total swabbed area

### Total coliform counts assay

Coliforms were tested and enumerated using Mac-Conkey agar. A volume of 0.1ml aliquot homogenate of the sample was inoculated onto duplicate plates of Mac-Conkey agar and incubated at 37°C for 24 hours. Recovered colonies were then visually

enumerated and expressed as CFU/cm<sup>2</sup> (A.P.H.A., 2015; ISO, 2013).

### Isolation of *E. coli* and *Staphylococcus aureus*

*Escherichia coli* was isolated on Eosin Methylene Blue (EMB) agar, and then all the isolates characterized morphologically by Gram's staining method and biochemically using motility, indole test, methyl-Red test, voges Proskauer test, simmon citrate test and Sugar fermentation tests (Cheesbrough, 2010; Purkayastha *et al.*, 2010). They were further characterized using the commercial identification system (Microbact™ 12A (12E) Identification System (Oxoid, Basingstoke, UK).

*Staphylococcus aureus* was isolated on Baird Parker Agar (Oxoid, CM0275) supplemented by Egg Yolk, and also the isolates identified by colony morphology, Gram staining, catalase, coagulase, haemolysis, DNase and sugar fermentation tests (Cheesbrough, 2010). The isolates were further characterized using commercial Identification System (Microbact 12S Staphylococcal Identification System (Oxoid, Basingstoke, UK).

## ANTIMICROBIAL SUSCEPTIBILITY

### TESTING

All confirmed *E. coli* and *S. aureus* isolates were tested for resistance to a panel of 10 and 12 antibiotics respectively using the disc diffusion method outlined by the Clinical Laboratory Standard Institute (2014). The following antibiotics obtained commercially from Oxoid (Oxoid Basingstoke, United Kingdom) were used for *E. coli*; amoxicillin (30 µg), ampicillin (AMP; 10µg), chloramphenicol (10 µg), ciprofloxacin (10 µg), erythromycin (5 µg), gentamicin (30 µg), imipenem (IMP; 30 µg), streptomycin (30 µg), tetracycline (30 µg) and trimethoprim (30 µg), while those tested for *S. aureus* are; amoxicillin (30 µg), ampicillin (30 µg), cefoxitin (30 µg), chloramphenicol (12 µg), ciprofloxacin (5 µg), erythromycin (5 µg), gentamicin (10 µg), oxacillin (1 µg), penicillin (10 µg), streptomycin (10 µg), tetracycline (30 µg) and trimethoprim (5 µg).

## DETERMINATION OF MULTIPLE ANTIBIOTIC RESISTANCE INDEX (MARI)

The multiple antibiotic resistance index (MARI) for each isolate was determined using the formula as describe by Sandhu *et al.* (2016);  $MARI = a/b$  Where; a is the number of antibiotics to which the test isolate was resistant to b is the total number of antibiotics to which the test isolates were subjected.

### DATA ANALYSIS

Data obtained were analyzed statistically using SPSS package (Version 21.0). Both TAPC and the TCC data were manually recorded in an Excel spreadsheet (Microsoft Corp., Redmond, WA) and were converted to CFU/cm<sup>2</sup> by multiplying each value by 10<sup>6</sup>. The mean of the CFU/cm<sup>2</sup> values of TACP and TCC of the contact surfaces were then determined.

Probability values of statistical significance among prevalence of *E. coli* and *S. aureus* from different food contact surfaces and locations were determined using Chi-square and Fisher's exact test at 5% level of confidence. A p value of < 0.05 was considered as significant.

Antimicrobial susceptibility results were analyzed for *E. coli* and *S. aureus* to observe trends in resistance for each tested antibiotic.

## RESULTS

### Total Aerobic Plate Count (TAPC) and Total Coliform Count (TCC)

The overall results showed that the mean total aerobic plate count (TAPC) obtained from pot ( $2.3 \times 10^7$  cfu/cm<sup>2</sup>) was significantly higher ( $P < 0.05$ ) than those obtained from the hand, plate, spoon and table (Table 1), while the mean total coliform count obtained from hand ( $4.5 \times 10^6$  cfu/cm<sup>2</sup>) is higher than those obtained from plate, pot, spoon and table respectively (Table 4.1). There was no significant difference ( $P > 0.05$ ) between the TAPC for hand ( $1.7 \times 10^7$  cfu/cm<sup>2</sup>), plate ( $1.9 \times 10^7$  cfu/cm<sup>2</sup>), spoon ( $1.7 \times 10^7$  cfu/cm<sup>2</sup>) and table ( $1.6 \times 10^7$  cfu/cm<sup>2</sup>). However, the TCC obtained for plate ( $2.4 \times 10^6$  cfu/cm<sup>2</sup>), spoon ( $2.3 \times 10^6$  cfu/cm<sup>2</sup>) and table were higher than  $1.7 \times 10^6$  cfu/cm<sup>2</sup> obtained for pot (Table 1).

### Isolation of *Escherichia coli* and *Staphylococcus aureus*

*Escherichia coli* (*E. coli*) had the highest occurrence with a prevalence of 36.6%, while *Staphylococcus aureus* (*S. aureus*) had the least occurrence with the prevalence of 27.3%, but all occurred at a significant rate ( $P < 0.05$ ) (Table 2). The occurrence of *E. coli* was significantly higher ( $P < 0.05$ ) in swab samples from hand (55.6%), followed by spoon with 40.7%, plate 33.3% and table with 27.8%. Similarly, *S. aureus* occurrence was highest in the hand (66.7%), followed by plate (27.8%) and spoon (22.2%). Both *E. coli* and *S. aureus* occurred least in pot with 22.2% and 16.7% prevalence respectively (Table 2).

### Antibiogram of the *E. coli* and *S. aureus* isolates

Of the 36 *E. coli* isolates, 7 (19.4%) were resistant to at least 1 of the 10 antimicrobial agents tested, and 13 (36.1%) were resistant to at least 2 of these antimicrobial agents (Table 3). *Escherichia coli* isolates were most resistant to ampicillin (30.6%), amoxicillin (27.8%) and tetracycline (25.0%), while lower level of resistance was recorded in the case of erythromycin (11.1%), streptomycin (8.3%), cefoxitin (5.6%), chloramphenicol (2.8%), and gentamicin (2.8%). All the *E. coli* isolates were 100% susceptible to ciprofloxacin, imipenem and Trimethoprim (Table 3). There was a statistically significant difference in the mean percentage resistance and mean percentage susceptibility ( $P < 0.05$ ) of the *E. coli* isolates. The multiple antibiotic resistance indices (MARI) of the *E. coli* isolates ranged from 0.2-0.6, greater percentage (38.9%) having a MARI of 0.3 (Table 4).

The antimicrobial resistant profile of the 27 *S. aureus* to various antibiotics was as follows: penicillin (100%), amoxicillin and ampicillin 88.9% each and tetracycline (85.5%), cefoxitin and oxacillin with 40.1% each, erythromycin (31.9%) and streptomycin with 33.3% each and Trimethoprim with 22.2% respectively. Ciprofloxacin was the only antibiotic that recorded 100% susceptibility (Table 3). Majority, (96.3%) of the *S. aureus* isolates show multi-drug resistant pattern with the MARI ranging between of 0.2-0.9 (Table 4). Greater percentage

(29.6%) of the *S. aureus* had MARI of 0.4, while 25.9% had multiple antibiotic resistance index value of 0.5 and 14.8% had multiple antibiotic resistance

index value of 0.6. Only one (1) isolate each having MRAI value of 0.8 and 0.9 respectively (Table 4).

**Table 1:** Mean Microbial Count of Food Contacts Surfaces from Restaurants and Food Canteens in Ahmadu Bello University Main Campus, Samaru, Zaria

Contact surface	No. of samples examined	TAPC (CFU/cm <sup>2</sup> )	TCC (CFU/cm <sup>2</sup> )
Hands	18	1.7 × 10 <sup>7</sup>	4.5 × 10 <sup>6</sup>
Plates	18	1.9 × 10 <sup>7</sup>	2.4 × 10 <sup>6</sup>
Pots	18	2.3 × 10 <sup>7</sup>	1.7 × 10 <sup>6</sup>
Spoons	27	1.7 × 10 <sup>7</sup>	2.3 × 10 <sup>6</sup>
Tables	18	1.6 × 10 <sup>7</sup>	2.9 × 10 <sup>6</sup>

**Table 2:** Occurrence of *E. coli* and *S. aureus* in Food Contact Surfaces from Restaurants in ABU Main Campus, Samaru, Zaria

Food contact surface	No. examined	<i>E. coli</i> No. (%) positive	<i>S. aureus</i> No. (%) positive
Hand	18	10 (55.6)	12 (66.7)
Plate	18	6 (33.3)	5 (27.8)
Pot	18	4 (22.2)	3 (16.7)
Spoon	27	11 (40.7)	4 (22.2)
Table	18	5 (27.8)	3 (16.7)
<b>Total</b>	<b>99</b>	<b>36 (36.4)</b>	<b>27 (27.3)</b>

**Table 3:** Antibiotic susceptibility of *E. coli* and *S. aureus* isolated from Food Contact Surfaces from Restaurants in ABU main Campus, Samaru, Zaria, Kaduna State, Nigeria

Antibiotic	<i>E. coli</i> (N=36) No (%) Resistant	<i>S. aureus</i> (N=27) No (%) Resistant
Amoxicillin	10 (27.8)	24 (88.9)
Ampicillin	11 (30.6)	24 (88.9)
Cefoxitin	2 (5.6)	11 (40.1)
Chloramphenicol	1 (2.8)	2 (7.4)
Ciprofloxacin	0	0
Erythromycin	4 (11.1)	9 (33.3)
Gentamicin	1 (2.8)	3 (11.1)
Imipenem	0	-
Oxacillin	-	11 (40.1)
Penicillin	-	27 (100.0)
Streptomycin	3 (8.3)	9 (33.3)
Tetracycline	9 (25.0)	23 (85.2)
Trimethoprim	0	6 (22.2)

**Table 4:** Multiple antibiotic resistance indices (MARI) of *E. coli* (N=36) and *S. aureus* (N=27) isolated from Food Contact Surfaces in Restaurants in ABU main campus, Samaru, Zaria

MAR Index	<i>E. coli</i> No. (%) of isolates	<i>S. aureus</i> No. (%) of isolates
0.2	7 (19.4)	1 (3.7)
0.3	14 (38.9)	2 (7.4)
0.4	10 (27.8)	8 (29.6)
0.5	3 (8.3)	7 (25.9)
0.6	2 (5.6)	4 (14.8)
0.7	-	3 (11.1)
0.8	-	1 (3.7)
0.9	-	1 (3.7)

## DISCUSSION

Good hygienic practices are essential for ensuring food safety. They are required by law under National and International Food Hygiene Regulations and are frequently considered as pre-requisites to food safety systems based on Hazard Analysis and Critical Control Point (HACCP) (Sudheesh *et al.*, 2013). Compromising good hygiene almost always results in establishment and proliferation of pathogens as well as spoilage microorganisms on the processing and storage food contact surfaces. This leads to contamination of food products with hazardous microorganisms making them unsafe for human consumption. Good hygienic practices are primary preventative measures and the monitoring of their effectiveness not only provides an early warning of potential problems but also evidence of due diligence (Orogu *et al.*, 2017).

The results obtained from this study showed that the mean TAPC cfu/cm<sup>2</sup> of the food contact surfaces examined were  $1.7 \times 10^7$  cfu/cm<sup>2</sup> for hands,  $1.9 \times 10^7$  cfu/cm<sup>2</sup> for plates,  $2.3 \times 10^7$  cfu/cm<sup>2</sup> for pots,  $1.7 \times 10^7$  cfu/cm<sup>2</sup> for spoons and  $1.6 \times 10^7$  cfu/cm<sup>2</sup> for tables (Table 1). According to Collins and Lyne (2004), the

standard TAPC for cookery and utensils in the USA, Public Health Service requires counts of not more than  $5.0 \times 10^5$  and  $2.5 \times 10^5$  cfu/cm<sup>2</sup> per container as fairly satisfactory and over  $2.5 \times 10^5$  Cfu/cm<sup>2</sup> as unsatisfactory. Majority of data suggests that, for routine cleaning/sanitizing surfaces the maximum Aerobic Plate Count (APC) counts should be in the range 10-100 cfu/cm<sup>2</sup>. It is evident from the results that the hands, plates, pots, spoons and tables all had TACP counts above  $2.5 \times 10^5$  cfu/cm<sup>2</sup>.

Based on the individual results obtained, TAPC in some of the swab samples indicated an acceptable level with contamination level was lower than  $5.0 \times 10^5$ , but the means of these samples resulted in values higher than the acceptable ones. According to World Health Organization report (2002), a high plate count concentration does not itself present a risk to human health, but indicates an overall quality of production systems (Rahimi *et al.*, 2019).

Several studies had been conducted to determine the total aerobic plate count of food contact surfaces in restaurants in Nigeria and elsewhere, which can be comparable to the present study. For instance, Nhlapo *et al.* (2014) in South Africa determined the microbial counts of food

contact surfaces at schools depending on a feeding scheme, and showed that the bacteria counts for hands, tables, apron and tray to be too numerous to be counted. Orogu *et al.* (2017) also assessed the microbiological qualities of cutlery—spoons, forks and knives in Delta State Polytechnic, Ozoro, and discovered the total bacterial count (TBC) cfu/ml of the samples to range between  $1.8 \times 10^3$  -  $6.1 \times 10^3$  for spoons,  $2.0 \times 10^3$  -  $5.4 \times 10^3$  for knives and  $4.0 \times 10^3$  -  $7.7 \times 10^3$  cfu/ml for fork. Zailani *et al.* (2016) reported that the total aerobic counts of meat contact surfaces were observed to be  $7.8 \pm 0.3$  obtained from tables at Darazo abattoir and  $6.4 \pm 0.6$  from cutting instruments from Ningi abattoir in Bauchi state, Nigeria. Adekolurejo *et al.* (2016) found that the total bacterial counts on the meat contact surface ranged from  $149.25 \pm 14.26$  to  $0.94 \pm 0.05 \times 10^4$  cfu/cm<sup>2</sup> in an abattoir in Akure, Nigeria.

The TCC was on the other hand observed to be higher in swab sampled from hands, followed by tables with  $4.5 \times 10^6$ , and plates with  $2.4 \times 10^6$ . These values are more than the standard of 1-5 cfu/100ml required for drinking water set by NAFDAC. Similarly, the results showed that the occurrences of coliforms are more than the standard set by World Health Organization (WHO) for drinking water. World Health Organization (WHO) stated that presence of one *E. coli* and greater than 10 coliforms renders water unsatisfactory for drinking by humans and animals (WHO, 2011). The result is similar to those of Zulfakar *et al.* (2018) in Malaysia who obtained the total coliform of  $2.52 \pm 0.52$  log CFU/cm<sup>2</sup> in Cafeteria K and  $0.36 \pm 0.11$  log cfu/cm<sup>2</sup> in Cafeteria F at a local University. In contrast Nhlapo *et al.* (2014) in South Africa showed the 60% of the counts obtained from hands to be satisfactory while 20% were

acceptable and 20% were not detectable. For preparation surfaces, 40% of coliform counts were satisfactory and 20% were acceptable, whereas 30% were unsatisfactory and 10% were not detectable according to the BCCDC guide.

It was observed from the study that the TAPC was higher in swab samples ( $2.3 \times 10^7$ ) from pots, followed by plates ( $1.9 \times 10^7$  cfu/cm<sup>2</sup>) and hand ( $1.7 \times 10^7$  cfu/cm<sup>2</sup>). This high TAPC recorded for hand swabs and easy contact surfaces could be a reflection of the level of exposure and thus cross contamination. Similarly, the TCC was found to be higher in swab samples from hands with  $4.5 \times 10^6$ , followed by tables with  $2.9 \times 10^6$  cfu/cm<sup>2</sup> and plates with  $2.4 \times 10^6$  cfu/cm<sup>2</sup>. Although some visual differences were observed among the contamination levels of hands, plates, pots, spoon and tables, there was statistically significant difference in microbial counts among these food contact surfaces ( $P < 0.05$ ). Therefore food contact surface samples with total coliform counts exceeding  $1.0 \log_{10}$  CFU/cm<sup>2</sup> were considered to fail the hygiene test (Cunningham *et al.*, 2011). Our findings revealed that the TCC were high in some food contact surfaces examined while no count was detected in some. The high occurrence indicates hygiene issues in restaurants. This tends to agree with the reports of Oranusi *et al.* (2013) and Nhlapo *et al.* (2014) in Ota, Ogun State, Nigeria and South Africa respectively. The hand is the main organ used for the preparation and manipulation of procedures, and can easily pick up bacteria from environments and transfer them to other food contact surfaces. The TAPC observed from this study is more than the recommended maximum permissible limit of aerobic plate count of  $2.5 \times 10^5$  cfu/cm<sup>2</sup> set by USA, Public Health Service. This may indicate that the various food

contact surfaces examined were contaminated with bacteria, and are at a risk of contaminating the food that may come into contact with the surfaces. This result suggests inadequate cleaning and unhygienic handling of food contact surfaces, which in turn could lead to contamination and re-contamination of surfaces, as suggested by Adekolurejo *et al.* (2016).

The results from the study revealed that the presence of *E. coli* and *S. aureus* in the food contact surfaces examined (Table 2). *Escherichia coli* had the highest occurrence of 36.6%, while *S. aureus* had 27.3%, but all occurred at a significant rate ( $P < 0.05$ ) (Table 2). The occurrence of *E. coli* was found to be higher ( $P < 0.05$ ) in swab samples from hand (55.6%), followed by spoon with 40.7%, plate 33.3% and table with 27.8%. Similarly, *S. aureus* occurrence was higher in the hands (66.7%), followed by plate (27.8%) and spoon (22.2%). Both *E. coli* and *S. aureus* occurred least in pot with 22.2% and 16.7% prevalence respectively (Table 2). This result can be comparable to several studies within Nigeria and elsewhere. For example; Oranusi *et al.* (2013) in their study showed that about 98% of hands and surfaces swabbed were contaminated with *Bacillus* spp., *Staphylococcus* spp., *Streptococcus* spp. and *Enterococcus* spp., *Aspergillus* and *Penicillium* spp. This result is similar, to that report of Orogu *et al.* (2017) who observed that *E. coli* had the highest result occurrence of 66.67% while *S. aureus* has the least occurrence of 33.33% in a study on microbiological assessment of cutleries in Delta State Polytechnic, Ozoro. Similarly, Mohammed *et al.* (2018) evaluated food contact surfaces in selected restaurants in Kaduna State University, Nigeria and discovered 13 (26 %) of the surfaces to be positive for *E. coli*. However, none (0%) of

the samples was positive for *S. aureus*. The results also showed that plates had the highest prevalence of 61.5 %, followed by chopping boards with 23.1 % and table and spoon with 7.7 % respectively.

The prevalence observed in the present study is higher than those obtained by Sudheesh *et al.* (2013) in Oman who reported that of the five restaurants sampled, one was negative for *E. coli* and all were negative for *S. aureus*, but lower than that of Zailani *et al.* (2013) who detected only 3 *E. coli* from meat contact surfaces from abattoirs in Bauchi State, Nigeria. Nhlapo *et al.* (2014) in South Africa observed 50% and 90% of hands and aprons to have satisfactory *E. coli* counts, while the remaining counts on other surfaces were not detectable. In Kano, Nigeria, Dahiru *et al.* (2016) observed a prevalence of 20.3% for *E. coli* and 14.7% for *S. aureus* among food handlers at various restaurants in Kano Metropolis, which is lower than the present study.

Although *E. coli* itself may not be harmful, its presence in any numbers can be regarded as evidence of sewage or faecal contamination which may be of human or animal origin. Similarly, *S. aureus* is not always pathogenic; it is a common cause of skin infections such as abscesses, respiratory infections such as food poisoning and sinusitis. Contamination of these surfaces might result possibly from inadequate cleaning and sanitization of these surfaces as well as inadequate personal hygiene of the food handlers which can lead to contamination of the surfaces and can serve as a vehicle for *E. coli* food borne infection. Another possible reason is the use of unclean water for washing the dishes, plates, spoons and utensils because some restaurants use the same water to wash the plates over and over throughout the day. And after

washing these contact surfaces, warm water is not usually used to sanitize them. Though the presence of *E. coli* on pots and tables from the result of this study was low, it might be attributed to the fact that the tables are not cleaned with water or were not cleaned frequently during service hours.

The antimicrobial susceptibility result of the 36 *E. coli* isolates showed that 7 (19.4%) were resistant to at least 1 of the 10 antimicrobial agents tested, and 13 (36.1%) were resistant to at least 2 of these antimicrobial agents (Table 3). *E. coli* isolates were observed to be resistant to ampicillin (30.6%), amoxicillin (27.8%) and tetracycline (25.0%). However, lower level of resistance or reduced susceptibility was also recorded in the case of erythromycin (11.1%), streptomycin (8.3%), cefoxitin (5.6%), chloramphenicol (2.8%), and gentamicin (2.8%). All the *E. coli* isolates were 100% susceptible to ciprofloxacin, imipenem and Trimethoprim (Table 4).

The multiple antibiotic resistance indices (MARI) of the *E. coli* isolates ranged from 0.2-0.6 (Table 4). The results showed that greater percentage (38.9%) of the *E. coli* isolates recorded a MARI of 0.2, while 27.8% had MARI value of 0.3, while 2 isolates recorded a MARI of 0.5 respectively (Table 4). The high MARI values might be an indication of abuse and/ or misuse of antibiotics. *Escherichia coli* can cause serious community acquired infections. Hence, appropriate hygienic measures should be adopted while handling naira notes. The average MARI value of the *E. coli* isolates was 0.4 and this signifies their high antibiotic resistance frequency to commonly used antibiotic for treating bacterial infections. It was observed that 29 (80.6%) of the *E. coli* isolates investigated had multiple antibiotic resistance indices (MARI) 0.2

(Table 4.7). This implies that they were resistant to at least 2 of the tested antibiotics. It has been shown that MARI greater than 0.2 indicates that an organism probably originated from an environment where antibiotics were frequently used (Tsaku *et al.* 2019). The selective resistance to the different antibiotics tested could be alluded to some obvious reasons, such as; inaccessibility to target site of action, decreased absorption of the active substance through efflux action, and the abuse of antibiotics that are commonly accessible; for example, tetracycline is easily accessible and it is administered orally whereas gentamicin is administered via parenteral routes (Tsaku *et al.*, 2019). Similar report was observed by Tsaku *et al.* (2019) in Nasarawa State University, Keffi, Nigeria, who showed that the *E. coli* isolates isolated from door handles were resistant to tetracycline (91.18%), streptomycin and ampicillin (76.47%), chloramphenicol (41.18%) and gentamicin 20.59%, while the multiple antibiotic resistance index (MARI) of 0.3 was recorded in 97.06% of the isolates.

The antimicrobial resistance profile of the *S. aureus* isolates showed high resistance to penicillin (100%), amoxicillin and ampicillin 88.9% each and tetracycline (85.5%) (Table 4). High resistance was also recorded against cefoxitin and oxacillin with 40.1% each, erythromycin (31.9%) and streptomycin with 33.3% each and trimethoprim with 22.2% respectively. However, all isolates were 100% susceptible to ciprofloxacin 7.4% to chloramphenicol and 11.1% to gentamicin (Table 4). This may suggest that ciprofloxacin, chloramphenicol and gentamicin could be the drugs of choice in the treatment of *S. aureus* infection in the study area. These findings are comparable to those of Suleiman *et al.* (2013)

who observed a 100% resistance of coagulase-positive *S. aureus* against penicillin and ampicillin in chickens in Maiduguri, Nigeria, and 100% susceptibility to ciprofloxacin. The total resistance of the isolates to penicillin and high resistance to amoxicillin (88.9%), ampicillin 88.9% and tetracycline (85.5%) may suggest the high abuse of these antibiotics in the treatment of infections in the area. In contrast, the susceptibility to ciprofloxacin, chloramphenicol, gentamicin and trimethoprim may suggest that these antibiotics are less abused, and therefore the drug of choice in the treatment of staphylococcal infections.

The abuse and indiscriminate use of antibiotics in animals and also their use in animal husbandry should be discouraged because resistant pathogens such as *S. aureus* can be spread to humans via foods contaminated by such resistant pathogens. Magiorakos *et al.* (2012) showed that emergence of resistance to multiple antimicrobial agents in pathogenic bacteria has become a significant public health threat as there are fewer, or even sometimes no effective antimicrobial agents available for treatments of infections caused by these bacteria. The emergence and re-emergence of antibiotic resistant foodborne bacteria in recent times calls for concerted efforts, especially in developing countries.

## REFERENCES

- Adekolurejo, O. O., Osho, G. T. and Bakare, A. (2016). Microbial evaluation of different cleaning techniques on meat contact surfaces in an abattoir in Akure, Nigeria. *Applied Tropical Agriculture*, **21** (3): 223-228.
- Alebouyeh, M., Asadzadehaghdaei, H., Zali, M. and Solaimannejad, K. 2014. Prevalence of antibiotic resistant bacteria isolated from foodstuff in kitchen of a hospital in Tehran. *Science Journal of Ilam University Medical Sciences*, **22**: 1-9.

## CONCLUSION AND RECOMMENDATIONS

Though some individual swab samples have values within the acceptable value, the mean TAPC and TCC of food contact surfaces from restaurants/canteens in ABU, Main Campus were observed to be greater than the standard set by the U.S.A Public Health Service, WHO and NAFDAC respectively, with the isolated *E. coli* and *S. aureus* showing multi drug resistant pattern.

The study recommends improvement in personal hygiene of food handlers, provision of potable water for washing and rinsing the food contact surfaces, proper sewage and garbage disposal, and general environmental sanitation to ensure free or very limited bacterial contamination and to reduce potential hazards.

## CONFLICT OF INTEREST

Authors declare that there was no conflict of interest. The research was carried out with the consent of the proprietors and managers of the restaurants/food canteens.

## ACKNOWLEDGEMENTS

The authors acknowledge the assistance rendered by the Clinical Veterinary Students for assisting in sample collection, and also to Mallam Mahmoud of Bacterial Zoonoses Laboratory for the technical assistance rendered.

- American Public Health Association (APHA) (2015). *Compendium of Methods for the Microbiological Examination of Foods*, fifth edition, edited by Salfinger, Y. and Tortorello, M. L., Alpha Press, An Imprint of American Public Health Association Washington, DC, DOI: 10.2105/MBEF.0222.003.

- Ayalew, H., Berhanu, A., Sibhat, B and Serda, B (2015). Microbiological assessment of meat contact surfaces at abattoir and retail houses in Jigjiga town, Somali National Regional

- State of Ethiopia. *ISABB-Journal of Food and Agricultural Science*, **5** (3): 21-26.
- Baghapour, M. A., Mazloomi, S. M., Azizi, K. and Sefidkar, R. (2015) Microbiological quality of food contact surfaces in a hospital kitchen in Shiraz, Iran, 2014. *Journal of Health Sciences and Surveillance System*, **3** (4): 128-132.
- Biranjia-Hurdoyal, S. and Latouche, M. C. (2016). Factors affecting microbial load and profile of potential pathogens and food spoilage bacteria from household kitchen tables. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2016: 1-6.
- Cheesbrough, M. (2010). *District Laboratory Practice in Tropical Countries*, second edition update, Cambridge University Press. Pp. 35-45.
- Christison, C., Lindsay, D. and Von Holy, A. (2008). Microbiological survey of ready-to-eat foods and associated preparation surfaces in retail delicatessens, Johannesburg, South Africa. *Food Control*. **19** (7): 727-733.
- Clinical and Laboratory Standards Institute (CLSI) (2014). Performance standards for antimicrobial susceptibility testing; Twenty-fourth informational supplement. Vol. 34 No. 1, CLSI document M100-S24 (ISBN 1-56238-897-5 [Print]; ISBN 1-56238-898-3 [Electronic]). Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087 USA, 2014.
- Cunningham, A. E., Rajagopal, R., Lauer, J. and Allwood, P. (2011). Assessment of hygienic quality of surfaces in retail food service establishments based on microbial counts and real-time detection of ATP. *Journal of Food Protection*, 74: 686-690.
- Dahiru, J. F., Abubakar, F. A., Idris, H. and Abdullahi, S. A. (2016). Bacterial contamination of food handlers at various restaurants in Kano State Metropolis, Kano Nigeria. *International Journal of Current Microbiology and Applied Sciences*, **5** (5): 165-170.
- Food and Drug Administration (2014). *Foodborne Illnesses*. United State Food & Drug Administration. Available from: <http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodborneIllnessRiskFactorReduction/UCM505471>. Assessed on 10<sup>th</sup> October, 2019.
- ISO 4833-1:2013 (2013). Microbiology of the Food Chain-Horizontal Method for the Enumeration of Microorganisms-Part 1: Colony count at 30 °C by the pour plate technique, first edition, 9 pages.
- Lani, M. N., Azmi, M. F. N., Ibrahim, R., Alias, R. and Hassan, Z. (2014). Microbiological quality of food contact surfaces at selected food premises of Malaysian Heritage Food ('Satar') in Terengganu, Malaysia. *The International Journal of Engineering and Science (IJES)*, **3** (9): 66-70
- Magiorakos, A. P., Srinivasan, A., Carey, R. B., Carmeli, Y., Falagas, M. E., Giske, C. G., Harbarth, S., Hindler, J. F., Kahlmeter, G., Olsson-Liljequist, B., Paterson, D. L., Rice, L. B., Stelling, J., Struelens, M. J., Vatopoulos, V., Weber, J. T. and Monnet, D. L. (2012). Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clinical Microbial Infection*, **18**: 268–281.
- Michaels, B., Keller, C., Blevins, M., Paoli, G., Ruthman, T., Todd, E. and Griffith, C. J. (2004). Prevention of food worker transmission of foodborne pathogens: risk assessment and evaluation of effective hygiene intervention strategies. *Food Service Technology*, **4**: 31-49.
- Mohammed, S. S. D., Ayansina, A. D. V., Mohammed, S. R., Oyewole, O. A. and Shaba, A. M. (2018). Evaluation of food contact surfaces in selected restaurants of Kaduna State University for the presence of *Escherichia Coli* and *Staphylococcus aureus*. *Science World Journal*, 13 (3): 45-49.
- National Agency for Food and Drug Administration and Control (NAFDAC) (2018). Current Good Manufacturing Practice Guidelines for Food and Food Products (Revised). Food Safety & Applied Nutrition (FSAN) Directorate. Doc. Ref. No: FSAN-GDL-006-01, 70 pages.
- Nhlapo, N., Lues, R. J. F. and Groenewald, W. H. (2014). Microbial counts of food contact surfaces at schools depending on a feeding scheme. *South African Journal of Science*, **110** (11/12): 1-5.

- Omoruyi, I. M., Wogu, M. D., and Eraga, E. M. (2011). Bacteriological quality of beef-contact surfaces, air microflora and wastewaters from major abattoirs located in Benin City, Southern Nigeria. *International Journal of Biosciences (IJB)*, **1** (3): 57-62.
- Oranusi, S., Dahunsi, S. O., Owoso, O. O. and Olatile, T. (2013). Microbial profiles of hands, foods, easy contact surfaces and food contact surfaces: A case study of a University Campus. *Novus International Journal of Biotechnology and Bioscience*, **2** (1): 30-38.
- Orogu, J. O., Ehiwario, N. J. and Adebisi, O. O. (2017). Microbiological assessment of cutleries. *MOJ Biorequity Availability*, **3** (6): 159-162.
- Purkayastha, M., Khan, M. S. R., Alam, M., Siddique, M. P., Begum, F. Mondal, T. and Choudhury, S. (2010). Cultural and biochemical characterization of sheep *Escherichia coli* isolated from in and around Bbau Campus. *Bangladesh Journal of Veterinary Medicine*, **8** (1): 51-55.
- Rahimi, S. M., M. Ebrahimi, Barikbin, B. and Zeinali, T. (2019). Evaluation of bacterial and fungal contamination of kitchens of Birjand University of Medical Sciences. *BMC Research Notes*, **12**: 703.
- Saad, M., Seea, T. P., Abdullah, M. F. F. and Nor, N. M. (2013). Use of rapid microbial kits for regular monitoring of food contact surfaces towards hygiene practices. *Procedia-Social and Behavioral Sciences*, **105**: 273-283.
- Sandhu, R., Dahiya, S. and Sayal, P. (2016). Evaluation of multiple antibiotic resistance (MAR) index and doxycycline susceptibility of *Acinetobacter* species among inpatients. *Indian Journal of Microbiology Research*, **3**: 299-305.
- Sudheesh, P. S., Al-Ghabshi, A., Al-Aboudi, N., Al-Gharabi, S. and Al-Khadhuri, H. (2013). Evaluation of food contact surface contamination and the presence of pathogenic bacteria in seafood retail outlets in the Sultanate of Oman. *Advance Journal of Food Science and Technology*, **5** (2): 77-83.
- Suleiman, A., Zaria, L. T., Grema, H. A. and Ahmadu, P. (2013). Antimicrobial resistant coagulase-positive *Staphylococcus aureus* from chickens in Maiduguri, Nigeria. *Sokoto Journal of Veterinary Science*, **11** (1): 51-55.
- Tsaku, P. A., Ngwai, Y. B., Pennap, G. R. I., Ishaleku, D., Ibrahimc, T., Nkene, I. H., Abimiku, R. H. (2019). Extended-spectrum beta-lactamase–production in *Escherichia coli* isolated from door handles in Nasarawa State University, Keffi, Nigeria. *Heliyon*, **5**: e02177.
- World Health Organization (WHO) (2011). Guidelines for drinking-water quality, fourth edition, WHO Graphics, Switzerland, 564 Pages, ISBN 978 92 4 154815 1.
- Zailani, S. A., Bello, M., Raji, M. A., Kabir, J. and Yahuza, S. M. (2016). Microbial evaluation of meat contact surfaces in red meat abattoirs of Bauchi State, North-Eastern Nigeria. *Open Journal of Medical Microbiology*, **6**: 3-8.
- Zulfakar, S. S., Hamid, N. H. A. and Sahani, M. (2018). Microbiological assessment of food contact surfaces in residential college cafeterias at a Local University in Malaysia. *Jurnal Sains Kesihatan Malaysia*, **16** (2): 33-38.