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# BACTERIOLOGICAL ASSESSMENT OF WATER USED BY FOOD VENDORS IN MAJOR MOTOR PARKS AND MARKETS WITHIN IJEBU-ODE, OGUN, SOUTHWESTERN, NIGERIA

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## ABSTRACT

Water, a critical raw material in many street-vended operations, when contaminated can create a public health risk when consumed. The bacteriological status of water used by food vendors for drinking, cooking, washing and other food-related activities in major motor parks and markets in Ijebu-Ode, Ogun State, Southwestern Nigeria was evaluated in this study to ascertain its extent of bacterial contamination. Water samples from a total of twenty-four (24) randomly selected food vending points within the major motor parks and markets were collected and analyzed for total bacterial, presumptive coliform and confirmed E. coli counts using standard methods. Microscopic and biochemical tests were further carried out on the isolated microorganisms to identify and characterize them. Values obtained were statistically analyzed using simple percentage and mean, compared with local (NAFDAC) and international (WHO) standards and then tested using ANOVA ($p \leq 0.05$). Results revealed heavy contamination of the water samples with mean values for all parameters exceeding the maximum permissible limit recommended by both NAFDAC and WHO; the mean total plate ranged between 10.00±0.00 and 254.67±10.67, mean presumptive Coliform counts between 10.00±0.00 and 45.20±1.00 and mean E. coli counts 5.03±0.10 and 45.00±0.00 (all in X $10^5$ CFU/ml). A significantly higher number of the samples ($p<0.05$) 75% had a range of 41 to 60 coliform counts per 100 ml for both presumptive coliform and confirmatory E. coli counts. Pathogenic bacteria isolates obtained

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from this study include Escherichia coli, Klebsiella sp. Bacillus subtilis, Citrobacter sp., Pseudomonas sp, Enterobacter sp., Proteus sp, and Staphylococcus. Saprophyticus (E. coli having the highest prevalence, being found in all the water samples). This suggests that the bacteriological status of water used by food vendors at Ijebu-Ode motor parks was above the recommended standard of WHO (E. coli < than 1) thus posing health and food safety risks on the public that feeds regularly on the vended foods and water.

**Key Words: Bacteriological, Food Vendors**

## 1. Introduction and Literature Review

‘‘Street foods are ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers especially in streets and other similar public places’’ [1]. Street vended foods are not only appreciated for their unique flavors, convenience and the role which they play in the cultural and social heritage of societies, they have also become important and essential for maintaining the nutritional status of the populations [2, 3]. Besides offering business opportunities for developing entrepreneurs, the sale of street foods can make a sizeable contribution to the economies of developing countries.

According to the Food and Agriculture Organization [4], 2.5 billion people eat street food everyday. People have the tendency to rely more on street vended foods because it saves their time and reduces the stress of cooking and other food related chores.

Since there is an increase in percentage of employed women nowadays, less time have been devoted to the kitchen, this has made many food industry mushroomed to such an extent that if left uncontrolled, it would constitute a hazard to the public health [5]. Also, with increasing pace of globalization and tourism, the safety of street food has become one of the major concerns of public health, and a focus of governments and scientists to raise public awareness on the need for effective measures of food safety. Food safety is a scientific discipline describing the handling, preparation and storage of food in ways that prevent food borne illness

[6]. Availability of safe food supply including street foods is very crucial to ensure the health of people.

Street foods are perceived to be a major public health risk due to lack of basic infrastructure and services, difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature [7, 8].

Importantly, Water and foods in particular have been described as vehicles for the transmission of microbial disease, among which are, those caused by coliforms [9]. Coliforms are gram-negative, rod shaped, non-spore forming aerobes and facultative anaerobes that ferment lactose to produce acid and gas within 48 hours at 38$^{o}$C. They are generally recognized as the normal flora of the intestine of humans and animals although some *Coliforms*, including *Salmonellae*, *Shigellae* and Enteropathogenic *Escherichia coli*, are notable enteric pathogens [10, 11]. The presence of coliforms in food and water would therefore, generally connote faecal contamination, resulting in the risk of exposure to pathogen that causes gastrointestinal diseases, such as diarrhea and typhoid fever [10].

Poor environmental sanitation is largely responsible for much of the contamination and poor personal hygiene, particularly among food handlers, accounts specifically for the contamination of food while improper storage leads to multiplication of pathogen in food to infective doses [12]. In the resource-poor tropical countries of the world particularly in Sub-Saharan Africa, food are often preserved at ambient temperature long before consumption, improperly handled by food vendor, and sold in street in the dirty unhygienic environment [13, 14].

Most vendors have limited education and therefore, lack knowledge on proper handling of the food and on the effect of improper handling with reference to transmission of food-borne pathogens [15, 7, 16]. The problems of food safety in the industrialized world differ considerably from those faced by developing countries. Whereas traditional methods are used for marketing fresh produce in the latter countries, food processing and packaging are the norms in industrialized countries. In developing countries a large proportion of ready-to-eat food is sold on the streets. The hygienic aspects of vending operations are a major source of concern for food control officers. For example, stands are often crude structures, and running water may not be readily available. Also toilets and adequate washing facilities are rarely available. The washing of hands, utensils, and dishes is often done in buckets or bowls. Disinfection is not usually

carried out, and insects and rodents may be attracted to sites where there is no organized sewage disposal. Finally food is not adequately protected from flies and refrigeration is usually unavailable.

The conditions described above, compounded by inadequate access to good pipe borne water, poor drainage system, and lack of appropriate waste disposal facilities as noted by Chukwuemeka *et al* [10] also prevail in Ijebu-Ode, one of the largest city in Ogun State, Southwestern Nigeria, which contributes negatively to poor personal and environmental hygiene of food vendor in this locality. It is with this background that this research work investigates bacteriological assessment of water used by food vendors in some major motor parks and markets in Ijebu-Ode Local Government aiming at assessing the microbial quality of water used by the food vendors, assessing the level of microbial contamination in relation to the local (NAFDAC) and International (WHO) standards, assessing the prevalent pathogen microorganisms in the water used by the food vendors, and to discuss the implication of the results obtained from the above on health-safety of the public, most especially that of the studied area and possibly put forward recommendations that may help promote proper and sanitary handling of vended foods and water.

## 2. MATERIALS AND METHODS

This describes the field and laboratory procedures used in carrying out this research work.

### 2.1 Field Procedure

This involves preliminary survey of the study area, sampling, and sample collection. The preliminary and familiarization process was carried out in March, 2013 and collection of samples was done in April, 2013.

The study area, Ijebu-Ode, Ogun State is in the sub-humid tropical region of Southwestern Nigeria and it lies between latitude $6^{o}49'N$ - $6^{o}82'N$ and longitude $3^{o}55'E$ - $3^{o}92'E$. Its geographical location is easily accessible from Sagamu/Lagos State and covers an area of about $195km^2$. It has population of over 222,000 projected from 2007 census.

#### 2.1.1 Sampling technique and sample collection

The simple random sampling technique was employed in this study. A total of twelve (24) food vending points; six (6) each from the two major motor parks (Lagos garage and Ibadan garage) and two major markets (Oke-Aje Market and New Market) in Ijebu-Ode were sampled

during this study for bacteriological analysis of the water used both for cooking by the vendors and served to the customers for drinking. Water samples were collected aseptically following the procedures described by Oparaocha *et al* [17] and Oladunjoye *et al* [18] into sterile bottles and the collection time was recorded. After recording the time of collection, the samples were labeled with code names before going to the laboratory for analysis, as recommended by Cheesbrough [19]

## 2.2 Laboratory Analysis

Bacteriological analysis of the samples was carried out at the Microbiology Department of the Sacred Heart Hospital, Oke-Lantoro Abeokuta, Ogun State.

Materials used include: Double and single strength MacConkey broth, test tubes, pipettes, Nutrient agar, water bath, incubator and microscope.

### 2.2.1 Presumptive coliform count

Presumptive coliform count was done as described by Arora and Arora [20]. Measured amount of water sample was added by sterile graduated pipette as follows: one 50ml volume of water to 50ml double strength medium; five 10ml volume of water each to 10ml double strength medium; five 1ml volume of water each to 5ml single strength medium; five 0.1ml volume of water each to 5ml single strength medium.

The inoculated tube/bottles were incubated at 37$^{o}$C for 48hours. The presumptive coliform count per 100ml was determined from the bottles showing acid and gas using the probability table.

### 2.2.2 Total Plate Count

Total plate count was performed as described by Baker and Breech [21]. briefly,1/10 and 1/100 dilution of water was prepared as follows; 1ml of water was added to each of the four sterile dishes and 1ml of water to 9ml of diluent in sterile test tubes. The pipette was discarded. With a fresh pipette 1ml of 1/10 dilution was added to each of the four Petri dishes and 9ml of diluent. The pipette was discarded. With a fresh pipette 1ml of 1/100 dilution was added to two Petri dishes and the pipette was discarded. To each plate, 20ml of molten yeast extract agar was added and mixed gently in clockwise and anticlockwise direction. Two of the plates inoculated with undiluted sample and two inoculated with 1/10 dilution were incubated at 37degree Celsius

for about 24 hours. The remaining plates including the two 1/100 dilution plate were incubated at 22$^{o}$C for 72 hours. Colonies were counted from plates containing 30 and 300 colonies.

### 2.2.3 Confirmed *Escherichia coli* count

After the presumptive test, subcultures were made from all the tubes/bottles showing acid and gas to fresh tubes of single strength MacConkey broth, and peptone water. These were incubated at 37$^{o}$C and 44$^{o}$C in thermal controlled water bath and examined after 24 hours. The *E. coli* count per 100ml was determined from the tubes/bottles showing acid and gas production at 37 $^{o}$C and 44$^{o}$C using the most probable number (MPN) table [20].

### 2.2.4 Identification and Characterization of Isolates

Bacterial isolates were identified by standard microbiological methods of American Public Health Association (APHA) [22] described in Arora and Arora [20], viz colony morphology, gram staining, urease, oxidase, indole, citrate, voges prosker (vp), motility, hydrogen sulphide and sugar fermentation tests.

### 2.3 Statistical Data Analysis

All the experiments were carried out in triplicates and the results were found reproducible within ± 3% error. The data were statistically analyzed by setting up and calculating mean (X±S.E.M), the obtained mean values were compared with National Food and Drug Law Agency and Control (NAFDAC) specified maximum permissible limit, and ANOVA for the various parameters using Statistical Package for Social Sciences (SPSS) software package (Norusis and SPSS Inc, 1997).

## Results

The results of the quantitative and qualitative microbiological analyses are presented in Tables 1, 2, 3, 4 and 5. The quantitative microbial analysis of all food-vendor water sampled within the motor parks and the markets (Table 1) revealed that all the samples contain highly significant load of bacteria that exceeded the Maximum Permissible Levels (MPL) stipulated by both NAFDAC and the WHO standards for drinking water. For samples within the motor parks, the mean Total plate counts in X $10^5$ CFU/ml ranged between 147.67±7.65 and 239.33±15.13 significantly above the 10 X $10^4$ CFU/100ml recommended by NAFDAC and WHO. The Mean presumptive Coliform counts and mean *E. coli* counts (both in X $10^5$ CFU/ml) gave values ranging between 20.00±0.00 and 45.20±1.00 and 20.23±1.05 and 45.00±0.00 respectively also

significantly exceed the NAFDAC and WHO recommendation (of zero) in potable water. In the same vein, for samples within the markets, the mean Total plate counts (in X $10^5$ CFU/ml) ranged between 10.00±0.00 and 254.67±10.67 significantly above the 10 X $10^4$ CFU/100ml recommended by NAFDAC and WHO. The Mean presumptive Coliform counts and mean *E. coli* counts (both in X $10^5$ CFU/ml) gave values ranging between 10.00±0.00 and 40.00±0.00, and 5.03±0.10 and 30.33±1.67 respectively also significantly exceeding the NAFDAC and WHO recommended standards

**Table 1: Mean Presumptive Coliform, Confirmed *E. coli* and Total Plate Counts (CFU/ml) of the water samples used by food vendors at the motor park in Ijebu-Ode**

| | Sample ID | Presumptive Coliform Count ($x10^5$ cfu/ml) | Confirmed *E. coli* Count ($x10^5$ cfu/ml) | Total Plate Count ($x10^5$ cfu/ml) |
|---|---|---|---|---|
| Motor Parks | $IG_1$ | 25.50±1.00 | $20.33±1.15^{ab}$ | 152.67±8.54 |
| | $IG_2$ | $35.00±0.00^{b}$ | 25.00±0.00 | $164.27±9.33^{cd}$ |
| | $IG_3$ | $45.00±0.00^{a}$ | $45.00±0.00^{a}$ | $202.03±14.83^{c}$ |
| | $IG_4$ | $40.67±2.10^{a}$ | $40.00±1.53^{a}$ | $215.33±15.15^{c}$ |
| | $IG_5$ | $30.00±2.00^{b}$ | $30.00±0.00^{b}$ | $147.67±7.65^{cd}$ |
| | $IG_6$ | $20.00±0.00^{ab}$ | $35.67±1.17^{b}$ | 150.00±6.50 |
| | $LG_1$ | $35.10±1.00^{b}$ | $20.23±1.05^{ab}$ | $167.00±10.23^{cd}$ |
| | $LG_2$ | $40.33±1.15^{a}$ | $35.00±0.00^{b}$ | $201.33±10.37^{c}$ |
| | $LG_3$ | $45.20±1.00^{a}$ | $40.33±0.67^{a}$ | $232.67±14.28^{c}$ |
| | $LG_4$ | $35.00±0.00^{b}$ | 30.67±0.33 | $239.33±15.13^{c}$ |
| | $LG_5$ | $40.00±0.00^{a}$ | $35.20±1.13^{b}$ | $199.33±10.87^{d}$ |
| | $LG_6$ | $40.67±1.12^{a}$ | 34.00±0.00 | $188.00±10.03^{d}$ |
| Markets | $NM_1$ | $30.00±0.00^{c}$ | $10.03±0.75^{b}$ | $93.33±5.27^{d}$ |
| | $NM_2$ | $10.00±0.00^{ab}$ | $6.00±0.00^{ab}$ | $10.00±0.00^{abcd}$ |
| | $NM_3$ | $25.00±0.00^{b}$ | $15.23±0.93^{b}$ | $78.27±4.23^{d}$ |
| | $NM_4$ | 17.67±1.10 | 10.00±0.00 | $38.00±0.00^{bc}$ |
| | $NM_5$ | 30.00±2.00 | 10.00±0.00 | $83.67±4.83^{d}$ |
| | $NM_6$ | $14.00±0.00^{ab}$ | 10.13±0.77 | $49.37±2.23^{bc}$ |
| | $OA_1$ | $17.33±1.17^{b}$ | $10.00±0.00^{b}$ | 47.00±2.03 |
| | $OA_2$ | 12.33±1.05 | 10.00±0.20 | $42.27±1.97^{c}$ |
| | $OA_3$ | 12.67±1.00 | $5.03±0.10^{ab}$ | $28.00±1.03^{ab}$ |
| | $OA_4$ | $12.00±0.00^{ab}$ | 10.00±0.00 | $25.33±1.13^{ab}$ |

| | | | | |
|---|---|---|---|---|
| | $OA_5$ | $40.00\pm0.00^{c}$ | $30.33\pm1.67^{b}$ | $254.67\pm10.67^{d}$ |
| | $OA_6$ | $25.33\pm1.47$ | $15.00\pm0.00^{b}$ | $96.33\pm5.03^{d}$ |
| | $NM_1$ | $30.00\pm0.00^{c}$ | $10.03\pm0.75^{b}$ | $93.33\pm5.27^{d}$ |
| | $NM_2$ | $10.00\pm0.00^{ab}$ | $6.00\pm0.00^{ab}$ | $10.00\pm0.00^{abcd}$ |
| Standards (MPL) | NAFDAC | 10 | 0 | 10 |
| | WHO [23] | NONE | NONE | 10 |

Values are expressed as mean ± S.E.M. of three determinations (triplicates).
Mean values with same letter are significantly different at ($P<0.05$).
*LG: Lagos Garage, IG: Ibadan Garage, NM: New Market, OA: Oke-Aje Market, MPL: Max. Permissible level*

Table 2 shows the distribution of presumptive coliform counts and confirmatory *E. coli* counts of the water samples.

For samples collected within the motor parks, presumptive count shows 8.33% (1) of the total samples and 16.67% (2) of the total sample for the *E. coli* counts falls within the range of 1 - 20 coliform/*E. coli* count/100 ml; 16.67% (2) of the total samples and 8.33% (1) of the total sample for the presumptive coliform count and *E. coli* counts respectively, falls within the range of 41 - 60 coliform/*E. coli* count/100 ml However, a total of 75.00% (6) of the samples collected equally had their presumptive coliform count and *E.* coli within the range of 41 - 60 coliforms.

However, for samples collected within the markets, presumptive count reveals 58.33% (7) of the total samples and 91.67% (11) of the total sample for the *E. coli* counts falls within the range of 1 - 20 coliform/*E. coli* count/100 ml; 41.67% (5) of the total samples and 8.33% (1) of the total sample for the presumptive coliform count and *E. coli* counts respectively, falls within the range of 21 - 40 coliform/*E. coli* count/100 ml while 0.00% (0) each had their presumptive coliform count and *E.* coli within the range of >41 coliforms.

**Table 2: Distribution of presumptive coliform counts and confirmatory *E. coli* counts (Motor Parks)**

| MPN of coliform/100 ml | Presumptive Coliform Count (%) | Confirmed *E. coli* Count (%) |
|---|---|---|
| 1 – 20 | 1 (8.33) | 2 (16.67) |
| 21 – 40 | 9 (75.00) | 9 (75.00) |
| 41 – 60 | 2 (16.67) | 1(8.33) |
| > 60 | 0 (0.00) | 0(0.00) |

**Table 3: Distribution of presumptive coliform and confirmatory *E. coli* counts all the Water samples (Markets)**

| MPN of coliform/100 ml | Presumptive Coliform Count (%) | Confirmed *E. coli* Count (%) |
|---|---|---|
| 1 – 20 | 7 (58.33) | 11 (91.67) |
| 21 – 40 | 5 (41.67) | 1 (8.33) |
| >41 | 0 (0.00) | 0(0.00) |

Table 4 indicates the distribution of bacteria isolates from different drinking-water sampled. *Escherichia coli is* the most prevalent in the samples with prevalence of over 35% (and present in all the water samples), followed by *Bacillus substilis* and *Klebsiella spp.* with approximate prevalence of 19% and 18% respectively. *Enterobacter sp.* had approximately 15% prevalence, *Pseudomonas sp.* 7% prevalence, *Proteus sp.* 2% while *Citrobacter sp.* and *Staphylococcus saprophyticus* had equal prevalence of 1% each.

**Table 4: Distribution of Bacterial Isolates in the different water samples**

| **Location** | Ec | Ks | Bs | Ps | Ens | Cs | Pr | Ss | Total |
|---|---|---|---|---|---|---|---|---|---|
| Ibadan Garage | 6 | 3 | 5 | - | 2 | - | 2 | 1 | 19 |
| Lagos Garage | 6 | 5 | 4 | 2 | 1 | 1 | - | - | 19 |
| New Market | 6 | 3 | 2 | 2 | 2 | - | - | - | 15 |
| Oke-Aje market | 6 | 1 | 2 | 1 | 5 | - | - | - | 15 |
| Total | 24 | 12 | 13 | 5 | 10 | 1 | 2 | 1 | 68 |

Es=*Escherichia coli* ; Ks= *Klebsiella sp.*,; Bs = *Bacillus subtilis,* ; Cs = *Citrobacter sp* ; Ps = *Pseudomonas sp* ; Ens = *Enterobacter sp.* ; Pr = *Proteus sp.*,; Ss = *Staph. saprophyticus*

The qualitative microscopic and biochemical bacteriological analysis revealed the presence of certain pathogenic organisms most of which are of faecal origin in all the water samples. A total of eight (8) pathogenic bacteria were identified and characterized. They include *Escherichia coli, Klebsiella sp. Bacillus subtilis, Citrobacter sp Pseudomonas sp, Enterobacter sp., Proteus sp,* and *Staphylococcus. Saprophyticus* (Table 5). This thus showed that all the samples from the study area were polluted with pathogenic bacteria which are of significant health implication.

**Table 5: Microscopic and Biochemical Characteristics of Bacteria Isolates in water sampled from Major Motor Parks and Markets in Ijebu-Ode, Ogun State.**

| Sample ID | Colony Morphology | Gram reaction | Urease | Oxidase | Indole | Citrate | Growth on MacConkey | Voges proskauer | motility | H2S | Sugar Fermentation | Probable Organism |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $IG_1$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $IG_2$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | - | AG | *Klebsiella sp.,* |
| | Rods | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| $IG_3$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis,* |
| | Cocci | + | ND | ND | - | ND | ND | - | - | ND | AG | *Staph. saprophyticus* |
| $IG_4$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Chains | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| | Rods | - | + | - | + | + | | - | + | ND | - | *Proteus sp.* |
| $IG_5$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $IG_6$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | - | - | ND | AG | *Klebsiella sp.,* |
| | Rods | - | + | - | - | + | + | - | + | + | A | *Proteus sp* |
| $LG_1$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.,* |
| | Chains | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| $LG_2$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.* |
| | Rods | - | - | + | - | + | + | - | + | ND | - | *Pseudomonas sp.,* |
| $LG_3$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.,* |
| | Rods | - | ND | - | - | + | - | + | + | - | A | *Enterobacter sp.* |
| $LG_4$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.,* |
| | Chains | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| $LG_5$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | ND | - | - | + | + | + | + | + | A | *Citrobacter sp* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $LG_6$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | - | + | - | + | - | - | + | - | - | *Pseudomonas sp.* |
| $NM_1$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | - | + | - | + | - | - | + | - | - | *Pseudomonas sp.* |
| $NM_2$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | - | AG | *Klebsiella sp.* |
| $NM_3$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $NM_4$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | - | AG | *Klebsiella sp.* |
| $NM_5$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.* |
| | Chains | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| $NM_6$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | - | + | + | AG | *Enterobacter sp.,* |
| | Rods | - | - | + | - | + | - | - | + | - | - | *Pseudomonas sp.* |
| $OA_1$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $OA_2$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $OA_3$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |
| $OA_4$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | - | - | - | + | + | + | + | + | AG | *Enterobacter sp.,* |
| | Chains | + | ND | - | - | + | - | - | + | - | A | *Bacillus subtilis* |
| $OA_5$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | + | ND | - | - | + | - | - | + | - | - | *Bacillus subtilis* |
| | Rods | - | - | + | - | + | - | - | + | - | - | *Pseudomonas sp.* |
| $OA_6$ | Rods | - | - | - | + | - | + | - | + | - | AG | *Escherichia coli,* |
| | Rods | - | + | - | - | + | + | + | - | ND | AG | *Klebsiella sp.* |
| | Rods | - | ND | - | - | + | + | + | + | + | AG | *Enterobacter sp.* |

A = Acid Production; AG =Acid and Gas Production; ND = Not Done;

## Discussion

Water is a vital source of human existence since body of man is made up of 70% water and gets thirsty when 1% loss of the fluid even risks death when up to 10% loss of the fluid [24]. Water has been implicated to be a well known vehicle for many enteropathogens such as *E. coli, Salmonella spp*., and *Campylobacter* spp. amongst others [25, 26, 27]. The fact that many of available water sources are under threat from pollution either from human life style manifested by the low level of hygiene practiced in the developing countries which are not devoid of contaminants in terms of chemical (both organic and inorganic), biological, physical and radiological which are not healthy for human health [28, 29, 30] has become a major focus of many researches.

Potable water is that which is free from microorganisms and chemical substances in concentrations which could cause illness in any form [31]. The water samples recorded a high mean value for total plate count, coliform and *E. coli* counts per 100 ml exceeding the maximum permissible levels recommended by NAFDAC and WHO. This can be attributed to poor unsanitary handling of water by the vendors including the sale and serving of food and water to customers with bare hands, unwashed cups and not well cleaned plates. Unsanitary handling of street foods by some of the vendors has been commonly found to be the source of contamination [32, 33]. The vendors can be carriers of pathogens like *Escherichia coli, Salmonella,* Shigella, *Campylobacter* and *S. aureus* who eventually transfer these food borne hazards to the consumers. The hands of the food handlers are the most important vehicle for the transfer of organisms from faeces, nose and skin to the food [34]. The finding that *Salmonella, non-typhi salmonellae, Campylobacter* and *E. coli* can survive on finger tips and other surfaces for varying periods of time [35] and in some cases even after washing, supports the reports of contamination of street vended food with toxigenic *S. aureus*, the major being suppurative lesions of human beings and the environment [36, 37].

The detection of coliforms and *E. coli* is an indication of faecal contamination of the served food by food vendors in these public places. Although according to WHO [31], the presence of not more than 3 coliforms/100 ml may be tolerated provided faecal *E. coli* count/100 ml is zero but none of the sampled water in this study fulfilled this. The detection of *E. coli* count in all water samples could be as a result of the prevailing unhygienic environmental conditions of the vending points and the shortage of potable water supply. As opined by Dawson and Canet

[33], due to this shortage of clean potable water, many vendors tend to reuse the water, especially for cleaning utensils and used dishes. The presence of E. coli in water does not only indicate contamination of faecal origin but it is in itself a major health concern. For example, verocytotoxin producing E. coli (VTEC) serogroup 0157, a major cause of hemorrhagic colitis, is acquired predominantly through the waterborne route [38, 39]. Other enteric pathogens detected in the water samples include *Klebsiella sp. Bacillus subtilis, Citrobacter sp, Pseudomonas sp, Enterobacter sp., Proteus sp,* and *Staphylococcus. Saprophyticus*. This report is similar to the findings of Dawson and Canet [33] that the stored water used by consumers and vendors, at the vending site, showed heavy bacteriological contamination of faecal origin. Such heavily contaminated water is a primary source of diarrhea diseases to the street food consumers, when water samples from storage tanks used by some vendors were checked at different localities in Pune, India, it was revealed that 29.6% of the water samples were not conforming to the WHO standards of potability and had coliform counts of more than 16/100 ml, while faecal coliform counts were more than 16/100 ml in 15.5% of water samples, 4.5% of samples were positive for E. coli and 2.7% for enteropathogenic E. coli [40]. Similarly, pathogens like Salmonella and Shigella have been detected in the water used by vendors for dishwashing [41].

## Summary and Conclusion

Water samples used by food vendors for drinking, cooking and other purposes from the major motor parks (Lagos garage and Ibadan Garage) and markets (Oke-Aje Market and New Market) were assessed for their microbial quality to ascertain the level and nature of contaminants that may be presented in the samples in order to enlighten the populace on the dangers associated with the consumption of such contaminated water and foods and to educate them on the need to maintain proper hygiene in food and water handling. A total number of twelve (24) samples (six each from the two garages and the two markets) were collected aseptically from randomly selected restaurants/major food vending points in the garages and markets and bacteriological analyses were carried out on them to ascertain the Presumptive Coliform, Confirmed *E. coli* and Total Plate Counts. Biochemical tests were further carried out on isolated pathogenic bacteria for their identification and characterization following standard methods. The mean counts obtained were statistically tested using ANOVA ($p<0.05$) and compared with local (NAFDAC) and international (WHO) recommended values. The results showed that all the water samples were heavily populated with bacteria above the recommended

values with presumptive coliform count and confirmed *E. coli* count within the rage of 21 – 40 MPN/100ml having the highest distribution (75% for both) in the samples. Pathogenic bacteria isolated and identified in the samples include *Escherichia coli, Klebsiella sp., Bacillus subtilis, Pseudomonas sp Enterobacter sp, Citrobacter sp., Staphylococcus saprophyticus* and *Proteus sp* with *E. coli* having the highest distribution (being present in all the samples).

From these results it can be concluded that all the water samples are not suitable for human consumption. This thus calls for strict public health regulations regarding the sale of foods on street by vendors or restaurants, regular laboratory checking of foods and water from those sources and routine inspection by health inspectors of these vendors and their environment to ensure hygienic standards are entrenched.

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