common business in Nigeria which leaves much to be desired considering the handling process of watermelon from farm to fork which is further compounded by the fact that watermelon is being processed for sale by vendors who do not have the knowledge of how to prevent microbial contamination. This calls for concern because food borne outbreaks linked to fruits and vegetables is on the increase worldwide (Elias, 2018).

The importance of carrying out the microbiological analysis of watermelon fruit cannot be over emphasized because microbiologically safe watermelon fruit are essential for maximizing the health benefits obtainable from adequate consumption of watermelon. The microbiological quality of sliced watermelon sold in Lokoja market is being investigated so as to find out how safe for consumption they are because of the prevailing circumstance of poor hygiene practice by the fruit vendors.

## 2.0 MATERIALS AND METHODS

### 2.1 Study Population/Site

Lokoja is situated at $7.8^0$ North Latitude, $6.74^0$ East Longitude and 55 meters elevation above the sea level. It is the capital of Kogi State and a confluence city in North Central part of Nigeria. The study population included sixteen vending points from four markets (Old market, New market, Phase one market and Adankolo market).

### 2.2 Sample Collection

Two hundred forty samples of sliced watermelon were purchased from sixteen vending points from the month of June to September, 2016 and taken to Federal University Lokoja laboratory for microbiological analysis.

### 2.3Microbiological Analysis

Twenty five grams (25g) of five slices of homogenized watermelon were weighed aseptically and transferred into 225ml of the sterile diluent, 0.1% peptone water to form the stock solution. 1ml of the inoculums from the stock solution was serially diluted in a set of test tubes containing 9ml of 0.1% peptone water from which further serial dilutions were carried out using the method of Daniel *et al.,* 2014 with slight modification. Pour plate technique was used for culturing and isolation of the microorganisms using nutrient agar and potatoes dextrose agar for the isolation of bacteria and fungi respectively at an incubation temperature of $37^0$C for 48 hour for bacterial growth and $28^0$C for 2-7 days for fungal growth. The colonies formed were counted and expressed as colony forming unit per gram (cfu/g). The bacteria isolated were identified using biochemical test: indole, simmon citrate, motility, methyl red, voges proskauer, catalase, oxidase and sugar fermentation test while the fungal isolates were identified based on their standard cultural and morphological characteristics as described by Barnett (1960).

### 2.4 Antibiotic Susceptibility Test

Antibiotic susceptibility test was carried out by using disc diffusion method on Mueller –Hinton agar according to National Committee for Clinical Laboratory Standards. Commercially available antimicrobial discs were used and plates were incubated at $35^0$C. Zones of inhibition were interpreted as resistant, intermediate and sensitive using the interpretation chart of zone sizes of Kirby-Bauer sensitivity test method as described by Cheesbrough (2006).

### 2.5 Statistical Analysis

Analysis of variance (ANOVA) was used to compare the microbial load of sliced watermelons from the four markets using SPSS 20.

## 3.0 RESULT AND DISCUSSION

### 3.1 Result

### 3.1.1 Mean Microbial Load of Bacterial and Fungal Isolates

The mean microbial load of fungi and bacteria are presented on Table 1. New market had the highest bacterial load of 6.60 ± 1.69 x $10^5$cfu/g while phase one market had the least bacterial load of 2.97±0.72 x $10^5$cfu/g. New market also had the highest fungal load of 4.92±0.92x$10^4$cfu/g while Adankolo market had the least fungal load of 3.33±0.14x$10^4$cfu/g as shown in Table 1.

### 3.1.2 Pectercentage of Occurrence of Bacterial and Fungal Isolates

**_S.aureus_ (34.2%) is the most occurring bact. followed by _E. coli_ (31.3%), _P. aeruginosa_ (16.6%), _K. aerogene_ (10.4% and _Proteus sp_ (7.6%) as the least occurring bacteria as seen in table 2. _Aspergillus niger_ (34.5%) is the occurring fungi followed by _Rhizopus_ sp (28.9%), _Mucor_ sp (24.4%) and _Alternaria_ sp (12.2%) as the least occurring fungi as seen in Table 2.**

### 3.1.3 Antimicrobial Sensitivity Test

The Gram positive bacteria *S.aureus* was most sensitive to pefloxacin and least sensitive to septrin as shown in Table 3. The Gram negative bacteria: *Klebsiella spp, Proteus spp, E.coli and P.aeruginosa* were most sensitive to ciprofloxacin and were not sensitive to vancomycin as shown in Table 3.

**Table 1 Mean microbial load of bacteria and fungi isolates from sliced watermelon collected from four Lokoja markets.**

| Market Location | Bacteria Load x10 (cfu/g) | Fungi Load x$10^4$ (cfu/g) | |
|---|---|---|---|
| New Market | 6.60±1.69[a] | 4.92±0.29[b] | 4.92±0.29[b] |
| Old Market | 4.88±1.32[a] | 3.65±0.39[a] | |
| Phase Market | 2.97±0.72[a] | 3.92±0.37[a] | |
| Adankolo Market | 4.43±1.20[a] | 3.33±0.14[a] | |

Values with same alphabets in a column do not differ significantly at p≥0.05, cfu/g-colony forming unit

**Table 2: Percentage of Occurrence of Bacterial and Fungal Isolates**

| Bacterial isolate: | Percentage of occurrence | Fungal isolate: | Percentage of occurrence |
|---|---|---|---|
| *S.aureus* | 34.2 | *Mucor* sp | 24.4 |
| *E.coli* | 31.3 | *Rhizopus* sp | 28.9 |
| *Proteus* sp | 7.50 | *Aspergillus niger* | 34.5 |
| *P.aeruginosa* | 16.6 | *Alternaria* sp | 12.2 |
| *k.aerogenes* | 10.4 | | |

**Table 3. Antibiotic susceptibility profile of the Gram positive isolate(*S.aureus*)**

| Antibiotics | Disc concentration (µg) | Zones of inhibition (mm) |
|---|---|---|
| Septrin | 30 | 5.00 |
| Chloramphenicol | 30 | 9.00 |
| Ciprofloxacin | 10 | 19.00 |
| Sparfloaxcin | 10 | 16.00 |
| Pefloxacin | 30 | 21.00 |
| Tarivid | 10 | 17.00 |
| Gentamycin | 10 | 10.00 |
| Streptomycin | 30 | 10.00 |
| Amoxicillin | 30 | 12.00 |
| Augmentin | 30 | 11.00 |

**Zones of inhibition of: ≥ 18 mm (sensitive), 13 – 17 mm (intermediate), < 13 mm (resistant).**

**Table 4. Antibiotics susceptibility profile of Gram Negative isolates.**

| Antibiotics | Disc Conc. (µg) | *Zone of inhibition (mm) E.C | K.A | P.A | P.S |
|---|---|---|---|---|---|
| Erythromycin | 15 | 6.00 | 11.00 | 9.00 | 16.00 |
| Gentamycin | 10 | 19.00 | 23.50 | 18.00 | 12.00 |
| Ampiclox | 30 | 3.00 | 9.00 | 6.00 | 19.00 |
| Chloramphenicol | 30 | 27.00 | 10.00 | 7.00 | 9.00 |
| Ciprofloxacin | 30 | 20.00 | 26.00 | 23.00 | 21.00 |
| Amoxicillin | 10 | 5.00 | 10.00 | 5.00 | 9.00 |
| Ampicillin | 10 | 5.00 | 9.00 | 5.00 | 7.00 |
| Septrin | 30 | 3.00 | 8.00 | 4.00 | 8.00 |
| Tetracycline | 30 | 4.00 | 7.00 | 3.00 | 5.00 |
| Vancomycin | 30 | 0.00 | 0.00 | 0.00 | 0.00 |

*** Zones of inhibition of: ≥ 18 mm (sensitive), 13 – 17 mm (intermediate), ≤ 13 mm (resistant).**

E.C-*E.coli* K.A- *K. aerogenes* P.A-*P.aeruginosa* P.S-*Proteus species*

### 3.2 Discussion

Food including fruits is important and beneficial to the body but can be a source for transmission of diseases that can lead to death when they are contaminated with harmful microorganisms (Alum *et al.*, 2016). Medical literature reveals that microbiological contamination of food

products is the most common form of food contamination that causes illness (Scallan *et al*., 2011).

All the watermelon fruits samples were found to be contaminated with bacteria and fungi which is an indication that the food hygiene practice of the fruit vendors is poor. The microorganisms isolated in this research reflect different aspects of food hygiene and safety of sliced watermelon sold by fruit vendors in Lokoja markets because the microbial safety and quality of food are determined by the kind and number of microorganisms that occur in them (Deak, 2003). For instance, the isolation of unsatisfactory level of *S.aureus* from sliced watermelon is an indication that the sliced watermelons are being processed (cut and sliced) with bare hands and displayed for sell at high temperature which promotes the contamination and proliferation of *S.aureus* in sliced watermelon as asserted by Center for Food Safety (2006) that an unsatisfactory level of *S.aureus* indicate that time/temperature abuse of food is likely to have occurred following improper handling of food with bare hands. The isolation of *E.coli* from sliced watermelon in this research provides direct evidence of faecal contamination; probably resulting from poor personal hygiene (hands not being washed thoroughly after using the toilet) during cutting, slicing and packaging of sliced watermelon (Centre for food safety, 2006). It is no surprise that there is a high number of the coliform group, *E.coli* because watermelon has a high water activity which according to Ferrati *et al.,* (2005) products with high water activity posses good amount of unbound water molecule that support the growth and survival of microorganisms. The isolation of *P.aeruginosa* is an indication of contamination from water, soil, sewage and faeces more so that *P.aeruginosa* can multiply in water environments and on the surface of suitable organic material in contact with water (Centre for Food, 2014)

The isolation of *P.aeruginosa, Proteus sp, klebsiella aerogenes, S.aureus, E.coli, A.niger, Rhizopus spp, Alternaria spp, and Mucor spp* from sliced watermelon can be linked to a number of factors such as improper handling, use of contaminated water for washing of the fruits, flies infestation, and use of improperly washed utensils like: knives and trays. Other sources of contaminations are from the dust containing microbes and their spores. Watermelons not being washed before they are cut up favours contamination by microorganisms like: *Alternaria spp, Pseudomonas spp* and *k.aerogenes* that greatly abound in the soil. The presence of *k.aerogenes* and *Alternaria sp* can be due to contamination from the soil, unclean water and dust in the environment. Handling of soiled notes and currency by street vendors might also act as vector for the transmission of pseudomonas in sliced watermelon samples (Barro *et al.,* 2006).

According to Nwanchukwu *et al.*(2008), fungi contaminants on sliced watermelon are from water and the environment (spores in the air). Mailafia *et al.,* (2017) implicated fungi as contaminations of fresh fruits and isolated 38% of A.niger from watermelon fruits. The presence of fungi isolates might be due to the open space prone to flies visitation and airborne spores contamination that watermelon is processed and sold since the sliced water melon are left exposed before they are tied up in a

polythene bag.

Almost all of the bacteria and fungi isolated in this study have been isolated by various researchers in some other part of the Nigeria from sliced watermelon except for the fungi *Alternaria*. Daniel *et al*., (2014) isolated *Staphylococcus aureus, Escherichia coli, Klebsiella aerogenes, Mucor spp and Aspergillus* spp in Bida, Niger State. Nwanchukwu *et al*. in 2008 isolated *E. coli, Proteus mirabilis, S.aureus, Rhizopus stolonifer* and *Mucor spp* in Umuahia, Abia State. Oranusi and Olorunfemi, 2011 isolated *S.aureus, E.coli, E. aerogenes, Proteus spp and A. niger* in Ota, Ogun State. Daniyan *et al*., 2011 isolated *S.aureus, E.coli, E. aerogenes, Mucor spp* and *A. niger* in Minna, Niger State, Afolabi and Oyebode in 2014 isolated: *E. coli, Pseudomonas spp, S. aureus, Proteus mirabilis, Mucor spp*. and *R. Stolonifer.* Eni *et al*., in 2010 isolated: *S. aureus*. Ijah *et al*., in 2015 isolated*: S. aureus, Pseudomonas,* and *A. niger, Chukwu et al.,* in 2009 isolated: *E. coli, S. aureus, Proteus spp, E. aerogenes* in Kano State.

The isolation of microorganisms from ready-to-eat sliced watermelon by different researchers from different part of Nigeria is an indication that consumers should be weary of buying and consuming sliced watermelon since most of them are contaminated with microorganisms that can cause various diseases; commonly diarrhea.

According to World Health Organization (2015), 2.2 million people worldwide die every year from eating contaminated food and water. Similar microbes may isolated because sliced watermelon are sold in Nigeria by vendors with little knowledge of hygiene as such they have the same poor processing technique.

The sliced watermelons sampled had a higher bacterial load of 1.0 - 9.9 x $10^5$ (cfu/g) than its fungi load of 2.0 - 5.0 x $10^4$ (cfu/g) because of the high water activity and high pH (alkalinity) of watermelon which is in accordance with the assertion of Ndife et al., (2013) who stated that food acid dictates the dominant microflora in food to a large extent (fungi dominate in acidic food while bacteria dominate in alkaline food). As such since watermelon is alkaline, bacteria will thrive in it more than fungi that are acid loving. More so that bacteria will readily inhabit a fruit with high water content than fungi. The bacteria load (1.0 - 9.9 x $10^5$cfu/g) obtained from the sliced water melon sold in Lokoja market is similar to the bacteria load of 3.0 -9.3 x $10^5$ (cfu/ml) obtained by Adetesan et al., (2013) and Daniyan et al., (2011) with a bacterial load of 3.5 x$10^4$- 9x$10^5$ while the mean fungi load of 2.0 – 5.0 x $10^4$cfu/g in this study is similar to the fungi load of 0.5 – 3.1 x $10^4$cfu/g obtained by Afolabi and Oyebode (2014) from sliced watermelon

Afolabi and Oyedele (2004) deduced that the presence of Mucor spp and Rhizopus stolonifers might be due to dusty and dirty environment.

The result of the antimicrobial sensitivity of the only Gram positive bacterial isolate, *S. aureus* corresponds with the report of Srinu *et al*., (2012) that reported that *S. aureus* was sensitive to the antibiotic; ciprofloxacin and Adetesan *et al*.,(2013) reported that *S. aureus* was resistant to the antibiotic; amoxicillin. The antibiotic sensitivity of Gram negative isolates

correspond to that of Marwa *et al*., (2012) and Adetesan *et al*., (2013) that isolated, *Proteus* spp and *E.coli (*from sliced watermelon) that are sensitive to ciprofloxacin. Adetesan *et al*., (2013) isolated *E.coli that* are sensitive to chloramphenicol; *E.coli and Proteus* spp that are resistant to amoxicillin which is similar to the result obtained in this research.

All the watermelon samples collected from the various markets are considered unsatisfactory going by their microbial load and the criteria for fruits and vegetables (fresh) stated in microbiological guidelines for ready-to-eat food recommended by Centre for Food Safety (2014) that the colony forming unit per gramme (cfu/g) of *E.coli* should be less than 100 (<100) in every one gramme (1g) of fruit sample and should be less than 1000 (<1000) for *S.aureus*.

**4.0 Conclusion**

The result of this study showed that the microbiological quality of all the sliced watermelon samples examined from the four markets in Lokoja are unsatisfactory as such fruit vendors and consumers are advised to follow good hygiene practice such as washing, peeling, slicing, handling and cutting fruits using clean and sanitized utensils and surfaces and finally storing cut fruits at $4^0$C or below until served or sold.

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