*Microbiology Research Journal International*

***31(3): 1-23, 2021; Article no.MRJI.67241***
***ISSN: 2456-7043***
*(Past name: British Microbiology Research Journal, Past ISSN: 2231-0886, NLM ID: 101608140)*

# Microbiological Assessment on Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of Different Varieties of Banana Fruit (*Musa* spp.)

**R. R. Nrior[1*], C. J. Ugboma[1] and C. A. Nzurumike[1]**

*[1]Department of Microbiology, Rivers State University, Nkpolu-Oroworukwo, P.M.B. 5080, Port Harcourt, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author RRN designed the study, author CAN performed the statistical analysis. Author RRN wrote the protocol, wrote the first draft of the manuscript, Author CAN managed the analyses of the study and literature searches under the strict supervision of authors RRN and CJU. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/MRJI/2021/v31i330301
Editor(s):
(1) Dr. Marcin Lukaszewicz, University of Wroclaw, Poland.
Reviewers:
(1) Bagiu Iulia-Cristina, Victor Babeş University of Medicine and Pharmacy, Romania.
(2) Siriphan Boonsilp, Navamindradhiraj University, Thailand.
(3) Jawad R. Alzaidi, Southern Technical University, Iraq.
Complete Peer review History: http://www.sdiarticle4.com/review-history/67241

***Original Research Article***

***Received 11 February 2021***
***Accepted 19 April 2021***
***Published 26 April 2021***

## ABSTRACT

**Aim:** The aim of this study was to carry out microbiological assessment on Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of Different Varieties of Banana fruit (*Musa* spp.) (Cavendish, Dwarf Cavendish, Red, Lady Finger and Grand Nain Banana).
**Study Design:** The study employs statistical analysis of the data and interpretation.
**Place and Duration of Study:** Three major markets - Oil Mill (OM), Fruit Garden (FG), Mile Three (MT), all located in the city of Port-Harcourt, Nigeria. Sample collection lasted for a week and the analysis was carried out every day and it lasted for six months.
**Methodology:** A total of forty-five (45) banana (Cavendish, Dwarf Cavendish, Red, Lady Finger and Grand Nain Banana) fruit samples were collected for a period of three months from three different markets (Oil Mill, Fruit Garden and Mile Three Markets) in Port Harcourt, Nigeria. The collected samples were grouped into three (Unripe, Healthy-Looking and Spoiled) and were subjected to standard microbiological procedures which includes standard plate counts, biochemical and molecular identification of the isolates.

**Corresponding author: E-mail: renner.nrior1@ust.edu.ng;*

**Results:** A total of 124 isolates were isolated from the different sampled parts (Cut stalk, Tip, Endocarp, Vascular Tissue and Epicarp) of the banana fruit. *Staphylococcus aureus* count in the unripe sampled Banana fruits from Oil Mill market showed high prevalent rate in the Cut Stalk of the Cavendish Banana at $4.17\pm0.31x10^2$ CFU/g followed by the Tips of the Grand Nain and Cavendish Banana at $4.03\pm0.21x10^2$ CFU/g and $4.00\pm0.20x10^2$ CFU/g, respectively. While the TCC in the Healthy-Looking sampled fruits from Fruit Garden showed more microbial load in the Epicarp of the Dwarf Cavendish Banana at $2.93\pm1.15x10^3$ CFU/g followed by the Tip and Epicarp of the Grand Nain Banana at $2.70\pm0.82x10^3$ CFU/g and $2.60\pm0.46x10^3$ CFU/g. The total fungal count (TFC) in Healthy-Looking sampled Banana fruits showed high prevalent rate in Oil Mill market at $2.79x10^3$ CFU/g > Mile Three market, $2.31x10^3$ CFU/g > $1.35x10^3$ CFU/g at Fruit Garden market. While the result of the total *Staphylococcal* count in the unripe sampled Banana fruits showed that *Staphylococcus aureus* was more prevalent in Creek Road market at $1.65x10^2$ CFU/g > Mile One at $1.64x10^2$ CFU/g and the least seen in Mile Three market at $1.50x10^2$ CFU/g. The result of the Coliform count in the spoiled sampled Banana fruits showed that coliform was more prevalent in Mile One market at $2.14x10^3$ CFU/g > $1.98x10^3$ CFU/g in Fruit Garden market and less prevalent in Creek Road market at $1.75x10^3$ CFU/g. The Grand Nain Banana had the most microbial load at 33.9% > Dwarf Cavendish Banana, 25% > Cavendish Banana, 16.9% > Lady Finger Banana, 14.5% > Red Banana at 9.7%. The study location with the most microbial load is the Oil Mill market at 21.23% > Mile One, 20.64% > Creek Road, 20.01% > Mile Three, 19.23% > Fruit Garden, 18.88%.

**Conclusion:** Grand Nain banana variety has the highest microbial load thus consumption of it should be washed or cleansed thoroughly. Secondly, of the different parts sampled, Cut stalk of banana is associated with highest microbial load, therefore it should checked properly or cut off when peeling/during consumption, The high load of *Staphylococcus aureus*, *Escherichia coli* and *Bacillus* is of great concern. These organisms associated with different parts and varieties of banana fruits (*Musa* spp.) in Port Harcourt Nigeria, poses serious threat to consumers. Prohibition of anthropogenic activities within the markets and farms should be encouraged in order to reduce the level of contamination of these fruits. Also, public awareness on safe and hygienic practices in the handling and distribution of Banana fruits from the farms to the markets should be encouraged.

*Keywords: Banana; grand nain banana; cavendish banana; epicarp; cut stalk; staphylococcus aureus.*

## 1. INTRODUCTION

Banana (*Musa* spp.) is one of the most widely cultivated tropical fruits, grown in over 130 countries, along the tropics and subtropics of Capricorn. It is the second largest produced fruit after citrus, contributing about 16% of the world's total fruit production and the fourth most important staple food crops in the world after wheat, maize and rice [1]. According to FAOSTAT [2], the major banana-producing countries that contribute about 75% of total banana production are situated in developing countries. In Ethiopia, it is a most important fruit in terms of both production and consumption [3]. In Nigeria, it's one of the easily assessed fruit in all nook and crannies of each state. Most times it's taken as an appetizer, and in some cases, it's consumed as a main food. Also, it can be incorporated into confectionaries like the common banana cake.

Banana fruits are highly nutritious and easily digestible than many other fruits [4]. Its wide consumption is due to its sensory characteristics, particularly its attractive texture and flavor make banana popular by the consumers [5]. Moreover, it has high caloric contribution leading to high demands mainly by developed countries which account for nearly 70% of world's consumption [6-7]. It also contains low-fat, excellent source of dietary fiber, Vitamin C, Vitamin $B_6$, and Manganese [7]. The presence of Potassium and fiber in large amounts in bananas may help combat atherosclerosis, which can lead to heart attack and stroke [1]. Almost all types of bananas produced in Nigeria are consumed fresh and play an important role in feeding the low-income families as well as providing a source of income to them. The fact that it is an annual fruit that produces its fruit throughout the year adds to its importance as a cash crop in the growing region [8-9]. Although banana fruits are highly demanded as nutritious and economically important fruits, they experience a different marketing problem [10].

One of the limiting factors that influence the fruits' economic value is its relatively short shelf-life caused by postharvest pathogens attack. It is estimated that about 20-25% of the harvested bananas are decayed by pathogens during post-harvest handling even in developed countries. Metabolic activities of microbes alter the condition of food, resulting in its spoilage [11]. In developing countries such as Nigeria, continued use of untreated waste water and manure as fertilizers for the production of fruits and vegetables is a major contributing factor to contaminations [12-13]. Another factor that affects the fruits is the post-harvest handling, transportation (from the farm to the market or from a farmer (wholesaler) to the retailers), storage and marketing. Bananas are known to be very soft and perishable, and if not handled properly, it may result in decay and production of microorganisms, which become activated because of the change in the physiological state of the fruits [14].

Bananas contain high levels of sugars and nutrients element, and their low pH values make them particularly desirable to fungal decay [15]. It has been known that fruits constitute commercially and nutritionally important indispensable food commodity [16].

Microorganisms especially bacteria and fungi have been identified as major organisms causing deterioration of bananas by the secretion of extracellular cell wall degrading enzymes [17]. Most of the reported outbreaks have been associated with bacterial contamination, particularly members of the Enterobacteriaceae [18]. A large number of lactic acid bacteria, molds, yeast, and coliforms, have been reportedly implicated in food spoilage as they use the carbohydrate content of the foods for undesirable fermentation processes [19]. The microorganisms normally present on the surface of raw fruits may consist of chance contaminant from the soil or dust. These include bacteria or fungi that have grown and colonized by utilizing nutrient exuded from plant tissue. Among the group of bacteria commonly found include faecal coli forms such as *Klebsiella* and *Enterobacter* [20].

The significance of this research is based on the fact that banana is a fruit of choice, widely consumed but easily attacked by post-harvest pathogens. This research was done to determine the different microorganisms associated with banana fruits (*Musa* spp.) in relation to the inner cut stalk (head), the inner tip, the epicarp (outer peel), the vascular tissue (inner peel), the center (loculus, endocarp, and placenta) and the flesh (mesocarp). It highlights the part of the fruit which has a higher microbial load. It also highlights the health implications associated with the consumption of affected banana fruits. The aim of this research was to: Isolate and identify the microorganisms associated with different parts (cut stalk, tip, endocarp, vascular tissue and epicarp) of a banana fruit (*Musa spp.*) and determine their percentage occurrence.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study area is three major markets (Oil-Mill Market, Fruit Garden Market and Mile Three Market) in Port-Harcourt, Rivers State, Nigeria.

### 2.2 Sample Collection for Analysis

A total of forty-five (45) banana (Cavendish, Dwarf Cavendish, Red, Lady Finger and Grand Nain Banana) fruit samples were collected for a period of three months from three different markets (Oil Mill, Fruit Garden and Mile Three Markets) in Port Harcourt, Nigeria. The fruits were collected in a polythene bag and transferred to the laboratory. The laboratory evaluation was conducted at the Microbiology laboratory of Rivers State University, Port-Harcourt, Nigeria.

The samples were categorized into three groups (Unripe, almost decaying (spoiled), Fresh and ripe (apparently healthy looking)). The sample names were coded for easy reference on the basis of their categories.

The codes for the sample conditions are:

i. Unripe – "U"
ii. Almost Decaying (Spoiled) – "S"
iii. Fresh and Ripe (Healthy Looking) – "H"

The codes for the different Banana fruit varieties are:

i. Cavendish Banana – "CAB"
ii. Dwarf Cavendish Banana – "DCB"
iii. Red Banana – "RDB"
iv. Lady Finger Banana – "LFB"
v. Grand Nain Banana – "GNB"

The codes for the different study areas are:

i. Oil Mill Market – "OM"
ii. Fruit Garden Market – "FG"
iii. Mile Three Market – "MT"

## 2.3 Media Preparation

Media (selective and enriched) used for isolation of microorganisms (Bacteria and fungi) associated with different parts of Banana (*Musa* spp.) fruit were Nutrient Agar, MacConkey Agar, Blood Agar, Salmonella-Shigella Agar, Mannitol Salt Agar and Mueller-Hinton Agar (for antibiotic sensitivity testing) while Sabouraud Dextrose Agar. All culture media were prepared according to manufacturer's instructions [21].

## 2.4 Microbiological Analysis

### 2.4.1 Microbial estimation

The total heterotrophic bacterial count (THB), total coliform count (TCC), total *Staphylococcal* count (TSC), total fungal count (TFC), total *Bacillus* and *Proteus* count were determined using the spread plate count method on nutrient agar according to Cheesbrough [21].

### 2.4.2 Serial dilution

One gram of the different sampling parts of each banana sample were weighed out using an electric weighing balance and aseptically transferred into a sterile tube containing 9.0ml of normal saline. 10-fold serial dilution were carried out on each sample.

### 2.4.3 Inoculation and incubation

One-hundred microliter of $10^{-2}$ and $10^{-3}$ dilutions were spread plated onto sterile solidified SDA (Sabouraud Dextrose Agar), MSA (Mannitol Salt Agar), NA (Nutrient Agar), Mac-Conkey Agar and Salmonella-Shigella Agar in triplicates and incubated for 24hrs (for the bacterial samples) and 3-7days (for the fungal samples).

### 2.4.4 Enumeration and isolation of pure culture

Colonies and spores that grew on the media after the incubation period were enumerated. Similarly, colonies and spores were picked for subculture to get pure cultures. Pure culture of fungi was stored on SDA slants, while the bacterial isolates were stored in 10% glycerol, all in Bijou bottles.

The colonies counted were expressed as Colony forming unit (CFU) per gram of Banana samples using the formula:

$T = N/V \times DF$

Where,

T= Total number of colonies in CFU/g of banana.
N= Number of colonies counted on the pate.
V= Volume of inoculum plated. i.e. 0.1ml.
DF= Dilution factor used for plating ($10^2$ or $10^3$).

### 2.4.5 Identification of microbial isolates

The fungal spores that utilized carbohydrate as their sole carbon energy source were viewed macroscopically and microscopically (using Lactophenol Cotton Blue Stain and the slide culture technique) while the bacterial isolates were viewed microscopically (using the Gram stain). This was carried out using the steps in Cheesbrough [21].

### 2.4.6 Molecular identification

*2.4.6.1 DNA extraction (boiling method)*

Four milimeters of an overnight grown culture broth in a Luria Bertani (LB) was spinned at 1400rpm for 3 minutes. The bacterial cells were further suspended in 500µl of normal saline and was heated at 95$^o$C for 20 minutes in a heating block. The heated bacterial cells were then cooled in an ice pack and then spinned for another 3 minutes at 1400rpm. After this process, the supernatant which contained the DNA of the bacteria or fungi was transferred to a 1.5ml microcentrifuge tube and was stored in the refridgerator at a temperature of 20$^o$C for other downstream reactions.

*2.4.6.2 DNA quantification*

The earlier extracted DNA genome was quantified using the Nanodrop spectrophotometer. The software for the equipment was launched by double clicking on the Nanodrop icon. The equipment was initialized with 2µl of sterile distilled water and was blanked with the aid of normal saline. After the equipment has been blanked, 2µl of the extracted bacterial or fungal DNA was then loaded on the lower pedestal. The DNA concemtration of the genome was measured by clicking on the "measure" icon.

*2.4.6.3 16S rRNA Amplification*

The 16S rRNA region of the rRNA gene of the isolates were amplified using the 27F: 5'-AGAAGTTTGATCMTGGCTCAG-3' and 1492R: 5'-CGGTTACCTTGTTACGACTT-3' primers on an ABI 9700 Applied Biosystems thermal cycler at a final volume of 40µl for 35 cycles. The PCR mix contained: the X2 Dream taq, Mastermix supplied by Inqaba, South Africa (taq polymerase, DNTPs, MgCl), the primers at a concentration of 0.5uM and the extracted DNA as template. The PCR conditions were as follows:

**i.** Initial denaturation at 95$^{o}$C for 5 minutes.
**ii.** Denaturation at 95$^{o}$C for 30 seconds.
**iii.** Annealing at 52$^{o}$C for 30 seconds.
**iv.** Extension at 72$^{o}$C for 30 seconds for 35 cycles.
**v.** Final extension at 72$^{o}$C for 5 minutes.

The product was resolved on a 1% agarose gel at 130V for 30 minutes and visualized on a blue light illuminator.

*2.4.6.4 Sequencing*

Sequencing was carried out using the BigDye Terminator Kit on a 3510 ABt sequencer by Inqaba Biotechnological, Pretoria South Africa. The sequencing was carried out at a final volume of 10µl, the components included a 0.25µl BigDye® terminator v1.1/v3.1, 2.25µl of 5 x BigDye sequencing buffer, 10Mm primer PCR primer, and 2-10ng PCR template per 100bp. The sequencing conditions were as follows: 32 cycles of 96$^{o}$C for 10seconds, 55$^{o}$C for 5 seconds and 60$^{o}$C for 4 minutes.

*2.4.6.5 Phylogenetic analysis*

The obtained sequences were edited using the bioinformatics algorithm, trace edit, similar sequences were all downloaded from the National Center for Biotechnology Information (NCBI) data base using BLASTIN. These sequences were aligned with the aid of MAFFT. The evolutionary history of the sequence was inferred with the aid of the Neighbor-Joining method in MEGA 6.0 [22]. The bootstrap concensus tree was inferred from 500 replicates [23] was taken to represent the evolutionary history of the taxa analyzed. The evolutionary distances were computed using the Jukes-Cantor method [24].

## 2.5 Statistical Analysis

The data that were obtained from the bioremediation set up were subjected to statistical analysis using computer-based program, SPSS version 22 for analysis of variance (ANOVA) and multiple range tests to find the difference in the means at 5% (0.05) significant level.

## 3. RESULTS AND DISCUSSION

### 3.1 Identification of Isolated Micro-organisms

Out of the 45 Banana (*Musa* spp.) fruit samples collected, 124 microbial isolates were identified of which 83 were bacteria and 41, fungal isolates. Table 1 shows the morphological characteristics of the bacteria isolates while the microscopic characteristics of the fungal isolates is seen in Table 2. The results of the molecular identification can be seen in Figs 1-4. The isolates are potential bacteria and fungi associated with food-borne disease.

### 3.2 Molecular Identification of Bacterial and Fungal Isolates

The obtained ITS sequence from the isolate produced an exact match during the megablast search for highly similar sequences from the NCBI non-redundant nucleotide (nr/nt) database. The ITS of the isolates showed a percentage similarity to other species at 99-100%. The evolutionary distances computed using the Jukes-Cantor method were in agreement with the phylogenetic placement of ITS of the isolates within the *Aspergillus* spp. and *Fusarium* spp. and revealed a closely relatedness to *Aspergillus flavus, Aspergillus sydowii* and *Fusarium lichenicola.* The Phylogenetic tree showing the evolutionary distance between the fungal isolates is represented in Fig. 4.

### 3.3 Microbial Counts/Assessment

The result of the total Microbial counts from the sampling parts (Cut Stalk, Tip, Endocarp, Epicarp and Vascular tissue) of the different varieties (Unripe, Heathy-Looking and Spoiled) of the sampled Banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the five study areas (Oil Mill, Fruit Garden and Mile Three markets) are represented in Table 3-8.

**Table 1. Cultural and biochemical characteristics of the bacterial isolates**

| Colonial morphology | Tests | | | | | | | | Sugar fermentation | | | | | | | Probable organism |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GR | Co | Ca | Ox | Mo | Mr | Vp | In | Ci | Gl | Su | Ma | La | Fr | Ga | |
| Dry, donut shaped, dark pink in color and flat. | - Rod | - | + | - | - | + | - | + | - | + | - | + | + | + | - | *Escherichia coli* |
| Round, yellowish-white or golden yellow in color and elevated. | + Cocci (cluster) | + | + | - | - | + | + | - | + | + | + | + | + | + | + | *Staphylococcus aureus* |
| Greenish-blue in color, moist surface and elevated. | - Rod | - | + | + | + | - | - | - | + | - | - | + | - | - | - | *Pseudomonas aeruginosa* |
| Opaque, round, creamy and elevated. | + Rod | - | + | - | - | + | - | - | + | + | + | - | + | - | - | *Bacillus flexus* |
| Colorless, round, smooth and elevated. | - Rod | - | + | - | + | + | - | - | + | + | - | - | - | - | - | *Proteus mirabilis* |
| Large, shiny and dark pink in color and elevated. | - Rod | - | + | - | - | - | - | - | + | + | + | + | + | - | - | *Klebsiella pneumoniae* |

*KEY: GR- Gram Reaction, Co- Coagulase, Ox- Oxidase, Mo- Motility, Mr- Methyl-Red, Vp- Voges Proskauer, In- Indole, Ci- Citrate, Gl- Glucose, Su- Sucrose, Ma- Mannitol, La- Lactose, Fr- Fructose, Ga- Galactos*

**Table 2. Microscopic Characteristics used for the identification of the fungal Isolate**

| Size (mm) | Color | Surface | Vesicle Serration | Shape | Conidia surface | Isolate |
|---|---|---|---|---|---|---|
| 400-800 | Roughened Pale Brown | Spherical | Biserate | Ellipsoid glubose | Smooth and finely roughened | *Aspergillus* spp. |
| 300-500 | Light yellow to Orange-Brown | Cylindrical | Biserate | | | *Fusarium* spp. |

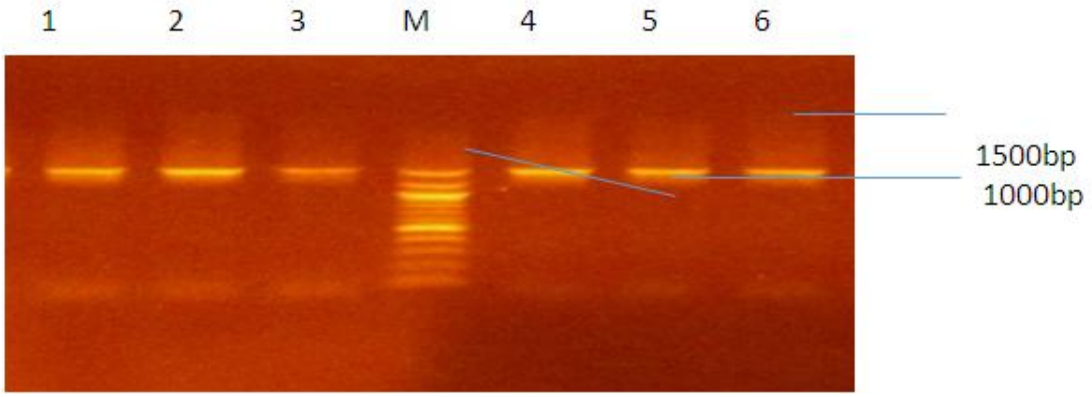


**Fig. 1. Agarose gel electrophoresis showing 16SrRNA gene of some bacterial isolates. Lane 1 – 6 represents the 16SrRNA gene (1500BP). Lane M represents the 100BP Molecular ladder**

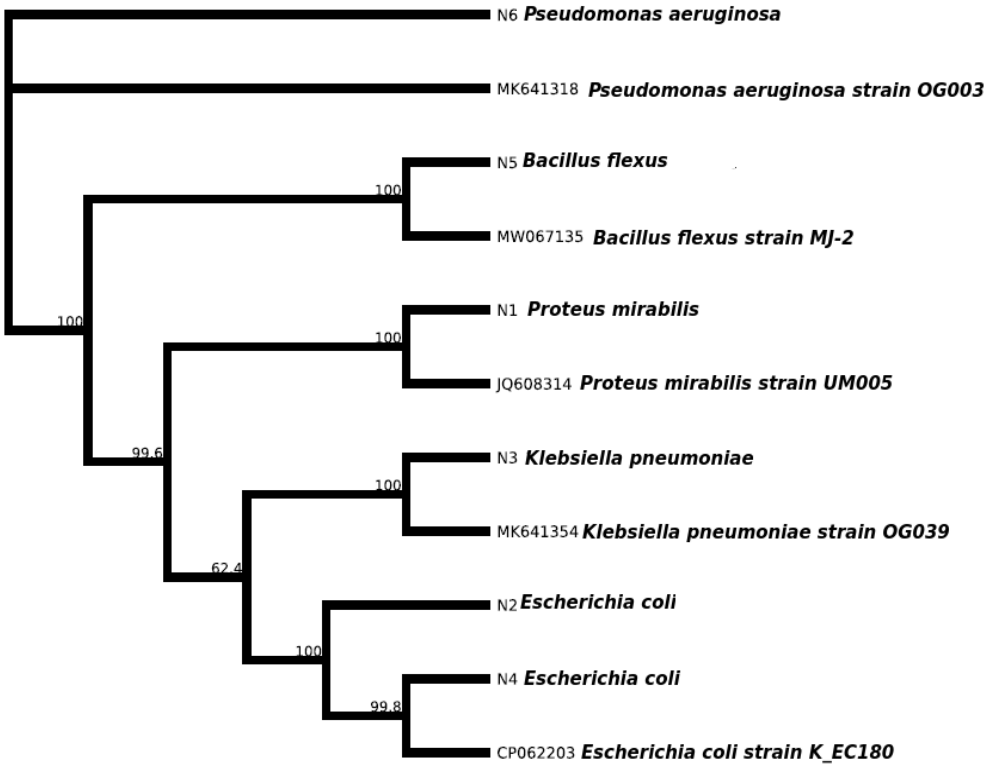


**Fig. 2. Phylogenetic tree showing the evolutionary distance between the bacterial isolates**

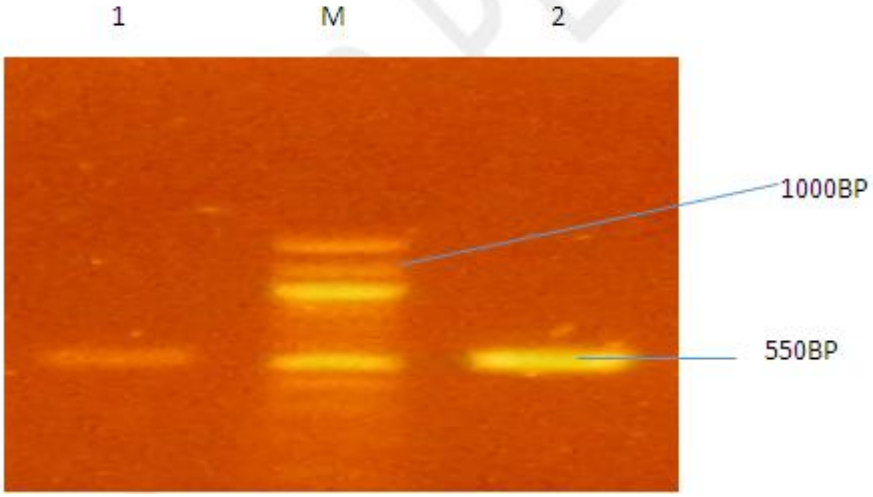


**Fig. 3. Agarose gel electrophoresis showing ITS gene of some selected fungi isolates. Lane 1 and 2 represents the ITS gene (550BP). Lane M represent 100BP Molecular ladder**

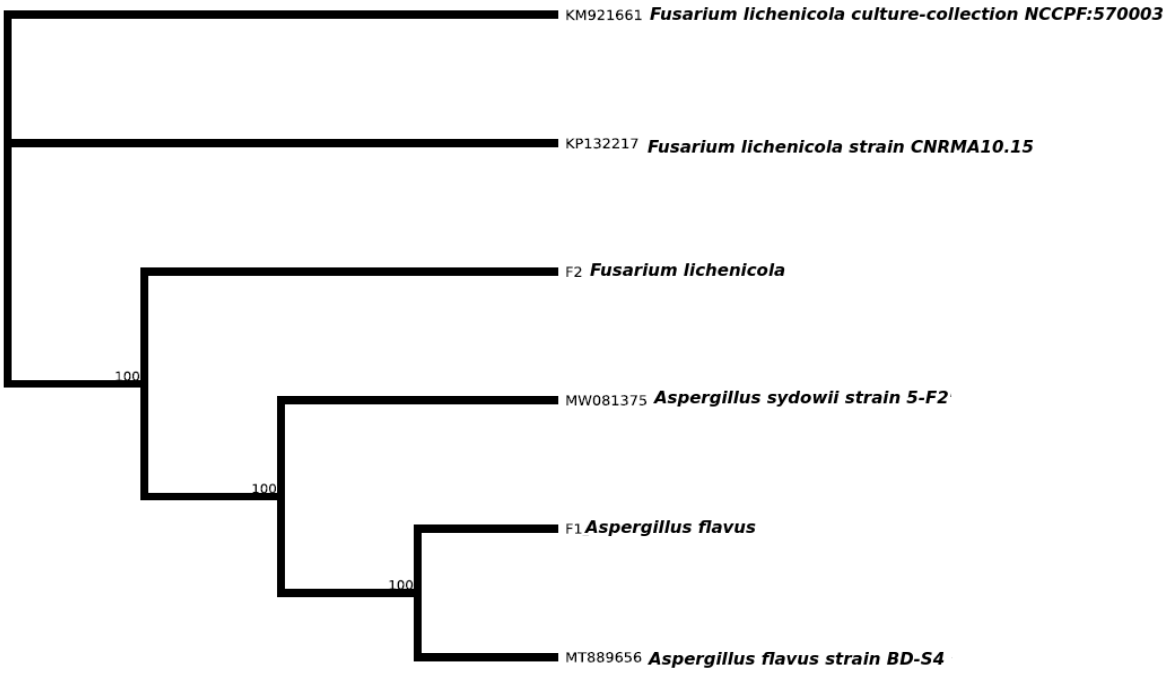


**Fig. 4. Phylogenetic tree showing the evolutionary distance between the fungal isolates**

The total Heterotrophic bacterial count of all the sampled banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the different stations (Oil Mill market, Fruit Garden market, Mile Three market, Mile One market and Creek Road market) are represented from Table 3. The counts ranged from $0.07x10^3$ CFU/g to $8.37x10^3$ CFU/g and are considered satisfactory based on the ACC limit of $1.0x10^4$ CFU/g for fruits and vegetables [25].

The highest Heterotrophic bacterial count is seen in the Tips of the Healthy-Looking Grand Nain Banana from Oil Mill market and Mile One market, at $8.37x10^3$ CFU/g Table3, Fig. 5. The highest heterotrophic bacteria load in this study is higher than the values (11.4 to $26.4x10^2$ CFU/g) reported by [26] in the spoilage of Banana fruit (*Musa acuminata*) sold in some selected markets in Eastern Nigeria.

**Table 3. Total Heterotrophic Bacteria (x10$^3$ CFU/g) from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Total Heterotrophic Bacteria (x10$^3$ CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana Varieties** | **Sampled Parts** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| | | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish Banana | Cut Stalk | 5.97±0.68$^c$ | 5.67±0.65$^b$ | 6.17±0.35$^c$ | 5.50±0.89$^b$ | 2.77±1.01$^b$ | 2.23±0.85$^b$ | 2.57±0.71$^b$ | 5.50±0.89$^b$ | 5.00±1.91$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.17±0.12$^a$ | 0.80±0.30$^a$ | 0.27±0.29$^a$ | 0.70±0.20$^a$ | 0.80±0.10$^a$ | 0.77±0.25$^a$ |
| | Epicarp | 5.00±0.20$^b$ | 4.87±0.70$^b$ | 6.40±1.06$^c$ | 6.63±0.67$^b$ | 4.40±0.76$^c$ | 3.37±0.83$^c$ | 4.73±0.97$^c$ | 6.60±0.62$^{bc}$ | 4.60±1.42$^b$ |
| | Tip | 6.43±0.91$^c$ | 5.50±0.44$^b$ | 4.37±0.74$^b$ | 7.27±1.16$^c$ | 3.53±0.85$^{bc}$ | 2.87±0.21$^{bc}$ | 3.40±0.70$^b$ | 7.27±1.16$^c$ | 5.83±1.47$^b$ |
| | Vascular Tissue | 0.20±0.10$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.17±0.12$^a$ | 0.97±0.21$^a$ | 0.18±0.10$^a$ | 0.27±0.15$^a$ | 1.03±0.42$^a$ | 0.63±0.31$^a$ |
| Dwarf Cavendish Banana | Cut Stalk | 1.97±0.15$^c$ | 3.80±0.30$^d$ | 1.90±0.20$^b$ | 5.00±1.91$^b$ | 2.10±0.62$^{bc}$ | 2.90±0.80$^b$ | 1.53±0.31$^a$ | 5.03±1.59$^b$ | 5.50±0.89$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.37±0.21$^a$ | 0.08±0.03$^a$ | 0.60±0.36$^a$ | 0.90±0.20$^a$ | 0.83±0.31$^a$ |
| | Epicarp | 3.80±0.30$^d$ | 4.97±0.31$^e$ | 4.87±0.86$^c$ | 4.93±1.99$^b$ | 3.70±0.87$^d$ | 4.40±0.75$^c$ | 4.53±0.97$^b$ | 5.40±1.77$^b$ | 6.63±0.67$^{bc}$ |
| | Tip | 1.47±0.45$^b$ | 2.17±0.40$^c$ | 1.80±0.30$^b$ | 5.83±1.47$^b$ | 2.87±0.21$^{cd}$ | 3.73±0.80$^{bc}$ | 1.53±0.49$^a$ | 5.80±1.50$^b$ | 7.27±1.16$^c$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 1.27±0.21$^{ab}$ | 0.10±0.02$^a$ | 0.67±0.35$^a$ | 0.97±0.21$^a$ | 0.23±0.15$^a$ |
| Red Banana | Cut Stalk | 1.33±0.47$^b$ | 2.63±0.74$^c$ | 3.97±4.37$^b$ | 1.30±0.20$^a$ | 1.13±0.31$^a$ | 5.40±0.72$^b$ | 1.13±0.31$^b$ | 1.47±0.25$^c$ | 5.23±0.51$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.13±0.06$^a$ | 0.30±0.20$^a$ | 1.20±0.36$^a$ | 0.30±0.20$^a$ | 0.27±0.21$^a$ | 1.20±0.36$^a$ |
| | Epicarp | 1.80±0.30$^b$ | 4.27±0.80$^d$ | 1.30±0.40$^{ab}$ | 1.77±0.25$^a$ | 4.37±0.74$^b$ | 7.30±1.05$^c$ | 1.70±0.53$^b$ | 1.70±0.36$^c$ | 7.30±1.05$^c$ |
| | Tip | 1.23±0.94$^b$ | 1.97±0.40$^{bc}$ | 1.70±0.26$^{ab}$ | 5.33±3.79$^b$ | 1.07±0.38$^a$ | 7.57±0.91$^c$ | 1.07±0.57$^b$ | 0.93±0.06$^b$ | 7.57±0.91$^c$ |
| | Vascular Tissue | 0.23±0.06$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.13±0.06$^a$ | 0.70±0.40$^a$ | 0.19±0.08$^a$ | 0.13±0.66$^a$ | 0.73±0.15$^b$ | 0.93±0.32$^a$ |
| Lady Finger Banana | Cut Stalk | 4.20±4.16$^b$ | 1.13±0.40$^b$ | 2.63±0.74$^c$ | 5.23±0.51$^c$ | 1.10±0.10$^b$ | 1.13±0.31$^a$ | 1.10±0.10$^{ab}$ | 3.60±0.96$^b$ | 1.47±0.25$^c$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.87±0.25$^a$ | 0.09±0.01$^a$ | 0.30±0.20$^a$ | 0.20±0.10$^a$ | 0.80±0.30$^a$ | 0.27±0.21$^a$ |
| | Epicarp | 1.77±0.31$^{ab}$ | 1.00±0.20$^b$ | 4.27±0.80$^d$ | 3.73±0.68$^b$ | 1.47±0.35$^b$ | 4.37±0.74$^b$ | 3.53±0.74$^{bc}$ | 2.80±0.70$^b$ | 1.70±0.36$^c$ |
| | Tip | 1.83±0.35$^{ab}$ | 1.63±0.35$^c$ | 1.97±0.40$^{bc}$ | 7.57±0.91$^d$ | 0.47±0.35$^a$ | 1.07±0.38$^a$ | 4.73±3.41$^c$ | 1.03±0.21$^a$ | 0.93±0.06$^b$ |
| | Vascular Tissue | 0.23±0.06$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.13±0.06$^a$ | 0.07±0.03$^a$ | 0.70±0.40$^a$ | 0.90±0.40$^{ab}$ | 0.23±0.15$^a$ | 0.73±0.15$^b$ |
| Grand Nain Banana | Cut Stalk | 5.87±0.93$^b$ | 5.87±0.93$^b$ | 1.33±0.47$^b$ | 4.90±0.82$^b$ | 2.83±0.70$^b$ | 1.30±0.20$^a$ | 2.83±0.70$^b$ | 4.90±0.82$^{bc}$ | 1.13±0.31$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.63±0.31$^a$ | 0.70±0.20$^a$ | 0.13±0.06$^a$ | 0.90±0.20$^a$ | 0.97±0.31$^a$ | 0.30±0.20$^a$ |
| | Epicarp | 6.83±0.35$^c$ | 6.27±1.07$^b$ | 1.80±0.30$^b$ | 4.57±0.80$^b$ | 2.67±0.91$^b$ | 1.77±0.25$^a$ | 4.93±0.97$^c$ | 3.20±1.93$^b$ | 1.70±0.53$^b$ |
| | Tip | 5.10±0.30$^b$ | 5.10±0.30$^b$ | 1.23±0.94$^b$ | 8.37±0.91$^c$ | 2.43±0.85$^b$ | 5.33±3.79$^b$ | 3.60±0.70$^b$ | 5.77±1.45$^c$ | 1.07±0.57$^b$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.20±0.10$^a$ | 0.13±0.03$^a$ | 0.53±0.15$^a$ | 1.17±0.21$^a$ | 0.19±0.01$^a$ | 0.13±0.07$^a$ |

**Table 4. Total Heterotrophic Fungi (x10$^3$ CFU/g) from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Total Heterotrophic Fungi (x10$^3$ CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana Varieties** | **Sampled Parts** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| | | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish Banana | Cut Stalk | 1.83±0.25$^b$ | 1.40±0.26$^b$ | 1.80±0.30$^b$ | 5.73±0.80$^d$ | 2.40±0.95$^b$ | 9.37±11.85$^a$ | 2.47±0.91$^b$ | 5.73±0.80$^c$ | 5.17±0.65$^{bc}$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.17±0.12$^a$ | 0.93±0.25$^a$ | 0.67±0.32$^a$ | 0.17±0.12$^a$ | 0.40±0.26$^a$ | 0.43±0.32$^a$ |
| | Epicarp | 4.13±0.65$^c$ | 1.53±0.60$^b$ | 2.80±0.89$^c$ | 4.63±0.60$^c$ | 3.07±1.11$^b$ | 3.00±1.41$^a$ | 2.60±0.62$^b$ | 4.60±0.46$^b$ | 6.63±1.63$^c$ |
| | Tip | 1.37±0.35$^b$ | 1.27±0.25$^b$ | 1.93±0.15$^b$ | 2.67±0.51$^b$ | 2.57±0.75$^b$ | 2.47±0.93$^a$ | 2.73±0.86$^b$ | 4.23±0.51$^b$ | 4.37±0.67$^b$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.17±0.12$^a$ | 1.90±0.20$^{ab}$ | 0.73±0.35$^a$ | 0.23±0.15$^a$ | 0.77±0.31$^a$ | 1.23±0.25$^a$ |
| Dwarf Cavendish Banana | Cut Stalk | 5.67±1.53$^c$ | 1.17±0.31$^{bc}$ | 5.00±2.00$^b$ | 5.17±0.65$^b$ | 2.33± 1.12$^{ab}$ | 2.53±1.18$^b$ | 2.23±0.85$^{ab}$ | 4.37±1.12$^b$ | 5.73±0.80$^c$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 1.00± 0.26$^a$ | 0.63±0.31$^a$ | 1.27±0.35$^{ab}$ | 1.70±1.14$^a$ | 0.73±0.38$^a$ |
| | Epicarp | 1.90±0.20$^b$ | 2.13±0.65$^d$ | 1.93±0.85$^a$ | 6.63±1.63$^b$ | 3.00±1.41$^b$ | 3.07±1.11$^b$ | 2.87±1.11$^b$ | 6.70±1.41$^c$ | 4.63±0.60$^{bc}$ |
| | Tip | 1.43±0.40$^{ab}$ | 1.77±0.42$^{cd}$ | 2.70±2.04$^{ab}$ | 4.37±0.67$^c$ | 2.467±0.93$^{ab}$ | 2.53±0.80$^b$ | 2.47±0.78$^{ab}$ | 4.50±1.18$^b$ | 3.93±0.85$^b$ |
| | Vascular Tissue | 0.40±0.10$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 2.10±0.35$^{ab}$ | 0.17±0.07$^a$ | 0.30±0.20$^a$ | 1.00±0.76$^a$ | 0.13±0.03$^a$ |
| Red Banana | Cut Stalk | 1.93±0.15$^c$ | 1.20±0.50$^b$ | 1.83±0.25$^b$ | 5.33±1.53$^b$ | 1.67±0.72$^c$ | 5.73±0.80$^d$ | 1.83±0.85$^{ab}$ | 4.67±0.78$^b$ | 2.47±0.91$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.53±0.25$^{ab}$ | 0.17±0.12$^a$ | 0.40±0.44$^a$ | 1.47±0.60$^a$ | 0.17±0.12$^a$ |
| | Epicarp | 0.47±0.25$^a$ | 1.90±0.20$^c$ | 4.13±0.65$^c$ | 1.83±0.65$^a$ | 1.03±0.15$^{abc}$ | 4.63±0.60$^c$ | 1.93±0.71$^{ab}$ | 3.63±3.10$^{ab}$ | 2.60±0.62$^b$ |
| | Tip | 1.40±0.45$^b$ | 1.83±0.42$^c$ | 1.37±0.35$^b$ | 2.67±2.08$^a$ | 1.43±0.76$^{bc}$ | 2.67±0.51$^b$ | 4.30±4.14$^b$ | 4.43±1.31$^{ab}$ | 2.73±0.86$^b$ |
| | Vascular Tissue | 0.23±0.23$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.13±0.06$^a$ | 0.17±0.12$^a$ | 0.23±0.12$^a$ | 1.57±0.76$^{ab}$ | 0.23±0.15$^a$ |
| Lady Finger Banana | Cut Stalk | 1.60±0.10$^c$ | 1.40±0.10$^c$ | 1.20±0.50$^b$ | 5.07±0.21$^c$ | 2.00±0.70$^{bc}$ | 1.67±0.72$^c$ | 1.63±0.42$^b$ | 4.73±0.67$^{bc}$ | 4.67±0.78$^b$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.90±0.20$^a$ | 0.47±0.25$^a$ | 0.53±0.25$^{ab}$ | 0.47±0.25$^a$ | 1.40±0.46$^a$ | 1.47±0.60$^a$ |
| | Epicarp | 1.47±0.15$^{bc}$ | 1.33±0.15$^c$ | 1.90±0.20$^c$ | 3.57±0.85$^b$ | 2.50±0.66$^c$ | 1.03±0.15$^{abc}$ | 2.40±0.82$^b$ | 3.30±0.82$^b$ | 3.63±3.10$^{ab}$ |
| | Tip | 6.00±1.00$^d$ | 0.40±0.10$^a$ | 1.83±0.42$^c$ | 3.90±1.15$^{bc}$ | 1.40±0.36$^{ab}$ | 1.43±0.76$^{bc}$ | 1.63±0.76$^b$ | 4.97±1.37$^c$ | 4.43±1.31$^{ab}$ |
| | Vascular Tissue | 0.63±0.31$^{ab}$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.43±0.31$^a$ | 1.27±0.40$^{ab}$ | 0.13±0.06$^a$ | 0.43±0.31$^a$ | 1.57±0.32$^a$ | 1.57±0.76$^{ab}$ |
| Grand Nain Banana | Cut Stalk | 1.83±0.25$^c$ | 1.83±0.25$^c$ | 1.93±0.15$^c$ | 5.67±1.00$^c$ | 2.63±0.93$^a$ | 5.33±1.53$^b$ | 3.67±0.74$^b$ | 5.37±0.74$^b$ | 1.83±0.85$^{ab}$ |
| | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.87±0.25$^a$ | 1.53±0.47$^a$ | 0.37±0.38$^a$ | 0.67±0.25$^a$ | 1.77±0.45$^a$ | 0.40±0.44$^a$ |
| | Epicarp | 1.40±0.30$^b$ | 1.43±0.35$^b$ | 0.47±0.25$^a$ | 3.37±0.67$^b$ | 2.40±0.98$^a$ | 1.83±0.65$^a$ | 3.03±1.16$^b$ | 3.30±1.23$^a$ | 1.93±0.71$^{ab}$ |
| | Tip | 1.20±0.20$^b$ | 1.33±0.31$^b$ | 1.40±0.46$^b$ | 6.03±1.56$^c$ | 2.93±0.86$^a$ | 2.67±02.08$^a$ | 2.93±0.86$^b$ | 6.27±1.57$^b$ | 4.30±4.12$^b$ |
| | Vascular Tissue | 0.67±0.15$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.30±0.20$^a$ | 2.20±0.46$^a$ | 0.67±0.15$^a$ | 0.30±0.20$^a$ | 2.00±0.82$^a$ | 0.23±0.12$^a$ |

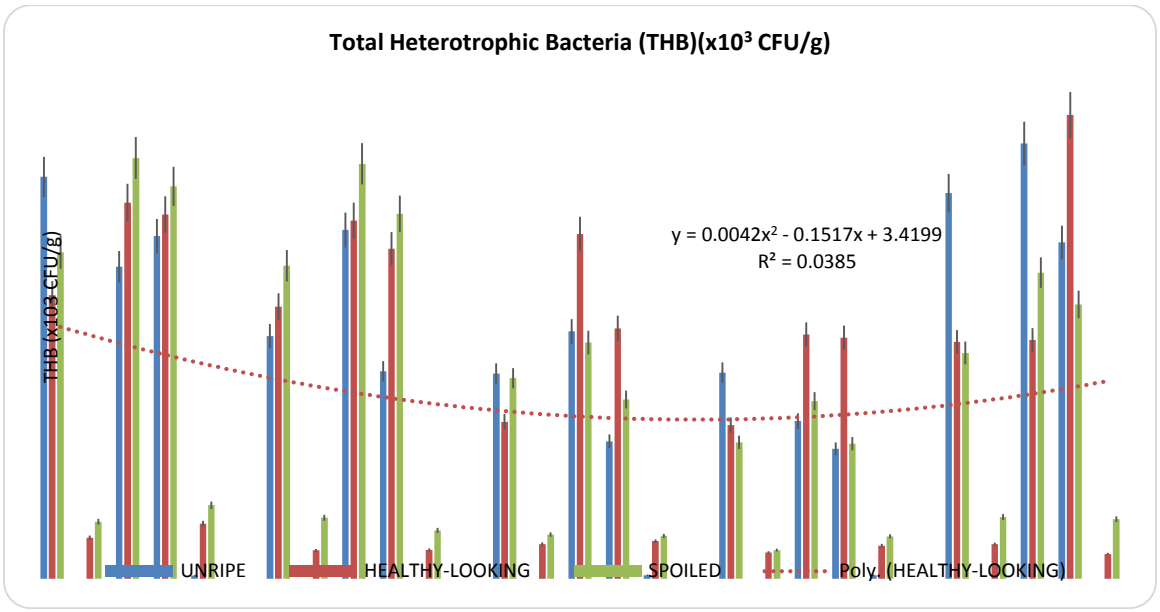


**Fig. 5. Mean values of total heterotrophic bacteria (x10$^2$ CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of banana varieties (cavendish (CAB), dwarf cavendish (DCB), Red (RDB), lady finger (LFB) and grand nain (GNB) from markets**

Microorganisms (such as Bacteria, fungi and viruses) are ubiquitous in nature and are mostly dispersed by wind, animals, man and anthropogenic activities. Microorganisms which are found in soil and water are usually influenced by anthropogenic activities such as indiscrimate dumping of refuse on land and in water, indiscriminate defecation on land and water, use of pesticides, agricultural fertilizers, amongst others [27].

Almost all types of bananas produced in Nigeria are consumed fresh and play an important role in feeding the low-income families as well as providing a source of income to them. The fact that it is an annual fruit that produces its fruit throughout the year adds to its importance as a cash crop in the growing region [28-29]. Although banana fruits are highly demanded as nutritious and economically important fruits, they experience a different marketing problem [30].

The Heterotrophic bacteria isolated in the course of this research are *Pseudomonas aeruginosa* and *Klebsiella pneumoniae. Pseudomonas aeruginosa* and *Klebsiella pneumoniae Klebsiella* are a normal flora found in the soil. *Klebsiella pneumoniae* is normally found in the human intestines (where they do not cause any infection) and are released in human stool (feces). Contamination of Banana fruits occur as a result of infected stools being used as a manure or as a result of the fruit being handled by an infected individual. Consumption of *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* infected Banana fruit can cause food poisoning [31]. Illness usually start 24-72hours after consumption of the fruit and the symptoms presented includes fever, headache and stooling. Antibiotics can be used in the treatment of this illness but the preventive measures to be taken to avoid an occurrence is by washing of hands before touching Banana fruits and washing of the fruit before consumption.

The total coliform count of all the sampled banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the different stations (Oil Mill, Fruit Garden and Mile Three markets) varied. The counts ranged from 0.09x10$^3$ CFU/g to 8.93x10$^3$ CFU/g Table 5. The above counts are considered unsatisfactory based on the limit for Microbiological criteria for Ready-to-eat food in general of 1.0x10$^2$ CFU/g [32].

The highest coliform count is seen in the cut stalks of the spoiled Grand Nain Banana from Oil Mill market 8.93x10$^3$ CFU/g Table 5, Fig. 7. All the organisms that were successfully isolated in this research are thus confirmed as the casual organism of fruit decay in a study on post-harvest diseases of fruit and vegetables and their management [33-34].

**Table 5. Total Coliforms (x10$^3$ CFU/g) from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Total Coliforms (x10$^3$ CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana** | **Sampled** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| **Varieties** | **Parts** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish | Cut Stalk | 4.63±0.45$^c$ | 4.13±0.45$^b$ | 4.37±0.67$^b$ | 4.03±0.25$^d$ | 1.77±0.31$^b$ | 1.97±0.23$^b$ | 1.83±0.25$^b$ | 3.30±0.62$^c$ | 5.13±0.59$^c$ |
| Banana | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.33±0.15$^a$ | 0.40±0.26$^a$ | 0.20±0.10$^a$ | 0.23±0.25$^a$ | 0.33±0.15$^a$ |
| | Epicarp | 3.37±0.67$^b$ | 3.50±0.89$^b$ | 3.50±0.52$^b$ | 1.97±0.47$^b$ | 2.50±0.82$^b$ | 2.93±1.15$^b$ | 2.73±0.80$^b$ | 3.17±1.05$^c$ | 5.43±1.27$^c$ |
| | Tip | 5.00±0.20$^c$ | 3.53±0.67$^b$ | 4.40±0.62$^b$ | 2.80±0.36$^c$ | 2.57±0.78$^b$ | 2.27±1.08$^b$ | 2.57±0.71$^b$ | 2.63±0.55$^{bc}$ | 3.87±0.35$^b$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.77±0.31$^a$ | 0.53±0.21$^a$ | 0.23±0.15$^a$ | 1.47±0.85$^{ab}$ | 0.57±0.31$^a$ |
| Dwarf | Cut Stalk | 5.33±1.53$^c$ | 2.27±0.47$^c$ | 4.73±3.41$^b$ | 5.13±0.59$^c$ | 1.80±0.26$^b$ | 1.83±0.31$^b$ | 1.60±0.20$^b$ | 4.63±1.10$^{bc}$ | 3.63±0.76$^d$ |
| Cavendish | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.40±0.26$^a$ | 0.33±0.15$^a$ | 0.27±0.21$^a$ | 0.83±0.61$^a$ | 0.17±0.12$^a$ |
| Banana | Epicarp | 2.10±0.36$^b$ | 3.60±0.46$^d$ | 1.73±0.21$^{ab}$ | 5.43±1.27$^c$ | 2.93±1.15$^b$ | 2.50±0.82$^b$ | 2.40±0.76$^b$ | 5.63±1.33$^c$ | 1.97±0.47$^b$ |
| | Tip | 2.23±0.42$^b$ | 2.23±0.31$^c$ | 1.93±0.91$^{ab}$ | 3.87±0.35$^b$ | 2.00±0.62$^b$ | 2.57±0.78$^b$ | 2.37±0.71$^b$ | 3.60±0.70$^b$ | 2.80±0.36$^c$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.53±0.21$^a$ | 0.08±0.03$^a$ | 0.37±0.31$^a$ | 1.67±0.51$^a$ | 0.37±0.31$^a$ |
| Red | Cut Stalk | 0.70±0.20$^c$ | 2.03±0.42$^b$ | 5.00±2.00$^c$ | 6.67±2.52$^c$ | 0.87±0.21$^a$ | 3.17±0.93$^c$ | 3.53±3.87$^a$ | 0.70±0.26$^{ab}$ | 3.40±0.53$^c$ |
| Banana | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.0±0.00$^a$ | 0.00±0.00$^a$ | 0.13±0.06$^a$ | 0.40±0.10$^a$ | 0.13±0.06$^a$ | 0.17±0.12$^a$ | 0.40±0.10$^a$ |
| | Epicarp | 1.87±0.25$^d$ | 3.20±0.62$^c$ | 1.40±0.56$^{ab}$ | 3.33±1.53$^b$ | 1.93±0.75$^b$ | 3.83±0.35$^c$ | 2.00±0.76$^a$ | 1.30±0.46$^b$ | 3.83±0.35$^c$ |
| | Tip | 0.50±0.10$^{bc}$ | 2.03±0.31$^b$ | 2.33±1.53$^b$ | 3.33±1.53$^b$ | 1.87±0.60$^b$ | 2.23±0.42$^b$ | 1.97±0.71$^a$ | 0.33±0.15$^a$ | 2.13±0.55$^b$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.33±0.15$^a$ | 0.09±006$^a$ | 0.10±0.00$^a$ | 1.27±0.47$^b$ | 0.09±0.06$^a$ |
| Lady | Cut Stalk | 7.00±2.00$^c$ | 0.50±0.20$^b$ | 2.03±0.42$^b$ | 3.40±0.53$^c$ | 1.03±0.70$^b$ | 0.87±0.21$^a$ | 3.60±3.82$^b$ | 3.30±0.66$^c$ | 0.70±0.26$^{ab}$ |
| Finger | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.40±0.10$^a$ | 0.17±0.12$^a$ | 0.13±0.06$^a$ | 0.13±0.06$^a$ | 0.27±0.21$^a$ | 0.17±0.12$^a$ |
| Banana | Epicarp | 1.83±0.31$^{ab}$ | 1.53±0.338$^c$ | 3.20±0.62$^c$ | 3.83±0.35$^c$ | 1.77±0.31$^c$ | 1.93±0.75$^b$ | 1.60±0.36$^{ab}$ | 3.83±0.35$^b$ | 1.30±0.46$^b$ |
| | Tip | 4.00±2.00$^b$ | 0.13±0.06$^a$ | 2.03±0.31$^b$ | 2.13±0.55$^b$ | 1.30±0.40$^{bc}$ | 1.87±0.60$^b$ | 1.73±0.67$^{ab}$ | 1.83±0.70$^c$ | 0.33±0.15$^a$ |
| | Vascular Tissue | 0.37±0.15$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.20±0.10$^a$ | 0.10±0.00$^a$ | 0.33±0.15$^a$ | 0.40±0.20$^{ab}$ | 0.17±0.12$^a$ | 1.27±0.47$^b$ |
| Grand Nain | Cut Stalk | 2.73±0.21$^b$ | 2.80±0.30$^b$ | 0.70±0.20$^c$ | 2.73±0.25$^c$ | 2.03±0.25$^b$ | 6.67±2.52$^c$ | 8.93±2.18$^a$ | 2.53±0.49$^b$ | 3.53±3.87$^a$ |
| Banana | Endocarp | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.73±0.35$^a$ | 0.37±0.15$^a$ | 0.70±0.20$^{ab}$ | 0.93±0.15$^a$ | 0.22±0.08$^a$ | 0.13±0.06$^a$ |
| | Epicarp | 4.13±0.35$^c$ | 3.70±0.46$^c$ | 1.87±0.25$^d$ | 1.83±0.55$^b$ | 2.60±0.46$^b$ | 3.33±1.53$^b$ | 2.93±0.80$^a$ | 2.67±0.91$^b$ | 2.00±0.76$^a$ |
| | Tip | 2.93±0.25$^b$ | 2.93±0.25$^b$ | 0.50±0.10$^{bc}$ | 3.30±0.82$^c$ | 2.70±0.82$^b$ | 3.33±1.53$^b$ | 2.77±0.71$^a$ | 3.67±0.85$^b$ | 1.97±0.71$^a$ |
| | Vascular Tissue | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.00±0.00$^a$ | 0.20±0.10$^a$ | 0.32±0.33$^a$ | 0.13±0.06$^a$ | 0.37±0.31$^a$ | 0.12±0.03$^a$ | 0.10±0.00$^a$ |

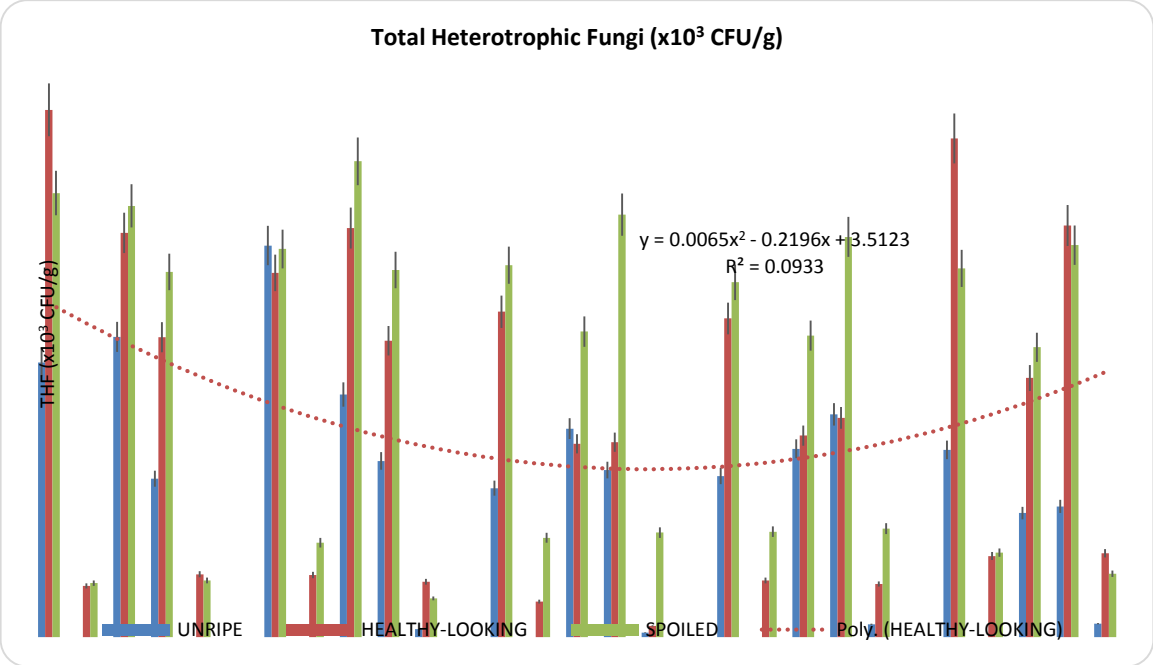


**Fig. 6. Mean values of total heterotrophic fungi (x10$^3$ CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of Banana varieties (Cavendish (CAB), dwarf cavendish (DCB), red (RDB), lady finger (LFB) and grand nain (GNB) from markets**

*Escherichia coli* was the isolated coliform in the course of this research. Some strains *Escherichia coli* are harmless and even help keep the digestive tract healthy while some strains can cause diarrhea if consumed as a result of eating contaminated food, fruit (Banana) or drinking contaminated water. Illness usually starts 2 to 5 days after consumption of contaminated fruit, food or water. The symptoms presented includes: Abdominal cramps, diarrhea (in most cases it can be bloody), nausea and constant fatigue. Antibiotics can be used in the treatment of this illness but the preventive measures to be taken to avoid an occurrence is by: Washing of hands before touching raw fruits (e.g. Banana fruit), after using the convenience or handling animals and Washing of the fruit before consumption.

*Escherichia coli* as earlier said resides in the digestive tracts (intestines) of humans and can be shed out of the intestines into the feces/stool. Therefore, Farmers are to take necessary precautions during the process of cultivating banana fruits (for those who use stool as a source of manure). Using of contaminated water (this happens when the water source is polluted by manure or by nearby animals dungs) to taint the Banana fruits. Therefore, farmers are to take precautionary measures in ensuring that the water used on the plants are free from contamination. Also, the vendors should ensure that the water they spray or wash these fruits (Banana fruits) are free from contamination.

## 3.4 Frequency and Percentage Occurrence of Isolates

The frequency of the isolates and their percentage prevalence are shown in Table 9. The percentage occurrence of microbial isolates from the different varieties of sampled Banana fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the three study areas (Oil Mill, Fruit Garden and Mile Three markets) are presented in Table 10.

Grand Nain Banana had the most microbial load at 33.9% followed by the Dwarf Cavendish Banana at 25% with the least being the Red Banana at 9.7%.

Also, it's a known fact that *Escherichia coli* is associated with raw meat, so contamination of Banana sometimes could be as a result of it being in contact with raw meat (this could be from cutting boards or countertop or from sellers who share same table with meat sellers in the local market). The marketers are advised to

adhere to some precautionary measures to avoid contamination from *Escherichia coli.*

The total fungal count of all the sampled banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the different stations (Oil Mill, Fruit Garden and Mile Three markets) are represented from Table 4. The counts ranged from $0.07x10^3$ CFU/g to $9.37x10^3$ CFU/g.

The highest fungal count is seen in the Cut stalk of the Healthy-Looking Cavendish Banana from Mile Three market, at $9.37x10^3$ CFU/g Table 4, Fig. 6. The highest fungal load in this study is lower than the values (8.7 to $4.6x10^5$ CFU/g) reported by [34] on common fungi associated with some fruits spoilage in Katsina metropolis. The results gotten from this research can be compared to a study on isolation and identification of fungi associated with local fruits of Barak valley, Assam, which isolated *Fusarium* spp. as one of the fungal contaminants of *Musa* spp. [35].

The total *Staphylococcal* count of all the sampled banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the different stations (Oil Mill, Fruit Garden and Mile Three markets) varied from $0.07x10^3$ CFU/g to $9.0x10^2$ CFU/g Table 6.

The highest *Staphylococcal* count is seen in the Cut stalk of the Spoiled Grand Nain Banana from Oil Mill market, at $9.0x10^3$ CFU/g Table 6, Fig. 8. The isolated bacteria in this research can be compared to a study on isolation and identification of Bacteria from spoiled fruits. Which showed that *Escherichia coli*, *Klebsiella* spp., *Bacillus* spp. and *Staphylococcus* spp. are the isolated organisms responsible for fruit spoilage of which Banana is one of them [35].

The presence of *Staphylococcus aureus* in fruits (such as Banana) can lead to *Staphylococcal* food poisoning if consumed. *Staphylococcal* food poisoning is a gastrointestinal illness caused by the consumption of food but in this case, Banana (*Musa* spp.) fruits contaminated with toxins produced by *Staphylococcus aureus.* It is a microflora of the skin and nose and barely causes illness in healthy people but its toxins (if released) has the ability to cause food poisoning. Banana fruits contaminated with the toxins of *Staphylococcus aureus* may not smell or look spoiled.

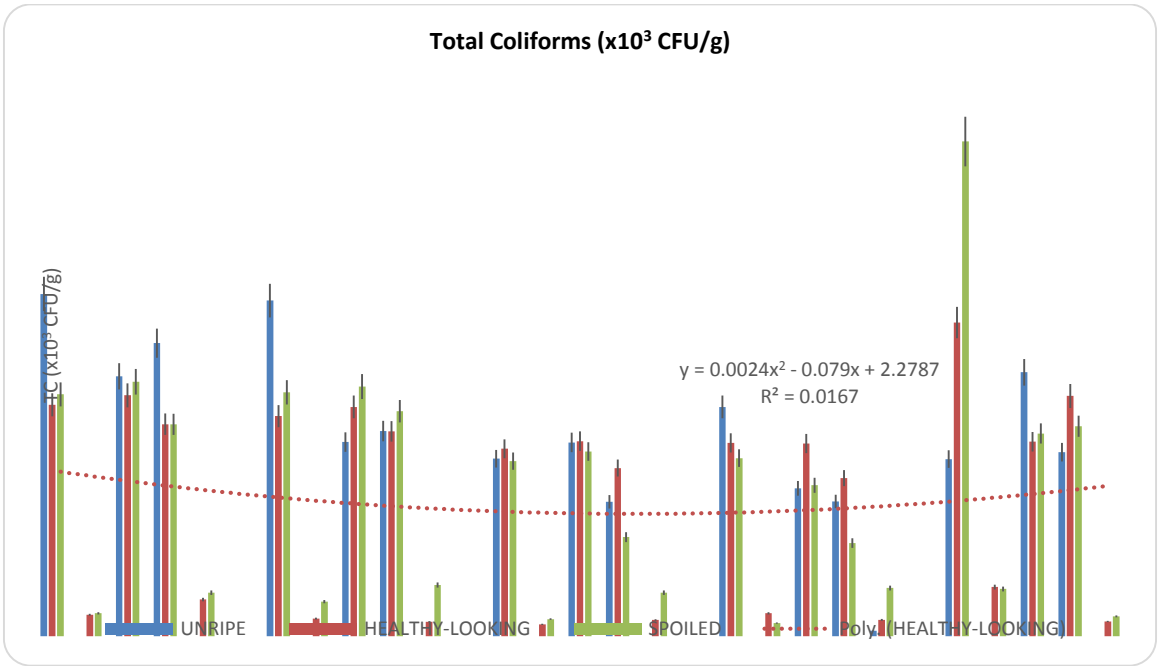


**Fig. 7. Mean values of total coliforms ($x10^3$ CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of banana varieties (Cavendish (CAB), Dwarf Cavendish (DCB), Red (RDB), Lady Finger (LFB) and Grand Nain (GNB) from markets**

**Table 6. *Staphylococcus aureus (x10² CFU/g)* from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Staphylococcus aureus (x10² CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana** | **Sampled** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| **Varieties** | **Parts** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish | Cut Stalk | 4.17±0.31$^{c}$ | 3.30±0.66$^{c}$ | 4.63±0.74$^{c}$ | 4.90±1.47$^{c}$ | 1.83±0.31$^{b}$ | 1.23±0.42$^{bc}$ | 1.83±0.31$^{ab}$ | 5.10±0.89$^{d}$ | 3.33±0.57$^{b}$ |
| Banana | Endocarp | 0.10±0.10$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.33±0.15$^{a}$ | 0.50±0.30$^{ab}$ | 1.37±0.55$^{a}$ | 0.47±0.25$^{a}$ | 0.40±0.10$^{a}$ |
| | Epicarp | 2.97±0.85$^{b}$ | 3.47±0.35$^{c}$ | 3.13±0.31$^{b}$ | 5.00±0.62$^{c}$ | 3.07±0.67$^{c}$ | 2.73±0.80$^{d}$ | 3.37±1.36$^{a}$ | 5.43±0.61$^{d}$ | 3.83±0.65$^{b}$ |
| | Tip | 4.00±0.20$^{c}$ | 3.17±0.65$^{c}$ | 3.37±0.74$^{b}$ | 3.57±0.40$^{bc}$ | 2.57±0.86$^{b}$ | 1.97±0.50$^{cd}$ | 2.50±0.66$^{ab}$ | 4.03±0.21$^{c}$ | 3.10±1.05$^{b}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.70±0.36$^{a}$ | 0.27±0.21$^{a}$ | 2.67±1.53$^{ab}$ | 1.83±0.31$^{b}$ | 0.47±0.21$^{a}$ |
| Dwarf | Cut Stalk | 1.73±0.21$^{c}$ | 2.57±0.61$^{b}$ | 2.23±0.49$^{b}$ | 3.33±0.57$^{b}$ | 1.23±0.42$^{ab}$ | 1.90±0.35$^{b}$ | 1.63±0.31$^{b}$ | 2.87±0.86$^{b}$ | 5.20±0.95$^{c}$ |
| Cavendish | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.56±0.21$^{a}$ | 0.57±0.31$^{a}$ | 0.47±0.38$^{a}$ | 0.83±0.12$^{a}$ | 1.67±0.51$^{a}$ |
| Banana | Epicarp | 3.17±0.35$^{b}$ | 3.83±0.65$^{c}$ | 3.37±0.67$^{c}$ | 0.10±0.10$^{a}$ | 2.73 ±0.80$^{c}$ | 3.07±0.67$^{c}$ | 2.53±0.65$^{b}$ | 4.50±0.44$^{c}$ | 5.23±0.45$^{c}$ |
| | Tip | 0.03±0.06$^{a}$ | 1.83±0.70$^{b}$ | 1.70±0.20$^{b}$ | 3.47±1.65$^{a}$ | 1.96±0.50$^{bc}$ | 2.67±1.03$^{bc}$ | 2.23±0.61$^{b}$ | 1.93±0.75$^{b}$ | 3.77±0.25$^{b}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.90±0.20$^{a}$ | 0.70±0.36$^{a}$ | 0.47±0.38$^{a}$ | 0.47±0.21$^{a}$ | 0.93±0.25$^{a}$ |
| Red | Cut Stalk | 1.90±0.20$^{c}$ | 1.83±0.60$^{a}$ | 1.73±0.21$^{b}$ | 1.90±0.20$^{b}$ | 1.37±0.42$^{bc}$ | 3.33±0.57$^{b}$ | 2.33±1.07$^{b}$ | 2.37±0.74$^{c}$ | 1.63±0.31$^{b}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.33±0.15$^{a}$ | 0.40±0.10$^{a}$ | 0.73±0.35$^{a}$ | 0.50±0.20$^{a}$ | 0.47±0.38$^{a}$ |
| | Epicarp | 2.13±0.35$^{c}$ | 3.27±1.07$^{b}$ | 3.17±0.35$^{c}$ | 1.43±0.38$^{ab}$ | 2.03±0.61$^{c}$ | 4.13±0.35$^{b}$ | 2.23±0.42$^{b}$ | 1.70±0.70$^{bc}$ | 2.53±0.65$^{b}$ |
| | Tip | 1.67±0.15$^{bc}$ | 1.53±0.45$^{a}$ | 1.83±0.31$^{b}$ | 1.37±0.61$^{ab}$ | 1.03±0.49$^{ab}$ | 3.47±1.65$^{b}$ | 2.07±0.60$^{b}$ | 0.97±0.15$^{ab}$ | 2.23±0.61$^{b}$ |
| | Vascular Tissue | 1.33±0.42$^{ab}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.33±0.15$^{a}$ | 0.47±0.21$^{a}$ | 0.47±0.15$^{a}$ | 1.00±0.10$^{ab}$ | 0.47±0.38$^{a}$ |
| Lady | Cut Stalk | 1.37±0.12$^{ab}$ | 1.27±0.15$^{b}$ | 1.83±0.60$^{a}$ | 4.57±0.57$^{b}$ | 1.17±0.42$^{b}$ | 1.37±0.42$^{bc}$ | 6.00±3.00$^{b}$ | 2.50±0.70$^{bc}$ | 2.37±0.74$^{c}$ |
| Finger | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.33±0.15$^{a}$ | 1.73±0.68$^{a}$ | 0.77±0.45$^{a}$ | 0.50±0.20$^{a}$ |
| Banana | Epicarp | 1.93±0.15$^{c}$ | 1.53±0.40$^{b}$ | 3.27±1.07$^{b}$ | 2.37±1.15$^{a}$ | 2.20±0.46$^{c}$ | 2.03±0.61$^{c}$ | 2.17±0.23$^{a}$ | 2.70±1.35$^{c}$ | 1.70±0.70$^{bc}$ |
| | Tip | 1.50±0.20$^{bc}$ | 1.13±0.35$^{b}$ | 1.53±0.45$^{a}$ | 3.90±0.36$^{a}$ | 2.17±0.90$^{c}$ | 1.03±0.49$^{ab}$ | 1.80±0.30$^{a}$ | 1.23±0.42$^{ab}$ | 0.97±0.15$^{ab}$ |
| | Vascular Tissue | 0.83±0.15$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.53±0.25$^{ab}$ | 0.33±0.15$^{a}$ | 1.23±0.15$^{a}$ | 0.37±0.25$^{a}$ | 1.00±0.10$^{ab}$ |
| Grand Nain | Cut Stalk | 3.73±0.47$^{b}$ | 3.73±0.47$^{c}$ | 1.90±0.20$^{c}$ | 7.30±1.15$^{c}$ | 2.03±0.31$^{bc}$ | 1.90±0.20$^{b}$ | 9.00±2.00$^{b}$ | 6.47±2.70$^{c}$ | 2.33±1.07$^{b}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 1.37±0.70$^{ab}$ | 0.93±0.15$^{a}$ | 1.87±0.32$^{a}$ | 1.40±0.61$^{ab}$ | 0.73±0.35$^{a}$ |
| | Epicarp | 3.80±0.30$^{b}$ | 2.27±1.16$^{b}$ | 2.13±0.35$^{c}$ | 3.37±1.12$^{b}$ | 3.57±0.40$^{d}$ | 1.43±0.38$^{ab}$ | 2.10±0.70$^{c}$ | 2.53±0.81$^{ab}$ | 2.23±0.42$^{b}$ |
| | Tip | 4.03±0.21$^{b}$ | 4.03±0.21$^{c}$ | 1.67±0.15$^{bc}$ | 4.37±0.67$^{b}$ | 2.60±0.90$^{cd}$ | 1.37±0.61$^{ab}$ | 8.00±1.00$^{b}$ | 4.10±1.35$^{bc}$ | 2.07±0.60$^{b}$ |
| | Vascular Tissue | 1.00±0.10$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.70±0.20$^{a}$ | 0.80±0.10$^{a}$ | 1.47±0.57$^{a}$ | 0.97±0.21$^{a}$ | 0.47±0.15$^{a}$ |

The symptoms presented in cases of *Staphylococcal* food poisoning after consumption of Banana fruit, includes: Nausea, Vomiting, Abdominal cramps and in most cases, Diarrhea. These symptoms usually develop within 30minutes to 8hours after the consumption of a Banana fruit containing the toxins of *Staphylococcus aureus.* Also, this is not transmissible from an affected person to another but only in cases where the patient consumed an infected Banana fruit.

Antibiotics can be used in the treatment of this illness but the preventive measures to be taken to avoid an occurrence is by: Washing of the banana fruit before consumption, Proper washing of hands before touching raw fruit to avoid contamination and Proper and hygienic storage methods (the ripe bananas can be stored in the refrigerator) should be employed to avoid contamination of the fruits.

Farmers and marketers are to take necessary precautions during the process of harvesting or selling of banana fruits. An example is the wearing of gloves while harvesting or selling of raw fruits (Banana fruit) if there are presence of wounds or infections on the wrist or hands, also not allowing the buyers touch their wares (Banana fruit) when trying to make a purchase.

Organisms in the *Bacillus* genus are spore forming and are able to act as opportunistic pathogens causing illnesses such as cerebrospinal fluid shunt infection, gastroenteritis, endocarditis, endophthalmitis, meningitis as well as bacteremia [36]. The total *Bacillus* count of all the sampled banana (*Musa* spp.) fruits (Cavendish Banana, Dwarf Cavendish Banana, Red Banana, Lady Finger Banana and Grand Nain Banana) from the different stations (Oil Mill, Fruit Garden and Mile Three markets) varied from $0.03x10^2$ to $2.10x10^2$ CFU/g Table 7. The highest *Bacillus* count is seen in the Epicarp of the Spoiled Grand Nain Banana from Oil mill market, at $2.10x10^2$ CFU/g Table 7, Fig. 9; while the *Proteus* count varied from $0.03x10^2$ CFU/g to $1.83x10^2$ CFU/g Table 8 with the highest *Proteus* count seen in the Cut Stalk of the Healthy-Looking Cavendish Banana at $1.83x10^2$ CFU/g Table 8, Fig. 10. The results above are in conformity with that of Iniekong and Elezar [37], who reported the presence of fungi (*Fusarium* spp.) in spoiled Banana samples.

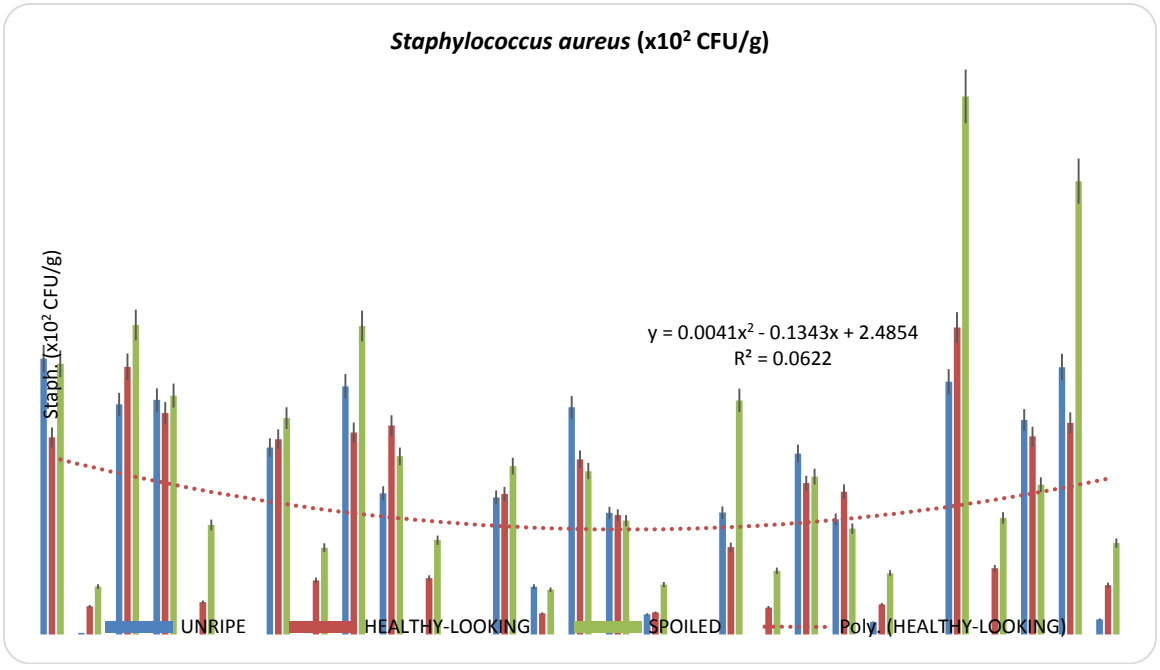


**Fig. 8. Mean values of *Staphylococcus aureus* ($x10^2$ CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of banana varieties (cavendish (CAB), dwarf cavendish (DCB), red (RDB), lady finger (LFB) and grand nain (GNB) from markets**

**Table 7. *Bacillus flexus (x10² CFU/g)* from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Bacillus flexus (x10² CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana** | **Sampled** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| **Varieties** | **Parts** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish | Cut Stalk | 0.20±0.10$^{a}$ | 0.23±0.40$^{ab}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 2.00±0.82$^{c}$ | 0.03±0.06$^{a}$ | 0.20±0.10$^{a}$ | 1.03±0.42$^{a}$ | 0.30±0.20$^{ab}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.33±0.32$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.15$^{a}$ | 0.63±0.31$^{a}$ | 0.03±0.06$^{a}$ |
| | Epicarp | 0.17±0.12$^{a}$ | 1.20±0.78$^{a}$ | 0.03±0.06$^{a}$ | 0.40±0.26$^{a}$ | 0.78±0.16$^{ab}$ | 0.07±0.12$^{a}$ | 0.37±0.21$^{a}$ | 0.73±0.45$^{a}$ | 0.53±0.15$^{aa}$ |
| | Tip | 0.20±0.10$^{a}$ | 0.80±0.92$^{ab}$ | 0.00±0.00$^{a}$ | 0.43±0.25$^{a}$ | 1.43±0.55$^{bc}$ | 0.13±0.15$^{a}$ | 0.70±0.20$^{b}$ | 2.00±0.50$^{b}$ | 0.37±0.31$^{ab}$ |
| | Vascular Tissue | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.43±0.32$^{a}$ | 0.00±0.00$^{a}$ | 0.30±0.20$^{a}$ | 0.40±0.10$^{a}$ | 0.17±0.15$^{ab}$ |
| Dwarf | Cut Stalk | 0.07±0.06$^{a}$ | 0.27±0.21$^{bc}$ | 0.03±0.06$^{a}$ | 0.20±0.10$^{a}$ | 0.46±0.25$^{ab}$ | 0.23±0.25$^{a}$ | 0.13±0.01$^{a}$ | 0.63±0.15$^{ab}$ | 0.17±0.12$^{a}$ |
| Cavendish | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.16±0.05$^{a}$ | 0.03±0.06$^{a}$ | 0.07±0.06$^{a}$ | 0.37±0.21$^{a}$ | 0.03±0.06$^{a}$ |
| Banana | Epicarp | 0.07±0.06$^{a}$ | 0.47±0.15$^{d}$ | 0.07±0.12$^{a}$ | 0.20±0.10$^{a}$ | 0.53±0.25$^{b}$ | 0.17±0.15$^{a}$ | 0.23±0.21$^{a}$ | 1.07±0.38$^{b}$ | 0.17±0.12$^{a}$ |
| | Tip | 0.17±0.12$^{a}$ | 0.30±0.10$^{cd}$ | 0.03±0.06$^{a}$ | 0.07±0.06$^{ab}$ | 0.26±1.52$^{ab}$ | 0.17±0.12$^{a}$ | 0.20±0.10$^{a}$ | 0.23±0.15$^{a}$ | 0.07±0.12$^{a}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{ab}$ | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ | 0.83±0.25$^{b}$ | 0.03±0.06$^{a}$ |
| Red | Cut Stalk | 0.13±0.15$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.53±0.38$^{c}$ | 0.20±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.77±0.15$^{b}$ | 0.20±0.10$^{a}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.10$^{ab}$ | 0.17±0.12$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.13±0.15$^{a}$ |
| | Epicarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.17±0.12$^{a}$ | 0.70±0.20$^{b}$ | 0.43±0.21$^{bc}$ | 0.40±0.26$^{a}$ | 0.57±0.25$^{b}$ | 0.90±0.20$^{a}$ | 0.37±0.21$^{a}$ |
| | Tip | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.43±0.25$^{a}$ | 0.00±0.00$^{a}$ | 0.37±0.29$^{b}$ | 0.70±0.20$^{b}$ |
| | Vascular Tissue | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.10±0.00$^{ab}$ | 0.10±0.10$^{a}$ | 0.00±0.00$^{a}$ | 0.23±0.15$^{a}$ | 0.30±0.20$^{a}$ |
| Lady | Cut Stalk | 0.20±0.10$^{b}$ | 0.07±0.12$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.20±0.17$^{a}$ | 0.53±0.38$^{c}$ | 0.27±0.15$^{a}$ | 0.33±0.15$^{ab}$ | 0.77±0.15$^{b}$ |
| Finger | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.06$^{a}$ | 0.10±0.10$^{a}$ | 0.10±0.10$^{ab}$ | 0.13±0.06$^{a}$ | 0.13±0.15$^{ab}$ | 0.20±0.10$^{a}$ |
| Banana | Epicarp | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ | 0.00±0.00$^{a}$ | 0.17±0.12$^{a}$ | 0.03±0.06$^{a}$ | 0.43±0.21$^{bc}$ | 0.27±0.15$^{a}$ | 0.50±0.40$^{b}$ | 0.90±0.20$^{b}$ |
| | Tip | 0.07±0.06$^{a}$ | 0.17±0.12$^{a}$ | 0.00±0.00$^{a}$ | 0.27±0.15$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.23±0.15$^{ab}$ | 0.37±0.29$^{a}$ |
| | Vascular Tissue | 0.07±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.10±0.00$^{ab}$ | 0.07±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.23±0.15$^{a}$ |
| Grand Nain | Cut Stalk | 0.07±0.12$^{a}$ | 0.40±0.10$^{b}$ | 0.13±0.15$^{a}$ | 0.17±0.12$^{a}$ | 0.40±0.20$^{a}$ | 0.03±0.06$^{a}$ | 0.47±0.25$^{a}$ | 0.47±0.21$^{abc}$ | 0.03±0.01$^{a}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.40±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.17±0.12$^{a}$ | 0.13±0.06$^{a}$ | 0.00±0.00$^{a}$ |
| | Epicarp | 0.03±0.06$^{a}$ | 0.60±0.10$^{c}$ | 0.00±0.00$^{a}$ | 0.13±0.15$^{a}$ | 0.67±0.21$^{ab}$ | 0.70±0.20$^{b}$ | 0.90±0.20$^{b}$ | 0.80±0.26$^{c}$ | 0.57±0.25$^{b}$ |
| | Tip | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.90±0.20$^{b}$ | 0.00±0.00$^{a}$ | 0.40±0.10$^{a}$ | 0.53±0.25$^{bc}$ | 0.00±0.00$^{a}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.67±0.25$^{ab}$ | 0.03±0.06$^{a}$ | 0.17±0.12$^{a}$ | 0.20±0.10$^{ab}$ | 0.00±0.00$^{a}$ |

**Table 8. *Proteus mirabilis (x10² CFU/g)* from Cut Stalk, Endocarp, Epicarp, Tip and Vascular Tissue of different varieties Banana fruits from different markets (Oil Mill (OM), Fruit Garden (FG), Mile Three (MT)) in Port Harcourt, Nigeria**

| Proteus mirabilis (x10² CFU/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banana** | **Sampled** | **Unripe** | | | **Healthy-Looking** | | | **Spoiled** | | |
| **Varieties** | **parts** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** | **OM** | **FG** | **MT** |
| Cavendish | Cut Stalk | 0.07±0.05$^{a}$ | 0.10±0.17$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.15$^{a}$ | 1.33±0.71$^{b}$ | 0.10±0.17$^{a}$ | 0.13±0.06$^{a}$ | 0.50±0.20$^{ab}$ | 0.47±0.25$^{b}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.17±0.12$^{a}$ | 0.03±0.06$^{a}$ | 0.23±0.15$^{a}$ | 0.20±0.10$^{a}$ | 0.10±0.10$^{a}$ |
| | Epicarp | 0.10±0.10$^{a}$ | 0.47±0.38$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.06$^{a}$ | 0.32±0.08$^{a}$ | 0.30±0.20$^{a}$ | 0.13±0.06$^{a}$ | 0.23±0.15$^{a}$ | 0.30±0.20$^{ab}$ |
| | Tip | 0.00±0.00$^{a}$ | 0.20±0.20$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.10$^{a}$ | 0.57±0.64$^{ab}$ | 0.17±0.21$^{a}$ | 0.17±0.12$^{a}$ | 0.60±0.20$^{b}$ | 0.13±0.06$^{a}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.23±0.15$^{a}$ | 0.13±0.15$^{a}$ | 0.17±0.12$^{a}$ | 0.20±0.10$^{a}$ | 0.03±0.06$^{a}$ |
| Dwarf | Cut Stalk | 0.03±0.06$^{a}$ | 0.20±0.10$^{cd}$ | 0.00±0.00$^{a}$ | 0.07±0.06$^{a}$ | 0.13±0.06$^{b}$ | 0.17±0.15$^{a}$ | 0.13±0.06$^{a}$ | 0.30±0.10$^{ab}$ | 0.30±0.20$^{a}$ |
| Cavendish | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{ab}$ | 0.13±0.15$^{a}$ | 0.10±0.10$^{a}$ | 0.13±0.06$^{a}$ | 0.07±0.12$^{a}$ |
| Banana | Epicarp | 0.00±0.00$^{a}$ | 0.27±0.06$^{d}$ | 0.00±0.00$^{a}$ | 0.17±0.12$^{a}$ | 0.13±0.06$^{b}$ | 0.27±0.15$^{a}$ | 0.17±0.12$^{a}$ | 0.50±0.20$^{b}$ | 0.37±0.31$^{a}$ |
| | Tip | 0.03±0.06$^{a}$ | 0.13±0.06$^{bc}$ | 0.00±0.00$^{a}$ | 0.20±0.10$^{a}$ | 0.07±0.06$^{ab}$ | 0.20±0.20$^{a}$ | 0.17±0.12$^{a}$ | 0.07±0.06$^{a}$ | 0.10±0.10$^{a}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.07±0.06$^{a}$ | 0.23±0.15$^{b}$ | 0.13±0.15$^{a}$ |
| Red | Cut Stalk | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.15$^{a}$ | 0.10±0.10$^{a}$ | 0.13±0.15$^{a}$ | 0.10±0.10$^{ab}$ | 0.20±0.10$^{ab}$ | 0.40±0.30$^{a}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.58$^{a}$ | 0.07±0.12$^{a}$ |
| | Epicarp | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ | 0.07±0.12$^{a}$ | 0.17±0.06$^{b}$ | 0.33±0.15$^{b}$ | 0.23±0.23$^{a}$ |
| | Tip | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.10$^{a}$ | 0.00±0.00$^{a}$ | 0.07±0.12$^{a}$ | 0.03±0.06$^{ab}$ | 0.17±0.12$^{ab}$ | 0.27±0.21$^{a}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.07±0.12$^{a}$ | 0.00±0.00$^{a}$ | 0.17±0.12$^{b}$ | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ |
| Lady Finger | Cut Stalk | 0.07±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.10$^{a}$ | 0.03±0.06$^{a}$ | 0.10±0.10$^{a}$ | 0.20±0.10$^{ab}$ | 0.17±0.12$^{ab}$ | 0.20±0.10$^{aab}$ |
| Banana | Endocarp | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.07±0.12$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.20±0.10$^{ab}$ | 0.07±0.06$^{ab}$ | 0.03±0.06$^{a}$ |
| | Epicarp | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.15$^{a}$ | 0.23±0.15$^{b}$ | 0.13±0.15$^{a}$ | 0.23±0.06$^{b}$ | 0.13±0.15$^{ab}$ | 0.33±0.15$^{b}$ |
| | Tip | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.13±0.06$^{ab}$ | 0.30±0.20$^{b}$ | 0.17±0.12$^{ab}$ |
| | Vascular Tissue | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.10±0.00$^{a}$ | 0.07±0.12$^{a}$ | 0.07±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ |
| Grand Nain | Cut Stalk | 0.00±0.00$^{a}$ | 0.17±0.06$^{b}$ | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ | 0.20±0.10$^{b}$ | 0.13±0.15$^{a}$ | 0.37±0.31$^{a}$ | 0.17±0.15$^{ab}$ | 0.10±0.10$^{ab}$ |
| Banana | Endocarp | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.03±0.06$^{a}$ | 0.00±0.00$^{a}$ |
| | Epicarp | 0.00±0.00$^{a}$ | 0.10±0.10$^{ab}$ | 0.03±0.06$^{a}$ | 0.07±0.12$^{a}$ | 0.23±0.06$^{b}$ | 0.03±0.06$^{a}$ | 0.30±0.20$^{a}$ | 0.30±0.10$^{a}$ | 0.17±0.06$^{b}$ |
| | Tip | 0.00±0.00$^{a}$ | 0.07±0.06$^{ab}$ | 0.00±0.00$^{a}$ | 0.07±0.12$^{a}$ | 0.10±0.10$^{ab}$ | 0.10±0.10$^{a}$ | 0.37±0.15$^{a}$ | 0.17±0.12$^{ab}$ | 0.03±0.06$^{ab}$ |
| | Vascular Tissue | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.00±0.00$^{a}$ | 0.03±0.06$^{a}$ | 0.13±0.15$^{a}$ | 0.10±0.10$^{a}$ | 0.07±0.06$^{a}$ | 0.17±0.12$^{b}$ |

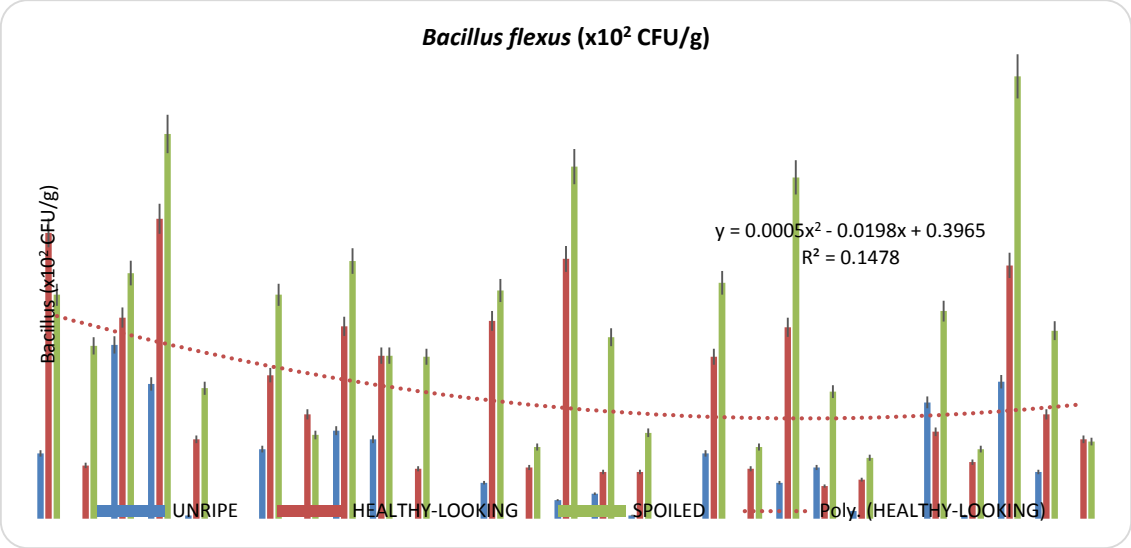


**Fig. 9. Mean values of *Bacillus flexus* (x10² CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of banana varieties (cavendish (CAB), dwarf cavendish (DCB), red (RDB), lady finger (LFB) and grand Nain (GNB) from markets**

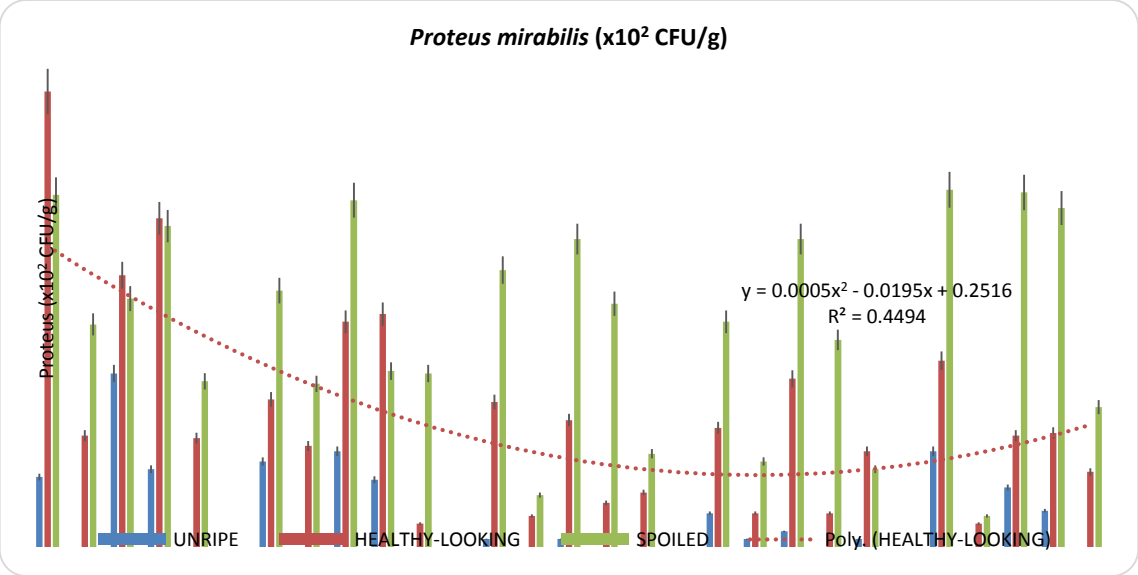


**Fig. 10. Mean values of *Proteus mirabilis* (x10² CFU/g) values of different parts (cut stalk, endocarp, epicarp, tip, vascular tissue) of banana varieties (cavendish (CAB), dwarf cavendish (DCB), red (RDB), lady finger (LFB) and grand nain (GNB) from markets**

**Table 9: Frequency and percentage of the bacteria isolates**

| Isolates | Frequency | Percentage Prevalence (%) |
|---|---|---|
| *Escherichia coli* | 19 | 15.32 |
| *Staphylococcus aureus* | 24 | 19.35 |
| *Pseudomonas aeruginosa* | 12 | 9.68 |
| *Bacillus flexus* | 9 | 7.26 |
| *Proteus mirabilis* | 8 | 6.45 |
| *Klebsiella pneumoniae* | 11 | 8.87 |
| *Aspergillus flavus* | 23 | 18.55 |
| *Fusarium lichenicola* | 18 | 14.52 |
| Total | 124 | 100 |

**Table 10. Percentage occurrence of isolates by banana (*Musa* Spp.) fruit samples**

| S/N | Banana (*Musa* spp.) Fruit Samples | No. of Isolates (%) |
|---|---|---|
| 1 | Cavendish Banana | 21 (16.9) |
| 2 | Dwarf Cavendish Banana | 31 (25.0) |
| 3 | Red Banana | 12 (9.7) |
| 4 | Lady Finger Banana | 18 (14.5) |
| 5 | Grand Nain Banana | 42 (33.9) |
| Total | | 124 (100) |

## 4. CONCLUSION

Conclusively, the present study reports the presence of bacterial and fungal contamination in Banana fruit (*Musa* spp.). Several pathogenic bacteria isolated from this study includes: *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Bacillus flexus* and *Proteus mirabilis,* as well as opportunistic Fungi such as *Aspergillus flavus* and Fusa*rium lichenicola.*

Grand Nain banana variety has the highest microbial load thus consumption of it should be washed or cleansed thoroughly. Secondly, of the different parts sampled, Cut stalk of banana is associated with highest microbial load, therefore it should checked properly or cut off when peeling/during consumption, The high load of *Staphylococcus aureus*, *Escherichia coli* and *Bacillus* is of great concern. These organisms associated with different parts and varieties of banana fruits (*Musa* spp.) in Port Harcourt Nigeria, poses serious threat to consumers. Prohibition of anthropogenic activities (such as indiscrimate dumping of refuse on land and in water, indiscriminate defecation on land and water, use of pesticides, agricultural fertilizers, amongst others) within the markets and farms should be encouraged in order to reduce the level of contamination of these fruits. Also, public awareness on safe and hygienic practices in the handling and distribution of Banana fruits from the farms to the markets should be encouraged.

The microorganisms normally present on the surface of raw fruits such as Banana may have high chances of contamination from the soil or dust. These include bacteria or fungi that have grown and colonized by utilizing nutrient exuded from plant tissue. Presence of these bacteria on bananas most especially Coliforms pose a serious threat to health of consumers as the organism could produce toxins, which are lethal when consumed.

Most times, contaminants in Banana fruits could be as a result of human contamination (This could be contamination from the microflora residing in the nostrils, mouth or skin of the vendor who's selling the fruit or from that of the consumer (buyer).

Consumption of some Banana fruits infected by these isolated Bacteria (*Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Bacillus flexus* and *Proteus mirabilis*) have been associated with Food Poisoning, which in most cases the consumer ends up with Diarrhea, Dysentery, Abdominal cramps, etc.

## 5. RECOMMENDATION

We therefore recommended that both the farmers and sellers are to take necessary and appropriate precautions in preventing contamination and eating of contaminated fruits. This will however reduce the risk of toxins associated with bacterial contamination which are dangerous to human health. An example is the wearing of gloves while harvesting or selling of Banana fruits if there are presence of wounds or infections on the wrist or hands, also not allowing their buyers touch their wares (Banana fruit) when trying to make a purchase.

Washing of hands before touching the fruits (Banana fruits) and washing of Banana fruits before consumption should be encouraged.

It's a known fact that *Escherichia coli* resides in the digestive tracts (intestines) of humans and can be shed out of the intestines into the feces/stool. Therefore, inappropriate disposal of waste or open defecation on lands used for plantation (farms) should be discouraged. *Escherichia coli* is also associated with raw meat, so contamination of Banana fruits sometimes could be as a result of it being in contact with raw meat (this could be from cutting boards or countertop or from sellers who share same table with meat sellers in the local market). These marketers are advised to adhere to some precautionary measures to avoid contamination from *Escherichia coli.*

Using of contaminated water (this happens when the water source is polluted by manure or by nearby animals dungs) to taint the Banana fruits. Therefore, farmers are to take precautionary measures in ensuring that the water used on the plants are free from contamination. Also, the vendors should ensure that the water they spray or wash these fruits (Banana fruits) are free from contamination.

*Pseudomonas aeruginosa* is a microflora of soil and water, and can contaminate Banana trees hence the contamination in the fruits. Farmers are to be enlightened on the dangers involved in planting on infected soils and use of contaminated water on their plants.

Acceptable management and control of bacterial disease in Banana fruits (*Musa* spp.) is achievable by following strict, coordinated and integrated activities. These activities, which are wide performed in a systematic way and based on epidemiological parameters, may guarantee sustainable control. Farmers/Marketers and extension workers should be trained on disease recognition, epidemiology and management practices, with the support of plant protection experts.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Ellyn S. What are the health benefits of banana bread? ; 2011;1.
   Available:http://www.livestrong.com/article/268303-what-are-the-health-benefits-of-banana bread/#ixzz2BVxmutdY.
2. FAOSTAT. Banana Market Review and Statistics. Inter-governmental Group on Bananas and Tropical Fruits. Market and Policy Analyses of Raw Materials, Horticulture and Tropical (RAMHOT) Products Team, Rome. 2014;1.
3. Woldu Z, Mohammed A, Belew D, Shumeta Z, Bekele A. Assessment of banana postharvest handling practices and losses in Ethiopia. Journal of Biology, Agriculture, and Healthcare. 2015;5(17): 82-86.
4. Mohapatra D, Mishra S, Sutar N. Banana and its by-product utilisation: An overview. 2010;1-3
5. Robinson JC, Saúco VG. Bananas and plantains. 2010;19:1.
6. FAO. Food and Agriculture Organization of United Nations. Agriculture data base Prod. 2012;1.
7. Vazquezshy JA, Karina D, Adriano-Anaya MDL, Salvador-Figueroa M, and Ov I. Sensory and physico-chemical quality of banana fruits Grand Naine grown with biofertilizer. African Journal of Agricultural Research. 2012;7(33):4620–46262
8. Daniel S. Banana in the southern region of Ethiopia (SRE). Bananas and food security. 1999;119–128.
9. Seifu, GM. Banana: Production and utilization in Ethiopia. Ethiopian Institute of Agricultural Research Organization (EIAR). 1999;58.
10. El-Naby SKMA. Effect of postharvest treatments on quality aspect of Maghrabi banana fruit. American-Eurasian Journal of Agricultural and Environmental Science. 2010;8(5):582–587.
11. Angela OE, Ibukunoluwa AO, Oranusi US. Microbial quality of fruits and vegetables sold in Sango Ota, Nigeria. African Journal of Food Science. 2010;4(5):291-296.
12. Olayemi AB. Microbiological hazard associated with agricultural utilization of urban polluted river water. Intern. Journal environmental health research. 2007;7(2):149-54.
13. Amoah P, Robert D, Abaidoo C, Abraham EM. Improving food hygiene in Africa where vegetables are irrigated with polluted water. Regional sanitation and hygiene symposium Accra, Ghana. 2009;10(12):1-9.

14. Wilson CL, Wisniewski ME, Biles CL, McLaughlin R, Chalutz E, Droby S. Biological control of post-harvest diseases of fruits and vegetables: Alternatives to synthetic fungicides. Crop Protection. 1991;10(199):172-177.

15. Singh D, Sharma RR. Postharvest diseases of fruit and vegetables and their management. New Delhi, India: Daya Publishing House. 2007;1.

16. Al-Hindi RR, Al-Najada AR, Mohamed SA. Isolation and identification of some fruit spoilage fungi: Screening of plant cell wall degrading enzymes. African Journal of Microbiology Research. 2011;5(4):443-448.

17. Ayanda OI, Ajayi AA, Olasehinde GI, Dare OT. Isolation, characterization and extracellular enzyme detection of microbial isolates. International Journal of Biological and Chemical Sciences. 2013;7(2):641-648.

18. Verma S, Srivastav G. Original Article Isolation and Characterization of Microorganisms. International Journal of Research in Pure and Applied Microbiology. 2011;1(2):22-31.

19. Essien E, Monago C, Edor EA. Evaluation of the Nutritional and Microbiological Quality of Kunun (A Cereal Based Non-Alcoholic Beverage) in Rivers State, Nigeria. The Internet Journal of Nutrition and Wellness. 2011;10 (2):1-10.

20. Anitha M, Swathy SR, Venkateswari P. Prevalence of disease-causing microrganisms in decaying fruits with analysis of fungal and bacterial species. International Journal of Research in Health Sciences. 2014;2(2):547-554.

21. Cheesbrough M. Microbiological tests. In: District laboratory practice in Tropical Countries (2nd Ed.). Cambridge University Press, Cambridge; 2006.

ISBN 978-0-521-67633-5.

22. Saitou, N, Nei, M. The neighbor-joining method: A new method for reconstructing phylogenetic trees. Molecular Biology and Evolution. 1987:4:406-425.

23. Felsenstein J. Confidence limits on phylogenies: An approach using the bootstrap. Evolution. 1985:39:783-791.

24. Jukes, T.H. and Cantor, C.R. Evolution of protein molecules. Mammalian Protein Metabolism. 1969:1:21-132.

25. Center for Food Safety (CFS). Microbiological Guidelines for Food; 2014.

26. Chibuzor CA, Ugwuanyi RC, Ogbonna OA. Isolation and Identification of Microorganisms involved in the the spoilage of Banana Fruit (*Musa acuminata*) sold in some selected markets in Eastern Nigeria. Journal of Applied Sciences. 2019;4(1):86-93.

27. Ogunniran BI. Harmful Effects and Management of Indiscriminate Solid Waste Disposal on Human and its Environment in Nigeria: A Review. Global Journal of Research and Review. 2019;6(1):1-4.

28. Daniel S. Banana in the southern region of Ethiopia (SRE). Bananas and food security. 1999;119–128.

29. Seifu GM. Banana: Production and utilization in Ethiopia. Ethiopian Institute of Agricultural Research Organization (EIAR). 1999;58.

30. El-Naby SKMA. Effect of postharvest treatments on quality aspect of Maghrabi banana fruit. American-Eurasian Journal of Agricultural and Environmental Science. 2010;8(5):582–587.

31. Sri Harminda PH. Chau ML, Tse HK. Min Y. Tseng YI. Delphine YHC. Ramona AG, Lee CN. Foodborne *Klebsiella pneumoniae*: Viruence Potential, Antibiotic Resistance, and Risks to Food Safety. Journal of Food Protection. 2020;83(7):1096-1103.

32. Singh D, Sharma RR. Postharvest diseases of fruit and vegetables and their management. *New Delhi, India:* Daya Publishing House; 2007.

33. Tango UM. Chains of Fruits. Journal for the study of Chains of Fruits in Africa. 2005;18(6):600-603.

34. Yusuf AM, Gidado SM. Study on Common Fungi associated with some fruits spoilage in Katsina Metropolis. Katsina Journal of Natural and Applied Sciences. 2018;7(2):143-149.

35. Thiyam B, Sharma GD. Isolation and Identification of Fungi Associated with Local Fruits of Barak Valley, Assam. Current World Environment. 2013;8(2): 319-322.

36. Hasan NA, Zulkahar IM. Isolation and Identification of bacteria from spoiled fruits. AIP Confrence Proceedings. 2018;10(1):1-6.

37. Miller JM, Hair JG, Herbert L, Roberts FJ and Weyant RS. Fulminating bacteremia and pneumonia due to *Bacillus cereus.* Journal of Clinical Microbioogy. 1997:35(1):504-507.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sdiarticle4.com/review-history/67241*