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Nutritional and Microbial Quality of Locally Processed Plantain Flour

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Abstract:- Flour is a fibre rich in carbohydrate but the preparation and packaging process are exposed to microbial contaminations and nutritional alterations. This study was therefore undertaken to evaluate the microbial and nutritional quality of packaged and unpackaged plantain flour. Cultural, microscopic, biochemical test and most probable number (MPN) methods were employed to determine the various microorganisms; while pproximate analysis was done to estimate inherent nutrients in the flour. Significant differences between packaging, nutritional and microbial qualities were determined using ANOVA or T-test, at P<0.05. Results show Heterotrophic bacterial count in packaged plantain flour was 4.52 ± 1.20 x 10^2 Cfu/g and unpackaged flour 6.01 ± 1.43 x 10^2 Cfu/g. Coliform bacterial count in plantain flour showed packaged 2.77 ± 2.01 x 10^2 Cfu/g and unpacked 3,45 ± 0.50 x 10^2 Cfu/g. The Pseudomonas count showed the packaged plantain flour count of 3.24 ± 0.60 x 10^2 Cfu/g and the unpackaged 4.31 ± 1.23 x 10^2 Cfu/g. The proximate analysis of the flour sample revealed an increase in nutritional contents. This study concludes that exposure of flour to the environment increases microbial content and therefore health and hygiene concerns.

Keywords:- *Plantain Flour; Packaged; Unpackaged; Heterotrophic Bacterial; Coliform Bacterial.*

I. INTRODUCTION

Flour is a powdery product formed from grinded uncooked grains, roots, beans, nuts or seeds. It is employed in the creation of several local and international dishes. Most flour are manufactured from cereal grains and they comprise the principal component used in the manufacturing of bread, pasta, crackers, cake, a domestic food. Flour especially wheat flour also used in preparation of thickening sauces.

Plantain (*Musa paradisiaca*) is an important staple food widely consumed in West and Central Africa, South America, and the Caribbean. Plantains can be processed into various products including plantain flour which has become increasingly popular due to its convenience and versatility. Locally processed plantain flour is a high-energy food rich in carbohydrates, fiber, vitamins, and minerals. However, the nutritional and microbial qualities of locally processed plantain flour may be affected by processing methods, storage conditions, and hygiene practices. Therefore, it is important to evaluate the nutritional and microbial properties of locally processed plantain flour to ensure its safety and quality.

Several studies have evaluated the nutritional and microbial quality of locally processed plantain flour. A study by Akingbala et al. (2005) reported that plantain flour had high starch, fiber, and ash content, but was low in protein and fat. Another study by Amoah et al. (2017) found that locally processed plantain flour had high levels of iron, phosphorus, and potassium, but low levels of calcium and zinc. These findings suggest that plantain flour is a good source of energy and nutrients but may not provide adequate amounts of certain essential nutrients.

The microbial quality of locally processed plantain flour has also been evaluated. A study by Olapade et al. (2017) reported that plantain flour samples had high total bacterial and fungal counts which exceeded the recommended limits. The presence of pathogenic bacteria such as Escherichia coli and Salmonella was also detected in some samples. Another study by Oyeyiola et al. (2018) reported that the high moisture content and poor hygienic practices during processing and storage contributed to the high microbial load in plantain flour.

In Nigeria, the usage of flour as foodstuff is more than a cultural phenomenon. It is used by most businesses in the sector that are engaged in baking and fast-food. All flour may be manufactured with most cereal. In Nigeria, the major source of dough is Cassava, plantain, yam and millet. Because of its abundance in vitamins - Ascorbic acid (Vitamin C) and carotene and its low amount, plantain flour is liked by patients

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suffering from cholesterol associated disorders such as obesity, diabetes, gallstone etc (Soliman, 2019).

In conclusion, locally processed plantain flour is a nutritious staple food with high energy, starch, and fiber content. However, its nutritional value may be limited by low protein and fat content, and inadequate levels of certain essential nutrients. The microbial quality of plantain flour can also be compromised by poor hygienic practices during processing and storage. Therefore, it is important to implement good hygiene practices and proper processing techniques to ensure the safety and quality of locally processed plantain flour.

The aim of the study is to examine the nutritional and microbiological quality of plantain flour acquired from the market.

II. MATERIALS AND METHODS

- *Sample Area*

This study was based on plantain flour samples collected from Swali Market (Yenagoa, Bayelsa State. I analysed and processed the flour samples in a microbiology laboratory at Niger Delta University's Wilberforce Island, Southern Ijaw Local Government Area, Bayelsa State, which is located in latitudes 04°C 15' north, 05°C 23' south, and longitudes of 06° C 45' east, with Delta State to the north, Rivers State to the east, and the Atlantic Ocean to the west and south.

- *Sterilization/Disinfection of Materials*

During the bacteriological investigation of the samples, the instruments and materials used in this study were sterilized to detect contamination. The autoclave was used for sterilization. Glassware, nutritional medium, and cotton wool are all included in this category. They were autoclaved at 121^0C for 15 minutes at 15 PSI. Droppers and glass rods that couldn't be autoclaved were disinfected with 70% ethanol. The bench was cleaned both before and after each shift using 70% ethanol.

- *Preparation of Nutrient Media*

Autoclaving was utilized to sterilize the nutritional medium in this investigation. The bacterial population of the samples was cultured and counted using Nutrient agar, Cetrimide agar, and MacConkey agar, while faecal and total coliform bacteria were estimated using MacConkey broth. Kliger iron agar was employed to identify lactose and glucose fermentation, gas generation, and hydrogen sulfide formation during biochemical testing of the isolates. Citrate utilization as a carbon source were performed using Simmon citrate agar, Indole production was detected using tryptone water.

It was done according to the manufacturer's instructions to dissolve the powder medium in distilled water. The containers were covered by loosened lid with aluminium foil for 15 minutes at 121°C to autoclave the dissolved medium.

- *Bacteriological Analysis*

Standard operating protocols such as determining the data, cleaning the data, etc were used to conduct the quantitative and qualitative investigation of the bacteria found in the flour samples. There were strict guidelines in place for the usage of the chemicals, nutrients, and other equipment.

- *Enumeration of Total Heterotrophic Bacteria*

Nutrient agar was used to estimate the population of the heterotrophic bacteria present in the flour samples. Before plating the flour samples, they were serially diluted. Transferring 5 grams of flour into a test tube filled with 10 ml of 0.85 percent normal saline, the stock culture was created. After a thorough shaking, the stock culture was ready to use. One millilitre of the stock culture was then diluted 1:10 with 9 millilitres of sterile water. A third dilution tube was used for the samples (1:1000). The pour plate technique was used after the third dilution (1ml of the sample was poured into the plates aseptically). It was then poured onto the petri dishes with the help of 20ml of the ready-made molten agar. The dishes were allowed to cool before dispensing (solidify). A 24-hour incubation period at 37^0C followed the plates being inverted.

- *Enumeration of Coliform Bacteria*

The coliform count was tallied using a modified version of the most probable number (MPN) approach developed by Ginigaddarage et al., (2018). MacConkey agar was used to count the number of coliform bacteria. 3.4.1 describes the plating procedure that made advantage of the third dilution of the material. The mixture was incubated at 37^0 C for 24 hours.

- *Enumeration of Pseudomonads*

In order to count the Pseudomonas species, the experiment was carried out on a Cetrimide agar. It took 48 hours to incubate the plates at 37^0 Fahrenheit. The reduced growth time of Pseudomonads on Cetrimide agar necessitated a longer incubation period.

- *Enumeration of Total and Faecal Coliform*

Following a modified Ginigaddarage et al. technique, the third (3rd) dilution was utilized to count faecal and total coliforms (2018). There were three tubes with 10ml each of double strength MacConkey broth, single strength MacConkey broth, and inoculum inoculation, and each tube had 10ml of dilution added to it. The inoculum was then divided into three and added to 10ml each of the three different concentrations. There was a total of nine tubes in each sample. For faecal and total coliform, two sets of tubes were utilized for each. The faecal and total coliform cultures were maintained at 36^0C and 44^0C, respectively, during the broth cultures. The test tubes were incubated for 48 hours. The Durham tubes were inspected at the conclusion of the incubation time for gas

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generation and fermentation. An MPN index was used to analyse the outcomes of the positive and negative tubes.

➢ *Isolation of Pure Cultures of Bacteria*

After the agar plates had been incubated, a random sample of colonies were chosen and removed using a sterile wire loop. Sub-cultured colonies on new nutritional agar plates were produced by streaking the colonies over the agar surface. Purified isolates were obtained by flipping the plates and incubating them at 37^0C in an aerobic environment.

III. BIOCHEMICAL CHARACTERIZATION AND IDENTIFICATION OF BACTERIAL ISOLATES

➢ *Gram Staining Technique*

Colonies from several pure culture plates were emulsified on a slide with a drop of distilled water. A drop of the suspended culture was transferred with an inoculation loop to ta microscope slide, and the culture spread on the slides to an even thin film over a circle of 15mm in diameter. The slide was then air-dried. Crystal violet stain was applied to the fixed culture for 60 seconds, the stain was poured off, and the excess stain rinsed with water. Lugol's iodine solution was used to cover the smear for 60 seconds. The iodine solution was poured off, and the slide was rinsed with running water. Excess water from the surface was shaken off. After being decoloured with alcohol, the slide was quickly rinsed with water in 5 seconds. The smear was counter stained with basic fuchsin solution for 60 seconds. The fuchsin solution was washed off with water, and slide air-dried after shaking off the excess water. The slide was examined under a microscope with x40 and x100 objective.

➢ *Oxidase Test*

Three milliliters (3ml) of hydrogen peroxide were added to three sterile test tubes, and the colony of the pure culture was chosen and dipped into one of these test tubes, and the bubbles were observed. (Cheesbrough, 2010).

➢ *Indole Test*

Tubes containing 10 millilitres of tryptophan broth were made. Test organisms were placed on a wire loop and cultured for 48 hours. The medium was then treated with five drops of Kovac reagent, after which the bubbles were observed for the presence or absence of cherry-red ring (Cheesbrough, 2010).

➢ *Kliger Iron Agar Slant Test*

Test tubes containing 10ml of Kliger Iron Agar were used to prepare the slants. With an inoculating needle, pick the centre of well-isolated colonies obtained from solid culture media. The test tubes were initially injected with the bacteria by stabbing the centre of the medium, inoculating needle, into the deep of the tube to within 3-5mm from the bottom. The inoculating needle was withdrawn and streaked on the surface of the slant. The tubes were incubated at 37^0C for 24 hours, with cotton wool covering the openings. Colour changes, darkening, and cracking of the media after incubation were observed and recorded (Cheesbrough, 2010).

➢ *Citrate Utilization Test*

Ten milliliters of Simmon citrate slants were prepared in test tubes. The media slope was inoculated with the test isolate using a wire loop. The tubes were then incubated at 37^0C for 24 hours, and the colour change in the medium was observed (Cheesbrough, 2010).

➢ *Catalase Test*

Three milliliters (3ml) of hydrogen peroxide were added to three sterile test tubes, and the colony of the pure culture was chosen and dipped into one of these test tubes, and the bubbles were then observed (Cheesbrough, 2010).

➢ *Methyl Red Test*

A new Methyl red medium was infected with a bacterial isolate and incubated at 37^0C for 24 hours. Five drops of methyl red were added to the soup after the incubation period.

IV. PROXIMATE ANALYSIS

➢ *Determination of Moisture*

An evaporating dish was dried in the oven for one hour. The evaporating dish was filled with 5g of the sample and put in an oven at 105^0C. The samples were weighed every hour until they reached a stable weight.

$$\% \text{ Moisture} = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of wet sample}} \times \frac{100}{1}$$

➢ *Determination of %Ash*

One gram of a moisture-free sample was placed in a crucible. Muffle furnaces were used to heat the sample and crucible for 12 to 18 hours. The furnace was set to 55^0C. The furnace was turned off and allowed to cool to a temperature of around 25^0C or lower at the conclusion of the process. The crucible was placed in a desiccator to enable it to cool and the ash weighed.

$$\%\text{Ash} = \frac{\text{Weight after Ash} - \text{Weight of Crucible} \times 100}{\text{Weight of original sample}} \quad 1$$

➢ *Determination of Crude Protein*

An amount of 0.55g of sample was added to the flask, followed by the addition of 1g of mercury catalyst and 30ml conc. H_2SO_4. When the foaming stopped, the flask was gently heated. For the next five hours, it was heated to boiling point. 100ml of cooled distilled water was added to the flask in order to finish chilling it. Another pair of flasks was used to hold the digest. Every last bit of residue was cleaned and then poured into the flask. A conical flask containing 50ml of boric acid and 1 ml of mixed indicators was put beneath the extractor of the distillation apparatus to collect the condensate.

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In the distillation flask, 150 ml of 10M NaOH was added, and the distillation process began. When 150ml of the distillate was collected, the operation was halted. It was measured by titrating the condensate with 0.01M H_2SO_4 to determine the quantity of N2 present. The color shifts from green to purple near the conclusion.

$$\%N = 0.01M\ H_2SO_4 \times M \times \frac{14}{100} \times \frac{50}{10} \times \frac{100}{10}$$

$$\%Protein = \%\ N \times 6.25$$

Where M = Molarity of the H_2SO_4
14= Atomic number of nitrogens
50= from the procedure
10= from the procedure
100= percentage
10= weight of original sample

➢ *Determination of Crude Lipid*

A thimble containing 2 grams of dried (moisture-free) material was put in a soxhlet extraction equipment. Glass wool was used to cover the thimble's mouth. The weight of the boiling flask was determined. With the addition of 120 ml of petroleum ether and two antibomps, the content of the flask was brought to a boil. With the help of an electro thermal heater, the three vessels were put together. The extraction process lasted about three hours to complete. A hot-air oven set to 1000°C for 30 minutes was used to dry out the boiling flask with the fat that was taken from it. It was then weighed after cooling in a desiccator.

$$\%Fat\ (lipid) = \frac{g\ fat\ in\ sample}{g\ sample} \times \frac{100}{1}$$

➢ *Determination of Crude Fibre*

Two hundred milliliters (200ml) of 1.25 percent H_2SO_4 were added to a beaker containing 2g of defatted dry sample, and the mixture was brought to a boil for 30 minutes while being constantly swirled. Suction or vacuum was used to cool and filter it at the conclusion of the process. The filter paper and fibres were flushed with water. The flask was refilled with 200ml of 1.25 percent NaOH and cooked for another 30 minutes, after which the residue was placed into the flask. After a period of time, the samples were filtered and washed three times with petroleum ether before being finished with three further washes. The filter paper and the residue were placed in an oven at 105^0C for 12 hours.

➢ *Data Analyses*

Quantitative data were analyzed using a statistical analysis software (SPSS version 20). The results were subjected to one way analysis of variance (ANOVA) or student t-test, as was appropriate. Significant differences between packaging and nutritional and microbial quality of the flour were determined at $P<0.05$. Such results were presented as mean ± standard error, microbial concentration, or as percentages.

V. RESULTS

➢ *Assessment of the Bacteriological Quality of Flour Samples*

The results for the total heterotrophic bacteria (THB) count on nutrient agar, coliform counts on MacConkey agar, and Pseudomonas count on Cetrimide agar associated with packaged flour samples as presented in table 1. below were expressed as mean x 10^2 Cfu/g. The THB ranged from 1.64 ± 0.49 x 10^2 Cfu/g in plantain flour A to 1.82 ± 0.06 x 10^2 Cfu/g in plantain flour C. The coliform bacteria count ranged from 0.38 ± 0.08x 10^2 Cfu/g in plantain flour A to 0.71 ± 0.10x 10^2 Cfu/g in plantain flour C, while the Pseudomonads counts ranged from 0.87 ± 0.05x 10^2 Cfu/g in plantain flour A to 1.28 ± 0.07x 10^2 Cfu/g in plantain flour C.

The results suggest the flour have different degree of bacterial contamination. For each of the samples (plantain, yam and cassava), the mean values of the bacterial count were done for their respective flour types (A, B and C) using analysis of variance (ANOVA). The results indicate statistically significant differences ($P< 0.05$) between the samples.

Table 1: Enumeration of Bacterial Population in Packaged Flour Samples

Samples	Total heterotrophic bacteria (10^2 Cfu/g)	Coliform bacteria (10^2 Cfu/g)	Pseudomonads (10^2 Cfu/g)
Plantain flour A	1.64 ± 0.49^a	0.38 ± 0.08^a	0.87 ± 0.05^a
Plantain flour B	1.05 ± 0.10^b	1.68 ± 0.18^b	1.09 ± 0.13^b
Plantain flour C	1.82 ± 0.06^c	0.71 ± 0.10^c	1.28 ± 0.07^c

Table 2: Enumeration of Bacterial Population in Unpackaged Flour Samples

Samples	Total Heterotrophic Bacteria (10^2 Cfu/g)	Coliform Bacteria (10^2 Cfu/g)	Pseudomonads (10^2 Cfu/g)
Plantain flour A	1.97 ± 0.28^a	1.15 ± 0.07^a	1.91 ± 0.18^a
Plantain flour B	2.50 ± 0.39^b	0.98 ± 0.10^b	1.26 ± 0.19^b
Plantain flour C	1.54 ± 0.10^c	1.31 ± 0.03^c	1.15 ± 0.09^c

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Table 2. Presents the results for the bacteriological assessment of the unpackaged flour samples. The THB associated with the Plantain flour ranged from 1.97 ± 0.28 x 10^2 Cfu/g in plantain flour A to 1.54 ± 0.10 x 10^2 Cfu/g in plantain flour C. The coliform bacteria count ranged from 1.15 ± 0.07 x 10^2 Cfu/g in plantain flour A to 1.31 ± 0.03 x 10^2 Cfu/g in plantain flour C, while the Pseudomonads counts ranged from 1.15 ± 0.09 in plantain flour A to 1.28 ± 0.07 in plantain flour C.

➢ *Occurrence of Bacterial Isolates in Packaged and Unpackaged Flour Samples*

Figures 1 and 2 presents the results for the occurrence of bacterial species associated with the packaged and unpackaged flour samples. Figure 1., shows *Lactobacillus* species occurred the most with 29%. *Bacillus* species recorded 26%, *Escherichia coli* 17%, *Citrobacter* species 15%, *Streptococcus* 95, and *Micrococcus* 4%.

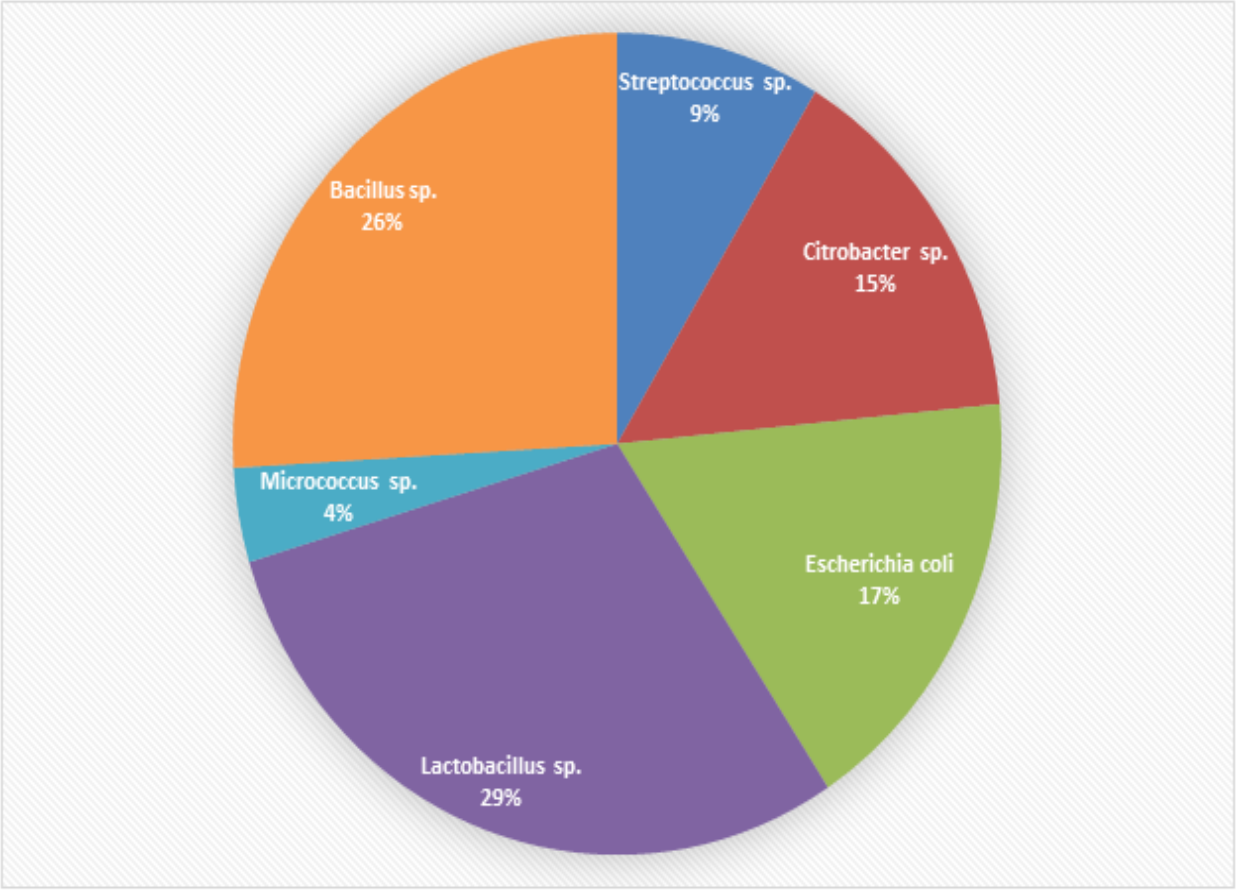

Fig 1: Percentage of Occurrence of Bacterial Isolates in Packaged Flour Samples

Figure 2., below presents the result for the percentage of occurrence of bacterial species associated with the unpackaged flour samples. *Bacillus* species recorded a percentage of 26, *Escherichia coli* 26%, *Staphylococcus* species 17%, *Micrococcus* 15%, *Pseudomonas aeruginosa* 12%, *Lactobacillus* 6%, *Serratia* species 4%, *Yersinia* species 4%, and *Erwinia* 3%

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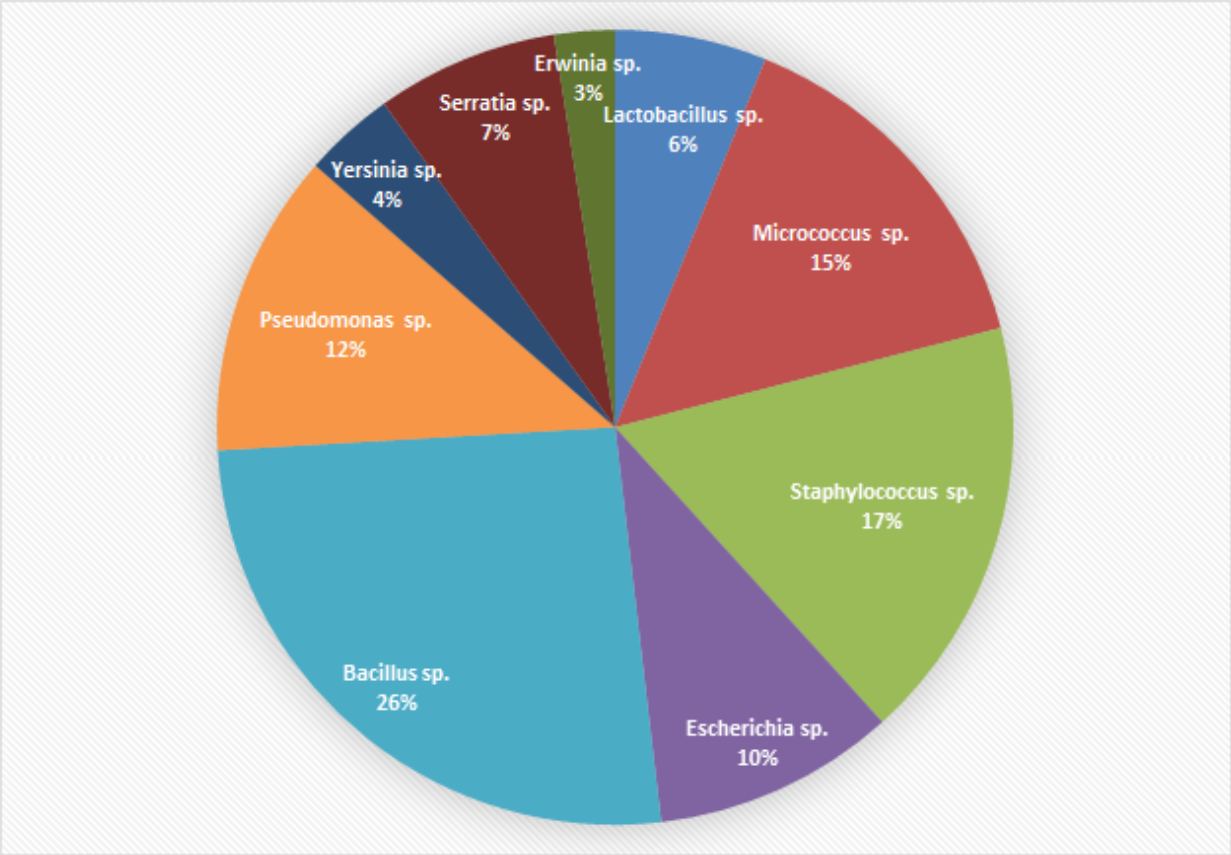

Fig 2: Percentage of Occurrence of Bacterial Isolates in Unpackaged Flour Samples

➢ *Comparison of the Bacteriological Quality between Packaged and Unpackaged Flour*

The comparison of the level of contamination between the packaged and unpackaged flour is presented in tables 3 - 5. The level of contamination by the heterotrophic bacteria is presented in table 4.3. The results show the packaged Plantain flour was less contaminated with mean value of 4.52 ± 1.20 x 10^2 Cfu/g, while the unpackaged plantain flour recorded higher (24.79%) contamination (6.01 ± 1.43 x 10^2 Cfu/g).

Table 3: Group Statistics on Total Heterotrophic Bacteria in Packaged and Unpackaged Flour Samples on Nutrient Agar

Flour Samples	Sample Class	Mean ± STD (10^2 Cfu/g)
Plantain Flour	Packaged	4.52 ± 1.2^a
	Unpackaged	6.01 ± 1.43^a

Table 4 Group Statistics on Coliform BACTERIA in Packaged and UNPACKAGED FLOUR SAMPLES on MacConkey AGAR

Flour Samples	Sample Class	Mean (10^2 Cfu/g)
Plantain Flour	Packaged	2.77 ± 2.01^a
	Unpackaged	3.45 ± 0.50^b

The results in Table 4 above show the packaged Plantain flour was less contaminated with coliform bacteria with mean value of 2.77 ± 2.01 x 10^2 Cfu/g, while the unpackaged flour recorded higher levels of contamination with mean value of 3.45 ± 0.50 x 10^2 Cfu/g.

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Table 5: Group Statistics on Pseudomonads in Packaged and Unpackaged Flour Samples on Cetrimide Agar

Flour Samples	Sample Class	Mean (10^2 Cfu/g)	Relative Increase (%)
Plantain Flour	Packaged	3.24 ± 0.60^a	
	Unpackage	4.31 ± 1.23^a	33.02

The results in table 5 above show the packaged Plantain flour was less contaminated with *Pseudomonas species* with mean value of $3.24 \pm 0.60 \times 10^2$ Cfu/g, while the unpackaged flour recorded higher levels of contamination with mean value of $4.31 \pm 1.23 \times 10^2$ Cfu/g, with a relative increase of. 33.02% above the packaged flour.

Table 6: Descriptive Statistics on Proximate Analysis of Packaged Flour Samples

Flour Samples		Packaged	Unpackaged
Moisture (%)	Plantain Flour	12.0 ± 0.02	17.2 ± 0.02
Ash (%)	Plantain Flour	2.00 ± 0.02	2.22 ± 0.02
Protein (%)	Plantain Flour	7.42 ± 0.02	6.24 ± 0.02
Lipid (%)	Plantain Flour	1.58 ± 0.02	1.54 ± 0.01
Fibre (%)	Plantain Flour	0.78 ± 0.02	0.65 ± 0.02
DM (%)	Plantain Flour	87.2 ± 0.02	82.7 ± 0.02
NFF (%)	Plantain Flour	88.2 ± 0.03	89.3 ± 0.04

VI. DISCUSSION

Flour may be used in a wide variety of dishes, both at home and abroad. In Nigeria, it's a popular option because of its abundance of key elements including vitamins, carotenoids, and low-fat level. Varieties, age, ripeness, and where plantain is cultivated, all affect the plantain's chemical content in a variety of ways: (soil type). Water content in the green plant ranges from 61% to 68% as it matures, and this number rises to roughly 68% when it is fully matured. Flour is a staple diet in Nigeria, and it's more than just a cultural tradition. Most companies in the bakery and fast-food industries employ it. The risk of contamination with microorganisms, particularly pathogenic ones, in flour is the same as it is with any other raw food ingredient. Moreover, there is a lack of information and study on flour's microbiological and nutritional characteristics. As a result, flour consumption must be evaluated for its safety and nutritional value. Flour samples were tested to determine the total heterotrophic bacteria count, as well as to evaluate the nutritional characteristics and provide strong recommendations for consumption and storage to the general public as a result of this investigation. Conventional microbiological methods were used in this investigation to assess the flour's microbial quality. As shown in table 1, the number of heterotrophic bacteria (THB) found in the packed samples.

Plantain flour was analysed in triplicate in this study. Plantain flour C had the greatest THB, averaging 184, when compared to plantain flours A, B, and C. More than 160 colonies were found in plantain flour A and less than 100 in flour B. This suggests that plantain flour C had greater levels of bacterial contamination than the rest of the samples.

Several variables may be responsible for the high levels of bacterial contamination in flour. The storage conditions, storage length, handling, and packing of flour samples may have contributed to the elevated THB levels found in some of them. The bacteria in flour, although it is a low-moisture food, can nevertheless be abundant, including some that may be dangerous.

This study's findings are consistent with those of prior investigations that have found THB in various types of flour. Furthermore, this study's stance on the identification of pathogenic microorganisms in flour.

Also shown in table 1 are the findings of the coliform bacterial enumeration in the tested flour samples. On MacConkey agar, the coliform bacteria were counted. A mean of 168 was reported by Plantain flour B, recording the highest mean amongst the plantain flour samples. Corrosion from human and animal sources can be detected if coliform bacteria are found. The presence or absence of indicator organisms determines the microbiological quality of food and water. The total coliforms and thermotolerant coliforms, as well as *E. coli*, are well-known indicators. Results from this study are consistent with findings from earlier research. Table 1. shows that the population of Pseudomonads has a wide range of characteristics. Plantain flour A had the greatest Pseudomonads contamination when compared to Plantain flour B and C. Depending on harvesting circumstances, storage and transit, bacterial populations might vary widely

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across the samples. Other research has indicated that these variables affect the number of bacteria in flour.

The microbiological quality of packaged and unpackaged food was also compared in this study. Samples of packaged and unpackaged flour were analysed for total heterotrophic bacteria, and the results are summarized in Table 3. The table demonstrates that the microbiological quality of the packaged flour samples was higher. Unpackaged plantain flour, for example, had a mean count of 600, whereas the THB of the packaged kind was 451.

Additionally, comparing the coliform bacterial populations of the various flour samples revealed that the packaged flour samples were of higher microbiological quality than the unpackaged samples. The unpackaged plantain flour samples had a mean of 345, whereas the packaged samples had a mean of 227.

There was a similar trend in the quality and quantity of pseudomonads in the samples. Plantain flour samples that were packaged and unpackaged exhibited different mean values. Unpackaged plantain flour samples had a mean of 436, whereas packaged plantain flour samples had a mean of 486, according to the research.

The microbiological quality of packed flour is clearly superior to that of unpackaged flour, as demonstrated by the results of this study. Using packaging to protect food from bacterial contamination and growth is an effective way to keep it safe for consumption.

Fig. 3., shows the proportion of each of the six bacterium isolates found in the packaged flour. *Lactobacillus sp.*, (29 percent), *Micrococcus sp.*, 4%, *Streptococcus sp.*, 9%, *Citrobacter, sp.*, 15%, and *Escherichia sp.* (26 percent) are some of the bacteria that have been isolated (17 percent). Packaging reduced the number of bacterial isolates, compared to the number of isolates from the unpackaged samples (8). In the unpackaged samples, certain bacterial species, such as *Pseudomonads sp., Yersinia sp., Erwinia sp.,* and *Staphylococcus sp.,* were detected.

Table 6, displays the nutritional qualities of the plantain flour samples, which reveal that they are of high quality. Analysis was performed to determine the moisture, ash, protein, fat, fiber, and free nitrogen content. Flour moisture content, which typically ranges between 11 and 14 percent, is a critical consideration. Flour's shelf life reduces and its taste, enzyme activity, and insect infestation increase when the moisture level climbs beyond 14 percent. Moisture impacts the shelf life of flour and aids the growth of microorganisms, making it an essential factor in determining flour quality (Syeda et al., 2012).

It is mostly the amount and quality of flour proteins that determine the flour's ability to bake well (Wujun et al., 2007). Humans and animals alike depend on protein as their primary source of nutrition. Flour's protein concentration can range from 10% to 18% of the total dry matter (Sramkova et al., 2009). In addition to its direct nutritional benefit, flour protein concentration has a significant impact on dough rheological qualities. Bread-making quality is frequently cited as a factor (Wujun et al., 2007).

Lipids are scarce in flour, but the inclusion complexes they form with proteins and starch, due to their amphipathic nature, have a substantial impact on food quality and texture. Wheat flour has 2.0 percent fat, while wheat germ contains 9.2 percent fat, and wheat bran contains 5.5 percent fat, according to Kumar et al. (2011). Shahedur and Abdul (2011) compared the nutritional and physicochemical features of Bangladeshi wheat varieties and found that the fat content of wheat flour was on average 1.4 per cent.

Flour contains a substantial amount of fiber as well. Many studies have shown the health benefits of fiber, such as lowering cholesterol, lowering blood lipids, regulating glucose absorption and insulin secretion, and preventing constipation and diverticular disease According to Rave et al 2007.

VII. CONCLUSION

The nutritional value of flour has been demonstrated. Protein, carbs, vitamins, and fats are all nutrients that contribute to flour's worth. Flour's nutritional value is dependent on its origin, according to this investigation. Nutrient levels in flours made from yam, plantain, and cassava would vary. Moisture and protein in flour encourage the growth of microbes. Microorganisms like fungi have been seen growing on flour, despite the fact that it is a rather dry food. Flour's shelf life is also affected by the amount of moisture it contains. Flour manufacturing has been shown to be contaminated by several sources, including harvesting, processing, storage, and transportation. Potential pathogens may be present as a result of this. The coliform bacteria group can be used as an indicator of flour's safety. Some of the coliform bacteria detected in wheat include Escherichia coli, Citrobacter, Salmonella, and others. These bacteria suggest that the flour samples had been contaminated by humans or animals. Total heterotrophic bacterial and fungus populations have been demonstrated to alter depending on flour storage. According to this research, packed flour is always of higher microbiological purity than samples of exposed flour. To explain the high number of bacteria found in the unpackaged samples, poor storage and exposure to the environment may have contributed to their low microbiological quality. Contaminated flour has the potential to create serious health problems due of the existence of harmful microorganisms that might be present.

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