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NUTRITIONAL AND BACTERIAL QUALITY OF PACKAGED AND UNPACKAGED PROCESSED CASSAVA FLOUR

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ABSTRACT
Public health is at risk when bacteria are found in edible flours that are typically regarded as microbiologically safe. This study was therefore undertaken to evaluate the bacterial and nutritional quality of packaged and unpackaged cassava flour. Cultural, microscopic, biochemical test and most probable number (MPN) methods were employed to determine the various microorganisms; while proximate analysis was done to estimate inherent nutrients in the flour. ANOVA or the T-test were used to identify significant differences in unpackaged, nutritional, and microbiological quality at P<0.05. According to the results, the packaged cassava flour had 5.25±0.56 x 10^2 CFU/g of heterotrophic bacteria, while the unpackaged cassava flour had 2.21±0.47 x 102 CFU/g. The packaged cassava flour had a coliform bacterial count of 2.60±0.28x 10^2 CFU/g, while the unpackaged cassava flour had a count of 1.44±0.47 x 10^2 CFU/g. when compared it was observed that the unpackaged cassava flour has a higher nutritional and bacterial quality than the packaged cassava flour. Bacterial isolated from the flour samples include *Bacillus* sp., *Escherichia coli*, *Staphylococcus* sp., *Micrococcus* sp., *Pseudomonas*, *Lactobacillus* sp. *Streptococcus* sp. and *Citrobacter* sp. respectively. The cassava flour sample's nutritional contents increased, according to the proximate analysis. According to the study's findings, flour packaged to the environment raises its microbiological concentration, raising issues with cleanliness and health.

KEYWORDS: Cassava flour; Packaged; Unpackaged; Heterotrophic bacterial; Ccoliform bacterial.

INTRODUCTION
Cassava (*Manihot esculenta*), a staple root vegetable in many tropical regions, is processed into various flour products for human consumption. The nutritional quality and safety of cassava flour can be significantly influenced by processing methods, including exposure to environmental conditions during drying and storage. Understanding the differences in bacteriological quality and nutritional profiles between packaged and unpackaged processed cassava flour is crucial for ensuring food safety and nutritional adequacy. Cassava (Manihot esculenta) is also a vital staple food in many tropical and subtropical regions due to its high starch content and resilience in various agro-ecological conditions. The production of cassava flour, a significant processing method, allows for extended shelf life and diversification of products. However, the processing methods, including exposure to air and different drying techniques, can greatly influence the nutritional and bacterial quality of the final product (Sanchez et al., 2022)

Cassava flour is primarily composed of carbohydrates, specifically resistant starch, which is beneficial for digestive health (Sanchez et al., 2022). It also contains essential nutrients, including vitamins, minerals, and dietary fiber. However, the nutritional value can be affected by the processing methods employed. For instance, exposing cassava to sunlight or ambient air during drying can lead to nutrient degradation, particularly of heat-sensitive vitamins like vitamin C and the B-group vitamins (Otoo et al., 2023). Additionally, improper processing can reduce the levels of cyanogenic glycosides, which are potentially toxic compounds present in cassava that can lead to adverse health effects if not adequately removed (Davies et al., 2021).

The bacterial quality of cassava flour is crucial for food safety. Contamination can arise from various sources, including raw cassava, handling during processing, and exposure to environmental factors. Bacterial pathogens such as Salmonella, E. coli, and Staphylococcus aureus can pose significant health risks if present (Adebayo-Tayo et al., 2020). Exposure during drying processes often allows for microbial proliferation, especially in humid environments, which raises concerns about the shelf-life and safety of the product. Conversely, controlled drying methods and proper storage conditions may reduce microbial load, enhancing the safety and quality of the flour (Ajayi et al., 2022).

According to a study by Odu et al. (2019), samples of cassava flour revealed high total bacterial counts that were higher than advised. In several samples, harmful bacteria like Salmonella and Escherichia coli were also found. According to another study by Oyeyiola et al. (2018), the elevated microbial load in cassava flour was caused by the high moisture content and inadequate sanitary procedures during processing and storage.

The use of flour as food is more than just a traditional practice in Nigeria. The majority of companies in the industry that deal with baking and fast food use it. The majority of cereals can be used to make all types of flour. The main sources of dough in Nigeria include millet, yam and cassava.

To sum up, locally produced cassava flour is a wholesome staple food that is abundant in fibre, starch, and energy. However, its low fat and protein content, as well as insufficient amounts of several vital elements, may restrict its nutritional value. Poor sanitary measures during processing and storage might potentially affect the microbiological quality of cassava flour. To guarantee the safety and quality of locally processed cassava flour, it is crucial to use appropriate processing methods and adequate hygiene standards.

The aim of the study is to examine the nutritional and bacterial quality of packaged and unpackaged cassava flour acquired from the market.

MATERIALS AND METHODS

Sample Area

This study was based on cassava flour samples collected from Swali Market Yenagoa, Bayelsa State. The flour samples was analysed and processed at the microbiology laboratory in Niger Delta University 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^o 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^{0}C 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^{o}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^{0}C 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 total and faecal coliform

Following a modified Ginigaddarage *et al*., (2018) technique, the third (3rd) dilution was utilized to count faecal and total coliforms. 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 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.

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.

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.

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

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.

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 colour 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 × 6.25

Where M = Molarity of the H_2SO_4
14= Atomic number of Nitrogen
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.

RESULTS

Assessment of the Bacteriological Quality of Flour Samples

The results for the total heterotrophic bacteria (THB) count on nutrient agar and coliform counts on MacConkey agar associated with packaged cassava flour samples as presented in table 1. below were expressed as mean x 10^2 CFU/g. The bacteriological analysis of the Cassava flour samples presented on the table shows the THB count range from 0.92 ± 0.04 x 10^2 CFU/g in Cassava flour A to 0.68 ± 0.18 x 10^2 CFU/g in Cassava flour C. The coliform bacteria count ranged from 0.35 ± 0.05 x 10^2 CFU/g in Cassava flour A to 0.66 ± 0.07 x 102 CFU/g in Cassava flour C.

The results suggest the flour have different degree of bacterial contamination. For each of the samples (cassava A, cassava B and cassava C), 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 Cassava flour samples.

Samples	Total heterotrophic bacteria (10^2 CFU/g)	Coliforma bacteria (10^2 CFU/g)
Cassava flour A	0.92 ± 0.04^{ac}	0.35 ± 0.05^{ac}
Cassava flour B	0.62 ± 0.10^{bc}	0.43 ± 09^{bc}
Cassava flour C	0.68 ± 0.18^{bd}	0.66 ± 0.07^{bd}

Table 2: Enumeration of bacterial population in Unpackaged Cassava flour samples.

Samples	Total Heterotrophic Bacteria (10^2 CFU/g)	Coliform Bacteria (10^2 CFU/g)
Cassava flour A	1.87 ± 0.34^{ac}	0.83 ± 0.10^{ac}
Cassava flour B	1.57 ± 0.30^{bc}	0.97 ± 0.13^{bc}
Cassava flour C	1.81 ± 0.18^{bd}	0.79 ± 0.16^{bd}

Table 2, Presents the results for the bacteriological assessment of the unpackaged cassava flour samples. The bacteriological analysis of the Cassava flour samples presented on the table 4.2 shows the THB count to range from 1.87 ± 0.34 in Cassava flour A to 1.81 ± 0.18 in Cassava flour C. The coliform bacteria count ranged from 0.83 ± 0.10 in Cassava flour A to 0.79 ± 0.16 in Cassava flour C.

Table 3: Bacteria isolated from Packaged Cassava flour sample and their percentage of occurrence.

S/n	Packaged Cassava Flour	Percentage of occurrence (%)
1	*Lactobacillus* sp.	25
2	*Bacillus* sp.	24
3	*Escherichia coli*	19
4	*Citrobacter* sp.	14
5	*Streptococcus* sp.	9
6	*Micrococcus* sp.	9

Table 3. above shows *Lactobacillus* sp. occurred with 25%. *Bacillus* species recorded 24%, *Escherichia coli* 19%, *Citrobacter* sp. 14%, *Streptococcus* sp. 9%, and *Micrococcus* sp. 9%.

Table 4: Bacteria isolated from Unpackage Cassava flour sample and their percentage of occurrence.

S/n	Unpackaged Cassava Flour	Percentage of occurrence (%)
1	*Staphylococcus* sp.	15
2	*Bacillus* sp.	20
3	*Escherichia coli*	21
4	*Lactobacillus* sp.	10
5	*Pseudomonas* sp.	18
6	*Micrococcus* sp.	16

Table 4., above presents the result for the percentage of occurrence of bacterial species associated with the unpackaged cassava flour samples. *Bacillus* sp. recorded a percentage of 20, *Escherichia coli* 21%, *Staphylococcus* sp. 15%, *Micrococcus* sp. 16%, *Pseudomonas* sp. 18%, *Lactobacillus* sp. 10%.

4.2 Occurrence of bacterial isolates in Packaged and Unpackaged Cassava flour samples

Figures 1 and 2 presents the results for the occurrence of bacterial species associated with the packaged and unpackaged cassava flour samples. Figure 1., shows *Lactobacillus* sp. occurred the most with 25%. *Bacillus* species recorded 24%, *Escherichia coli* 19%, *Citrobacter* sp. 14%, *Streptococcus* sp. 9%, and *Micrococcus* sp. 9%.

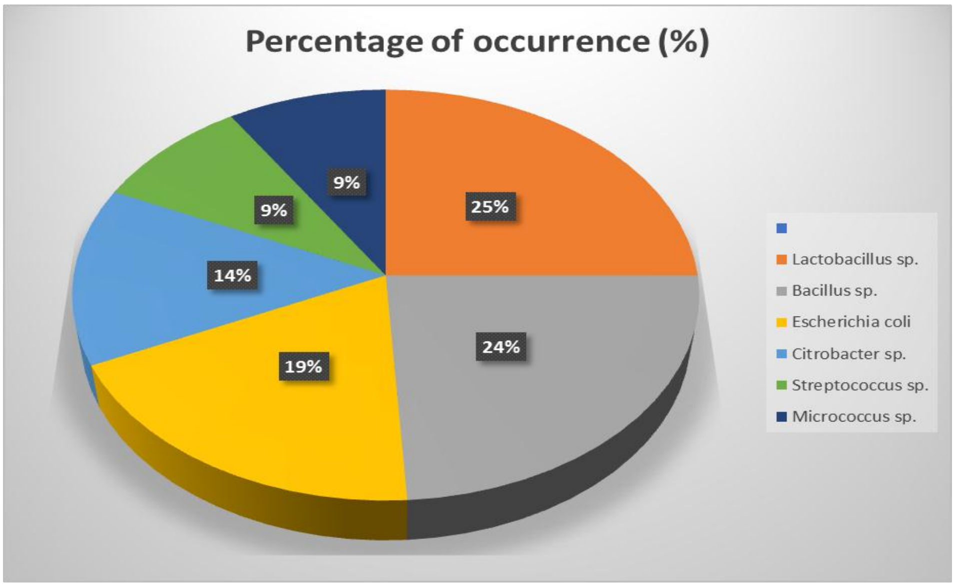

Figure 1: Percentage of occurrence of bacterial isolates in Packaged Cassava flour samples.

Figure 2., below presents the result for the percentage of occurrence of bacterial species associated with the unpackaged cassava flour samples. *Bacillus* sp. recorded a percentage of 20, *Escherichia coli* 21%, *Staphylococcus* sp. 15%, *Micrococcus* sp. 16%, *Pseudomonas* sp. 18%, *Lactobacillus* sp. 10%. *Escherichia coli* is observed as the most occurring microorganism.

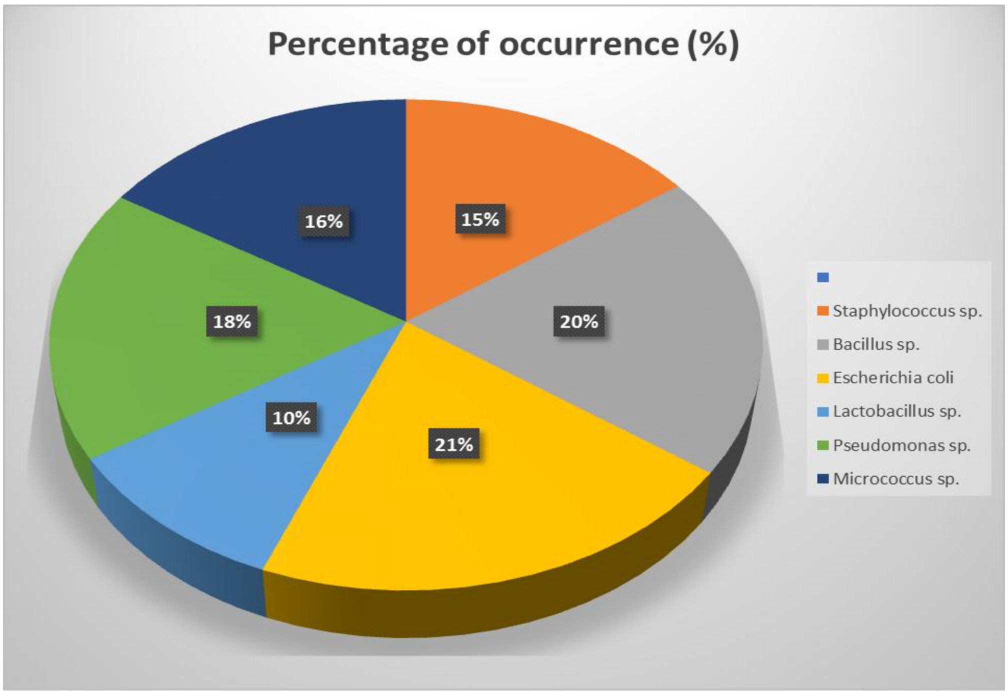

Figure 2: Percentage of occurrence of bacterial isolates in Unpackaged Cassava flour samples.

Comparison of the bacteriological quality between Packaged and Unpackaged Cassava flour samples

The comparison of the level of contamination between the packaged and unpackaged cassava flour samples is presented in tables 5 - 6. The level of contamination by the heterotrophic bacteria is presented in table 5.

Table 5: 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)
Cassava Flour	Packaged	2.21 ± 0.47^c
	Unpackaged	5.25 ± 0.46^c

The results obtained above showed that packaged cassava flour recorded less bacterial contamination with mean of 2.21 ± 0.47 x 10^2 CFU/g, while the unpackaged cassava flour recorded 57.90 % higher level of contamination, with a mean of 5.25 ± 0.46 x 10^2 CFU/g.

Table 6: Group Statistics on Coliform Bacteria in Packaged and Unpackaged Cassava flour samples on MacConkey Agar.

Flour Samples	Sample Class	Mean (10^2 CFU/g)
Cassava Flour	Packaged	1.44 ± 0.47c
	Unpackaged	2.60 ± 0.28c

The results in Table 6 above showed the Packaged Cassava flour recorded less coliform bacterial contamination with mean of 1.44 ± 0.47 x 10^2 CFU/g, while the unpackaged recorded a higher level of contamination with mean of 2.60 ± 0.28 x 10^2 CFU/g.

Table 7: Descriptive Statistics on Proximate analysis of Packaged and Unpackaged Cassava flour samples.

	Flour Samples	Packaged	Unpackaged
isture (%)	Cassava Flour	13.0 ± 0.01	14.3 ± 0.02
Ash (%)	Cassava Flour	1.50 ± 0.02	1.55 ± 0.01
Protein (%)	Cassava Flour	5.64 ± 0.02	4.56 ± 0.03
Lipid (%)	Cassava Flour	1.10 ± 0.02	1.02 ± 0.01
Fibre (%)	Cassava Flour	2.87 ± 0.01	3.76 ± 0.02
DM (%)	Cassava Flour	86.3 ± 0.01	85.6 ± 0.02
NFF (%)	Cassava Flour	88.8 ± 0.01	89.0 ± 0.04

DISCUSSION

There are numerous domestic and international recipes that call for flour. It is a well-liked choice in Nigeria due to its low-fat content, high vitamin content, and carotenoids. Cassava varieties, ripeness, age, and cultivation location all have an impact on the chemical composition of the cassava in different ways (soil type). As the green plant ages, its water content increases from 61% to 68%, reaching approximately 68% at full maturity. In Nigeria, flour is more than simply a traditional custom; it is an essential food. It is used by the majority of businesses in the fast-food and baking sectors.

As with any other raw food ingredient, flour has the same risk of contamination with microorganisms, especially pathogenic ones, and the microbiological and nutritional characteristics of flour are not well understood, so flour consumption needs to be assessed for its safety and nutritional value. The investigation used conventional microbiological methods to assess the microbial quality of the flour, and 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 shown in table 1., the total heterotrophic bacteria (THB) and coliform bacteria found in the Packaged cassava flour samples revealed that cassava flour sample was analysed in triplicate in this study. Cassava flour sample A had the greatest THB, averaging 92, when compared to cassava flours B 62, and C 68. This suggests that cassava flour A had greater levels of bacterial contamination than the rest of the samples. For coliform bacteria, cassava flour A had 35, flour B 43 and flour C 56. From this result it is observed that cassava flour C has the highest coliform contamination.

In table 2., the total heterotrophic bacteria (THB) and coliform bacteria found in the unpackaged cassava flour samples revealed that cassava flour sample was analysed in triplicate in this study. Cassava flour sample A had the greatest total heterotrophic bacteria (THB), averaging 187, when compared to cassava flours B 157, and C 181. This suggests that cassava flour A had greater levels of bacterial contamination than the rest of the samples. For coliform bacteria, cassava flour A had 83, flour B 97 and flour C 79. From this result it is observed that cassava flour B has the highest coliform contamination.

Several variables may be responsible for the high levels of bacterial contamination in cassava flour. The storage conditions, storage length, handling, and packing of flour samples may have contributed to the elevated total heterotrophic bacteria (THB) and coliform 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 findings are consistent with those of prior investigations (Okoronkwo *et al*., 2017), that have found total heterotrophic bacteria (THB) and coliform bacteria in various types of flour. Furthermore, this study's stance on the identification of pathogenic microorganisms in flour.

The microbiological quality of Packaged and unpackaged cassava flour samples was also compared in this study. Samples of Packaged and unpackaged cassava flour were analyzed for total heterotrophic bacteria, and the results are summarized in Table 5 and 6 respectively. The table demonstrates that the microbiological quality of the Packaged cassava flour samples was higher than unpackaged cassava flour. The Packaged cassava flour sample had a mean count of 221, whereas the THB of the unpackaged cassava flour sample was 525. Additionally, comparing the coliform bacterial populations of the various flour samples revealed that the Packaged cassava flour samples were of higher microbiological quality than the unpackaged cassava flour samples. The unpackaged cassava flour samples had a mean of 260, whereas the Packaged samples had a mean of 144.

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.

Table 3., shows the proportion of each of the six bacteria isolates found in the Packaged cassava flour. *Lactobacillus* sp. occurred the most with 25%. *Bacillus* sp. recorded 24%, *Escherichia coli* 19%, *Citrobacter* sp. 14%, *Streptococcus* sp. 9%, and *Micrococcus* sp. 9%. *Lactobacillus* sp. recorded the highest proportion amongst other bacteria isolates.

Table 4., shows the proportion of each of the nine bacteria isolates found in the unpackaged cassava flour. *Bacillus* species recorded a percentage of 20, *Escherichia coli* 21%, *Staphylococcus* species 15%, *Micrococcus* 16%, *Pseudomonas* sp. 18% and *Lactobacillus* 10%. *Escherichia coli* was observed to have the highest proportion of bacteria isolates.

Table 7, displays the nutritional qualities of the cassava flour samples, which reveal that they are of high quality. Analysis was performed to determine the moisture, ash, protein, fat, fibre, and free nitrogen content. Cassava flour moisture content, recorded 13% for Packaged flour sample and 14.3% for unpackaged flour sample. Flour's shelf life reduces 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).

Cassava flour proteins recorded 5.64% for Packaged flour sample and 4.56% for unpackaged flour sample. 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).

Cassava flour lipids recorded 1.10% for Packaged flour sample and 1.02% for unpackaged flour sample. 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.

Casava flour contains a substantial amount of fiber as well. Packaged cassava flour contains 2.87% fiber and unpackaged 3.76% fiber. 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.

CONCLUSION

The microbial quality of locally processed cassava flour is a significant concern that directly impacts food safety, public health, and the economic potential of cassava-based products. Cassava flour, widely consumed in many regions, particularly in developing countries, is often processed using traditional methods. While these methods are integral to local livelihoods, they frequently fail to meet hygiene and quality standards, leading to microbial contamination. Research indicates that the microbial contaminants found in cassava flour include pathogenic bacteria such as *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus*, as well as Molds like *Aspergillus* spp. and *Penicillium* spp. These microorganisms pose serious health risks, including foodborne illnesses, gastrointestinal infections, and exposure to mycotoxins such as aflatoxins, which are associated with chronic diseases like liver cancer. The root causes of contamination include the use of untreated water, poor personal and environmental hygiene, inadequate fermentation, insufficient drying, and improper storage in humid conditions.

The proliferation of these microorganisms is exacerbated by traditional processing techniques that lack proper sanitation and quality control. High moisture content in cassava flour during storage has been identified as a critical factor promoting the growth of fungi and the production of harmful toxins. These challenges not only compromise the safety of cassava flour but also affect its shelf life, nutritional quality, and marketability.

Addressing the microbial quality of cassava flour requires a multifaceted approach. Improved processing practices, such as the use of clean water, hygienic handling, and solar drying, can significantly reduce microbial loads. Proper storage methods, including the use of airtight containers and environments with low humidity, are essential to prevent fungal growth. Additionally, education and training for local processors on good manufacturing practices (GMPs) and hazard analysis and critical control points (HACCP) can promote adherence to hygiene standards. Policy interventions are equally important. Regulatory agencies must establish and enforce microbiological quality standards for cassava flour to ensure its safety for consumers. Investment in modern processing technologies and infrastructure, particularly for small-scale processors, can enhance the quality and safety of cassava flour. Furthermore, ongoing research and monitoring are needed to identify emerging microbial threats and develop innovative solutions for their control.

Lastly, the microbial quality of locally processed cassava flour remains a pressing issue that requires urgent attention. By implementing improved processing techniques, enhancing storage practices, educating local producers, and enforcing regulatory standards, the risks associated with microbial contamination can be significantly mitigated. These efforts will not only protect consumer health but also unlock the full potential of cassava as a sustainable and economically viable food source.

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