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Physiochemical and Microbial Quality of Melon and Bush Mango Seeds and Milled Products in Local Markets In Rivers State,Nigeria.

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Risk of food borne infection contamination of food, in Africa is increased due to environmental, agronomic and socio-economic factors. This study assesses the microbial quality of melon and bush mango displayed in the local markets, aiming to provide valuable insights into the safety and quality of these widely consumed food products. Standard procedure for microbiological and proximate analysis were employed. The heterotrophic bacteria count ranged from 8.5 x 10^5 cfu/g to 1.35 x10^6 cfu/g. The total staphylococcus count ranged from 1.2 x 10^3 cfu/g to 4.35 x 10^3 cfu/g. The coliform count ranged from 2.8 x 10^4 to 7 x 10^5, Total Samonella count ranged from 4 x 10^2 cfu/g to 1.5 x 10^3 cfu/g and Fungi count 6.5 x 10^2 cfu/g to 2.5 x 10^3 cfu/g. Morphological and Biochemical characterization of heterotrophic bacteria isolated from both melon and bush mango identified nine genera, including *Staphylococcus* (14.6%) *Bacillus* (20%), *Corynebacterium* (5.6%) *Enterobacter* (4.4%), *Micrococcus* (3.3%) *Pseudomonas* (12.2%), *Escherichia coli* (13.3%), *Salmonella* (11.1%)

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and *Proteus* (11.1%). Fungal species like *Penicillium spp., Fusarium spp., Aspergillus flavus, Candida spp., Mucor spp., Saccharomyces sp.,* and *Aspergillus niger* were isolated from both seed and milled seeds samples of melon and bush mango. The frequency of occurrence revealed variations among bacterial isolates in melon and bush mango seeds. The most frequent fungal species included *Candida* spp. (9.4%) *Aspergillus niger* (20%) *Mucor* (9.4%), *Fusarium* (11.4%), *Aspergillus flavus* (9.4%)*, Penicillium* (13.2%), *Rhizopus* spp (3.7%) and *Saccharomyces* (15%). Proximate and heavy metal analysis indicated variations in the composition of Carbohydrate (7.11%), Lipid (15.03%), Ash (1.89%), Moisture (7.31%), Protein (23.86%), Crude Fiber (12.66%), Lead (0.213 mg/kg), Copper (2.11mg/kg), calcium (0.49mg/kg) and Cadmium (0.0169mg/kg) in melon and bush mango, Carbohydrate (15.03%), Lipid (58.24%), Ash (1.74%), Moisture (10.48%), Protein (11.95%), Crude Fiber (2.64%), Lead (1.7903mg/kg), Copper (2.11mg/kg), calcium (0.148mg/kg) and Cadmium (0.000385mg/kg). The presence of heterotrophic bacteria in such ranges suggests potential differences in hygiene practices during cultivation, processing, and storage. Therefore; Implement stringent quality control measures during the production, processing, and storage of both melon and bush mango seed.

Keywords: Physiochemical; microbial quality; melon seeds; Bush mango seed; milled seed products; food borne contamination.

1. INTRODUCTION

"World Health Organization estimates that about a quarter of the diseases facing human being today occur due to bio-accumulation of toxins in human system as a result of consumption of food materials that are improperly handled and processed" [1]. "The notion that consumption of foods that are improperly handled is sometimes hazardous to human health cannot be overemphasized. Improper handling of food materials from the field, store to the market place is a common phenomenon in Nigeria" [2,3]. "These food materials sold in the open market are often contaminated with fungi which produce mycotoxins, when these foods are consumed by human beings and animals, the toxins accumulate in the body with serious health effects" [4,5].

"Risk of food borne infection contamination of food and raw material in Africa is increased due to environmental, agronomic and socio-economic factors" [6]. "The socio-economic and food security status of the majority of inhabitants of sub-Saharan Africa leaves them with little option in choosing good quality products" [7]. "Many individuals in developing countries are not only food insecure but chronically exposed to high levels of mycotoxins through their diets. In many developing countries such as Nigeria, mycotoxins affect staple foods such as maize, groundnut, rice etc. such that exposure is continuous and often at high levels. The exposures occur in towns, villages and communities that produce and consume their own food; hence regulatory measures to control exposure are largely ineffective" [8].

"Biochemical changes in food when perceived undesirable are called spoilage. Microorganisms can contribute to the degrading of the food quality that leads to spoilage" [9,10]. "Because, foods are excellent sources of nutrient, microorganism grow rapidly and make what once was an attractive and appealing into a sour, foul smelling mass suitable only for the garbage can. In other words, food can also serve as vehicles for disease transmission. The detection and control of pathogens in food spoilage micro-organisms are important parts of food microbiology" [11,12].

"During the entire sequence of food handling from the producer to the final consumer, microorganisms can affect food quality and human health" [13]. "The number and types of micro-organism present in food are influenced by the general environment from which the food items were originally obtained. The microbiological quality of the food in its raw state, sanitary condition under which the food is handled and processed as well as the adequacy of subsequent packaging, handling and storage are conditions in maintaining the flora at a low level" [14]. Melon seed (egusi) belongs to the family cucurbitaceous and grows in pods with seeds that are covered with a mucilaginous coating. They are used as the major ingredients in preparation of a traditional soup called "Egusi" soup, which is popularly consumed in West Africa, particularly in Igbo tribe of Nigeria. The seeds can be roasted and eaten or ground as flour and used as a soup thickner. Various "Egusi" soups are favourites in Nigeria. In West Africa, plants and seeds of cucurbitaceous as well as soup, cakes and stews made with them are all called "Egusi" [15,16].

"Melon, *Citrullus vulgaris* belongs to the family Curcubitaceae. They are widely cultivated in Nigeria especially in the southern part and usually inter-planted with yam and cassava where melon serves as a cover crop" [17]. "It is one of the most important vegetable crops in the tropical, subtropical, and Mediterranean zones of the world. A native of Africa, and has been introduced to Asia, Iran and Ukraine. Its common names include egusi in Yoruba, agushi in Hausa, epingi or paragi in Nupe and eashi in Gwari. Melon seeds have been classified into various varieties according to the thickness of the seed coat and the flatness of the edges" [18]. "They are classified into three groups based on oil extraction characteristics. The seeds usually are white or cream color and can be of different sizes. In Nigeria, the seeds are boiled in salted water, roasted or the roasted seeds ground and added to meals. It is a major soup ingredient and a common component of daily meals in West Africa. The vegetable oil extracted from the seeds is expensive and nutritious; this oil is used for cooking and cosmetics purposes and of interest to pharmaceutical industries" [19]. The residue from the oil extraction is made into balls that are fried to produce local snack in Nigeria, or is used as cattle feed. In many parts of Africa, where farmers lack access to meat or dairy, the high oil and protein content can make an excellent dietary supplement. Studies conducted showed melon seed contain about 50% oil (Karaaslan, A. (2023), 42-57% oil [18], 44-53% oil for seeds cultivated in different bioclimatic regions of Cameroon. These studies showed that melon seeds contain good amounts of oil that can be used as edible oil and for industrial productions.

"Irvinga gabonensis (Bush mango*)* has a variety of important uses; both the fruit and kernel of the seed are edible and thus play important roles in nutritional supplements and food security in West and Central Africa, especially among rural dwellers and its fruits constitute a very important soup condiment in Nigeria" [20]. "It is rich in vitamin C and is widely consumed as a dessert fruit or snack throughout Western and Central Africa. *I. gabonensis* is in high demand due to its nutritional, medicinal, economical worth and agricultural potentials. *I. gabonensis* is especially valued for their fat and protein rich seed a kernel which serves as a sauce thickening agent and oil. A major setback in the sales and consumption of *Irvingia* seed kernels is their susceptibility to postharvest spoilage fungi and its intended health risks. Several studies have shown that *Irvingia* seed kernels displayed on shelves for sales in Nigerian markets are often contaminated with spoilage fungi like *Aspergillus flavus and A. parasiticus* and in turn the contaminated seed kernels possess aflatoxin, which are harmful to the consumers. Consumption of high levels of aflatoxin in food has been reported to have caused illness among several hundreds of Kenyans in 2004, and leaving 125 people dead and it is estimated that more than 5 billion people in developing countries worldwide are at risk of chronic exposure to aflatoxins through contaminated foods" [21,22]. The study was aimed at determining the microorganisms associated with bush mango (*Irvinga gabonensis*) and melon (*Citrullus vulgaris)* displayed in local market for sale.

2. MATERIALS AND METHODS

Sample collection and procedure: 20 melon and bush mango seeds samples and 20 milled melon and bush mango seed samples were randomly procured locally using simple random sampling technique were bought from vendors at Choba Port Harcourt Rivers State.

Samples preparation: 25g of samples into 225ml of diluent/peptone water then homogenized in a stomacher to get the stock solution. The respective samples were serially diluted and 0.1 ml each of the dilutions of the different samples were plated using pour-plate method on MacConkey agar, Mannitol Salt agar (MSA) Nutrient agar (NA), Potato dextrose agar (PDA), Plate count agar (PCA), and Salmonella Shigella agar (SSA). The plates were incubated at 37^0C for 24 hours for bacteria isolates and 25^0C at 72hours for fungi isolates. The distinct colonies were carefully sub-cultured on separate petri dishes using the streak plate method on Nutrient agar. Pure cultures were characterized using Gram reaction and biochemical tests following the standard protocols and identified using the Bergey's manual of determinative bacteriology.

Enumeration of total bacterial count, total staphylococcus count, and total coliform count.

Counts from the incubated agar plates were enumerated after 24hours for bacteria and 72 hours for fungal count.

Determination of Colony Forming Unit per meter cube (CFU/g)

The cfu/g was determined using
Cfu/ml = Number of colonies x dilution factor / Volume of culture plate

2.1 Identification of Isolates

Morphological identification of bacteria: Bacterial isolates were characterized and identified using cultural, morphological and microscopic examinations. The macroscopic examination of the colonies was differentiated based on size, color, pigmentation, elevation surface texture and margin. Different biochemical tests such as Gram staining, Catalase, Coagulase, Methyl-red, Oxidase, Voges-proskauer and sugar fermentation test were employed to differentiate the bacterial isolates according to the standard microbiological methods as described Chesbrough (2006).

Fungal identification: Identification of all fungal isolates was also carried out using standard methods based on macroscopic and microscopic features as described by Lacto-phenol (Cotton blue test). On a clean slide, a drop of methanol was placed and a portion of fungi growth was cut with the aid of surgical blade and tested in the methanol. A drop of lacto-phenol cotton blue was added. A cover slip was placed on it gently and observed under the microscope with X40 objectives.

2.2 Physicochemical Analysis

Proximate Composition Analysis: The proximate analysis of the samples for Carbohydrate, lipids moisture, total ash and crude fibre were carried out in triplicate using methods described [23]. Determination of Trace Metal Contaminants was done using The Dry Ashing Method (AOAC 2005) which was used for the Atomic Absorption Spectrometry (AAS) analysis. Flame Atomic Absorption Spectrophotometer (Buck Scientific, Inc. East Norwalk, USA) as described by Winifred et al*.* [24].

3. RESULTS AND DISCUSSION

The Total heterotrophic bacteria count (THBC) of Milled melon seed ranged from $3.8x10^5$ to $5.25x10^6$ cfu/g. The Staphylococcus counts of milled melon seed ranged from $1.65x10^3$ to $4.35x10^3$ cfu/g. The total coliform counts of milled melon seed ranged from $2.85x10^4$ to $7.0x10^4$ cfu/g. Salmonella count of milled melon seed ranged from, $1.5x10^2$ to$1.5x10^3$ cfu/g. The Total fungi count (TFC) of milled melon seed ranged from $6.5x10^2$ to $1.8x10^3$ cfu/g.

The Total heterotrophic bacteria count (THBC) of melon seed ranged from $4.25x10^5$ cfu/g to $1.04x10^6$ cfu/g. The Staphylococcus counts of melon seed ranged from $1.2x10^3$ cfu/g to $3.95x10^3$cfu/g. The total coliform counts of melon seed ranged from $2.45x10^4$ to $6.6x10^4$ cfu/g. The salmonella count ranged from $1.0x10^3$ to $4.0x10^2$ cfu/g. The Total fungi count (TFC) of melon ranged from $2.5x10^2$ to $2.7x10^3$ cfu/g.

The Total heterotrophic bacteria count (THBC) of milled bush mango seed ranged from $3.4x10^5$ to $1.35x10^6$ cfu/g. The Staphylococcus counts of milled bush mango seed ranged from $1.05x10^3$ to $3.0x10^3$ cfu/g. The total coliform counts of milled bush mango seed ranged from $1.75x10^4$ to $9.75x10^4$ cfu/g. The salmonella count ranged from $1.4x10^2$ to $7.5x10^2$ cfu/g .The Total fungi count (TFC) of milled bush mango seed ranged from $1.45x10^3$ to $2.9x10^3$ cfu/g.

The Total heterotrophic bacteria count (THBC) of bush mango seed ranged from $3.75x10^5$ to $8.85x10^5$ cfu/g.The Staphylococcus counts of bush mango seed ranged from $1.5x10^3$ to $3.65x10^3$ cfu/g .The total coliform counts of bush mango seed ranged from $2.1x10^4$ to $3.95x10^4$ cfu/g .The salmonella count was 1.2x 10^3 to $2.2x10^3$ cfu/g .The Total fungi count (TFC) of bush mango seed ranged from $1.25x10^2$ to $3.95x10^3$ cfu/g .

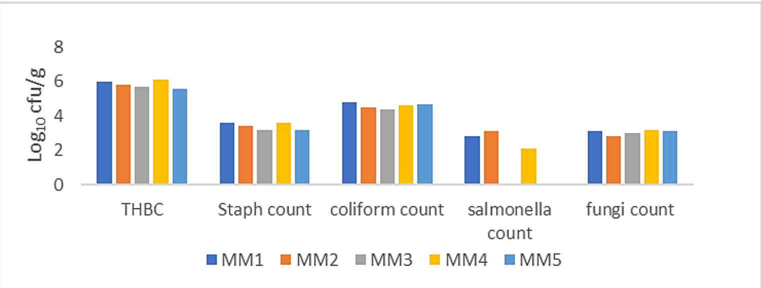

Fig. 1. Mean microbial counts of different milled melon seed studied
Legend: MM1 - MM5= Milled melon seed studied

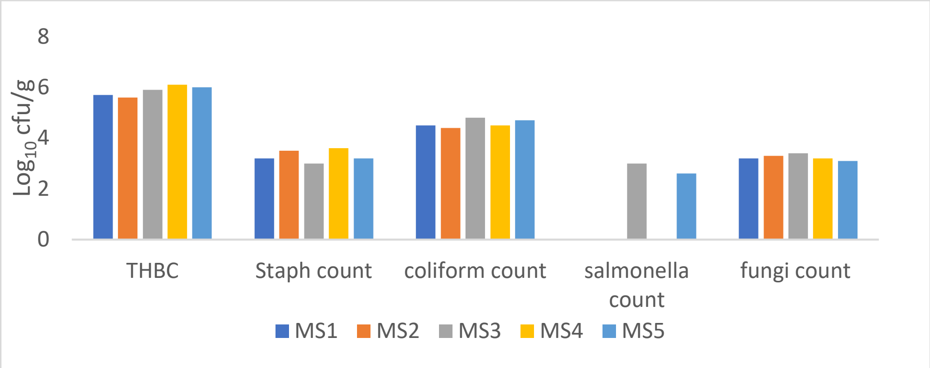

Fig. 2. Microbial counts of melon seed samples studied
Legend: MS1- MS5= Melon seed Samples Studied

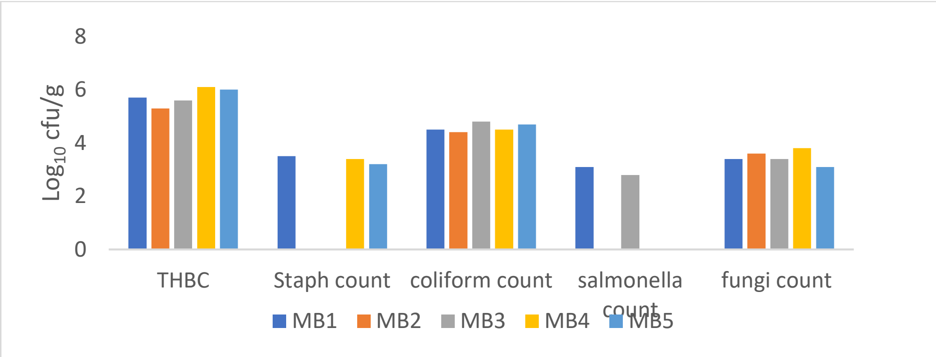

Fig. 3. Microbial counts of milled bush mango seed samples studied
Legend: MB1- MB5= Milled bush mango seed Samples Studied

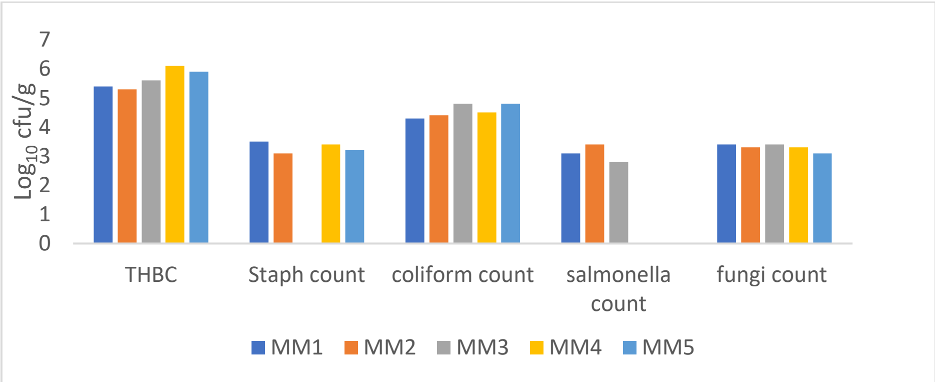

Fig. 4. Microbial counts of bush mango seed samples studied
Legend: BM1- BM5= Bush mangos seed Samples Studied

3.1 Microbial Quality of Melon and Bush Mango Seed

The microbial analysis of melon seeds and bush mango seeds from local markets revealed significant variations in total heterotrophic bacteria count (THBC). When comparing the THBC it is evident that milled melon samples exhibited a broader range, with counts ranging from 3.8×10^5 CFU/g to 5.25×10^6 CFU/g. In contrast, milled bush mango seed samples showed a slightly narrower range, spanning from 3.4×10^5 CFU/g to 1.35×10^6 CFU/g. This is in agreement with the finding of Azuonwon et al., [25] reported 1.67×10^6 CFU/g in bush mango seed and contrary to THBC of melon seed of 2.8×10^4 cfu/g. Overall, the higher average THBC in milled melon suggests a potentially higher risk of microbial contamination compared to milled bush mango seed Similarly, the THBC in melon seed and bush mango seed exhibited notable differences. Melon seed ranged from 4.25×10^5 CFU/g to 1.21×10^6 CFU/g, while bush mango seed varied from 3.75×10^6 CFU/g to 8.85×10^6 CFU/g. The range observed in our THBC is however lower than the 2.0×10^4 to 7.0×10^4 cfu/g reported by Tsado et al. [26] in Minna, Niger State for food ingredients Our study is also comparable with the range published by Salari et al*.,* [27] who reported THBC for food ingredients to be 1.0×10^2 to 4.0×10^6 cfu/g. The source of microbial contamination in these samples could be due to the environment in which the sample are displayed for sale, and it might be due to the fact that some of the melon and bush mango seeds could have been stored for a very long period before selling.

Table 1. Frequency of occurrence of bacteria melon and bush mango samples

Bacterial Isolates	Milled melon seed (%)	Melon seed (%)	Milled bush mango seed (%)	Bush mango seed (%)	Total N (%)
Staphylococcus spp.	5(19.2)	3(13.6)	3(14.3)	3(14.3)	14(15.6)
Bacillus spp.	5(19.2)	6(27.3)	4(19.1)	3(14.3)	18(20.0)
Corynebacterium spp.	2(7.7)	1(4.6)	1(4.8)	1(4.8)	5(5.6)
Escherichia coli	3(11.5)	2(9.0)	2(9.5)	5(23.8)	12(13.3)
Micrococcus spp.	0	0	2(9.5)	1(4.8)	3(3.3)
Pseudomonas spp.	3(11.5)	3(13.6)	2(9.5)	3(14.3)	11(12.2)
Yersinia spp.	1(3.9)	1(4.6)	0	0	2(2.22)
Salmonella spp.	3(11.5)	3(13.6)	2(9.5)	3(14.3)	11(12.2)
Proteus spp.	4(15.5)	2(9.0	3(14.3)	1(4.8)	10(11.1)
Enterobacter spp.	0	1(4.6)	2(9.5)	1(4.8)	4(4.4)
Total	26(100)	22(100)	21(100)	21(100)	90(100)

Table 2. Frequency of occurrence of fungi isolated from melon and bush mango samples

Fungi Identity	Milled melon seed%	Melon seed %	Milled bush mango seed%	Bush mango seed %	Total N (%)
Aspergillus niger	4(28)	3 (23.1)	1(7.6)	3(23.1)	11(20.8)
Aspergillus flavus	1(7)	1(7.6)	2(15.3)	11(7.6)	5(9.4)
Mucor spp.	3 (21)	1(7.6)	3(23.1)	2(15.3)	9(17.0)
Fusarium spp.	2(14)	1(7.6)	1(7.6)	2(15.3)	6(11.3)
Penicillium spp	2(14)	2(15.3)	1(7.6)	2(15.3)	7(13.2)
Rhizopus spp	0	1(7.6)	0	1(7.6)	2(3.7)
Saccharomyces spp	1(7.1)	3(23.1)	3(23.1)	1(7.6)	8(15.1)
Candida spp.	1(7.1)	1(7.6)	2(15.3)	1(7.6)	5(9.4)
Total	14(100)	13(100)	13(100)	13(100)	53(100)

Table 3. Proximate and heavy metal composition of melon and bush mango seed studied

	Melon seed	Bush mango seed
Carbohydrate (%)	7.11	15.03
Lipid (%)	58.34	28.24
Ash (%)	1.89	1.74
Moisture (%)	7.31	10.48
Protein (%)	23.86	11.95
Crude Fibre (%)	12.66	2.64
Lead (mg/Kg)	0.21646	1.17903
Copper (mg/Kg)	2.10947	0.49634
Cadmium (mg/Kg)	0.00164	0.00385
Chromium (Cr)	0.08461	0.02957
Calcium (Ca)	0.46172	0.14821

The Staphylococcus counts in milled melon samples displayed a range from 1.65x10^3 cfu/g to 4.35x10^3 cfu/g. In contrast, milled bush mango seed exhibited a lower range, from 1.05x10^3 CFU/g to 3.0x10^3 cfu/g. Comparatively, milled melon samples generally had higher Staphylococcus counts than milled bush mano seed, suggesting a potential variation in the microbial contamination between these two food ingredients. Melon seed samples had Staphylococcus counts ranging from 1.2x10^3 cfu/g to 3.95x10^3 cfu/g . On the other hand, bush mango seed samples exhibited a range from 1.5x10^3 cfu/g to 3.65x10^3 cfu/g. On average, milled melon samples appeared to have slightly higher Staphylococcus counts compared to bush mango seed, indicating that the initial state of the seeds might contribute to the variation in Staphylococcus contamination. When comparing Staphylococcus counts between melon and bush mango seed, melon consistently exhibited higher counts on average. This suggests that melon is more prone to Staphylococcus contamination than bush mango. This is comparable the report of Salari et al. [27] who reported higher range of staphylococcus counts 1.9x10^2 to 3.25x10^6 CFU/g in food ingredient. Factors such as harvesting, processing, and storage conditions may contribute to these observed differences. The presence of Staphylococcus in food products is a concern due to the potential production of enterotoxins that can cause foodborne illnesses. The higher Staphylococcus counts observed in melon samples, particularly in the milled form, emphasize the need for strict hygiene measures during processing and handling to minimize the risk of contamination. The presence of Staphylococcus aureus Indicate a potential risk and could be harmful to humans when ingested, due to their ability to produce toxins [28].

The total coliform counts in milled melon samples exhibited a range from 2.85x10^4 cfu/g to 7.0x10^4 cfu/g. Milled bush mango seed samples, on the other hand, showed a slightly wider range, varying from 1.75x10^4 cfu/g to 9.75x10^4 cfu/g. The variation in counts between milled melon and milled bush mango seed suggests a potential difference in microbial contamination, with milled bush mango seed showing higher counts on average. Melon seed samples had total coliform counts ranging from 2.45x10^4 CFU/g to 6.6x10^4 CFU/g. bush mango seed samples, on the other hand, had counts ranging from 2.1x10^4 CFU/g to 3.95x10^4 CFU/g. The average total coliform counts in melon seed appeared to be slightly higher than those in bush mango seed, indicating that the initial state of the seeds may influence the microbial load. When comparing the total coliform counts between melon and bush mango seed in both forms, Melon seed consistently exhibited higher counts on average. The differences observed could be attributed to variations in the agricultural and processing practices, as well as the inherent characteristics of the seeds. The presence of elevated total coliform counts in food items can be indicative of poor hygiene during cultivation, processing, or storage, and may pose a potential risk to consumer health. The results emphasize the importance of implementing and maintaining rigorous hygiene practices throughout the supply chain to minimize the risk of microbial contamination in these commonly consumed ingredients.

The Salmonella counts in milled melon seed revealed varying levels, showing counts ranging from 1.5x10^2 to 1.5x10^3 CFU/g. In contrast, milled bush mango seed samples displayed lower counts, ranging from 1.4x10^2 to 7.5x10^2 CFU/g. The results suggest that, on average, milled bush mango seed had a lower Salmonella count compared to milled melon seed. Melon seed samples showed Salmonella counts ranging from 4.0x10^2 CFU/g to 1.0x10^3 CFU/g. Bush mango seed exhibited Salmonella count ranging from 2.2x10^3 to 1.65x10^3 CFU/g. In this case, the average Salmonella counts in melon seed appeared to be lower compared to bush mango seed. When comparing Salmonella counts between melon and bush mango seed, there is a trend of slightly higher counts in melon seed. The factors contributing to these differences could include variations in agricultural practices, post-harvest handling, and processing conditions. The presence of Salmonella in food items is a significant concern, as it is a common cause of foodborne illnesses. The results highlight the importance of stringent hygiene measures, particularly during the processing and handling to minimize the risk of Salmonella contamination. The detection of Salmonella in some samples underscores the need for continuous monitoring and quality control in the production and distribution of these food products.

The Total Fungi Count in milled melon seed samples showed a range from 6.5x10^2 CFU/g to 1.8x10^3 CFU/g. While milled bush mango seed displayed a slightly wider range, varying from 1.45x10^3 CFU/g to 2.9x10^3 CFU/g. On average, milled bush mango seed appeared to have higher TFC compared to milled melon, suggesting a potential difference in the susceptibility of these seeds to fungal contamination. Melon seed samples exhibited TFC ranging from $8.5x10^2$ CFU/g to $2.7x10^3$ CFU/g. Bush mano seed, on the other hand, showed a wider range, from $1.25x10^2$ CFU/g to $3.95x10^3$ CFU/g. This is contrary to the findings of Iyayi et al., [29] whose findings had fungal count ranged between 2.7 x 10^5 and 4.5 x 10^5 with the same dilution factor. The TFC in bush mango seed, on average, was higher than melon seed, indicating that bush mango seed may be more susceptible to fungal contamination in its natural state. When the results suggest that bush mango seed generally exhibits higher fungal counts. This may be attributed to differences in the composition, storage conditions, or inherent characteristics of the seeds. The variation in susceptibility to fungal contamination between melon and bush mango seed highlights the importance of considering the specific risks associated with each food item. While many fungi are harmless, some may produce mycotoxins that can pose health risks to consumers. The presence of fungi in food items, particularly at elevated levels, underscores the importance of proper storage, handling, and quality control measures to ensure food safety. Continuous monitoring and adherence to good agricultural and processing practices are crucial in mitigating the risk of fungal contamination. Most of the moulds may be from the field whose spores may have attached to the seeds during processing of the fruits to extract the seeds and subsequent drying before sending to the market in this process mycotoxins may be elaborated on the seeds by the infecting fungi. Mycotoxin accumulation in fruits and vegetables may occur in the field, and during harvest, postharvest and storage and factors affecting mycotoxin production include the fruit or vegetable type and cultivar, geographical location, climate, pre-harvest treatments, method of harvest, postharvest treatments and storage conditions.

The high microbial count from this study may be linked to improper handling of melon and bush mango seed and poor sanitary practices, which indicate inefficient process controls. Milling methods, residue build-up in milling machines, and storage practices may constitute a significant source of microbiological contamination which may negatively affect the safety and health of the consumer. Evidently, the sellers store the milled melon and bush mango seed in plastic bowls/buckets. This practice may easily expose the food product to microbial contamination and adversely compromise its safety. Melons tend to have a higher water content and softer surface compared to bush mango seeds. This higher water content and softer surface can provide a more conducive environment for microbial growth, potentially making melons more susceptible to contamination compared to bush mango seeds. Nevertheless, both food ingredients can be contaminated if proper hygiene and handling practices are not followed throughout the supply chain.

The morphological and biochemical characterization of heterotrophic bacteria in both melon and bush mango seed samples revealed a commonality in the genera identified. *Staphylococcus, Bacillus, Corynebacterium, Enterobacter, Micrococcus, Pseudomonas, Escherichia coli, Salmonella,* and *Proteus* were identified in both sets of seeds. Notably, Bacillus exhibited a remarkably higher frequency of occurrence for both samples registering at 20.0% followed by Staphylococcus which was prevalent in both samples with a frequency of 14%. The bacterial isolates obtained from this study is similar to the study of Adebayo-Tayo et al. [30], Iyayi et al., [29], Adegbehingbe et al. [31] who isolated similar bacteria from seeds of I. gabonensi.

In fungal characterization, *Penicillium* spp., Fusarium spp., *Aspergillus flavus, Candida* spp., *Mucor* spp., *Saccharomyces* sp., and *Aspergillus niger* were identified in melon and bush mango seed. The frequencies of these fungi, however, exhibited variations between the two seed types. *Aspergillus niger*, for instance, was notably higher at 20.8% followed by *Mucors spp* at 9.0% for both melon and bush mango seeds. This is similar to the findings of Okobiebi and Ezennia, [31] on identification of fungi in bush mango seeds spoilage in Benin. The fungi isolated from *Irvingia gabonensis* are similar to those isolated by Okobiebi and Ezennia [32], Duru and Ayadoh (2009) in which seed rot fungal pathogens of *Irvingia gabonensis* was investigated It had been previously observed that *Aspergillus flavus, Rhizopus spp* were amongst the fungi that reduced the viscosity and storability of Irvingia gabonensis [33].

Aspergillius, Rhizopus and *Penicillium* amongst other organisms have been isolated from shelled melon seeds purchased from markets in some randomly selected towns in some in Nigeria.

Bankole and Joda [34]. Fungi of the group *Aspergillus, Rhizopus, Penicillium* amongst others are seed pathogens of some Nigerian melons Chiejina [35]. The observed differences in the frequency of occurrence for both bacteria and fungi between melon and bush mango seed may be attributed to variations in the natural characteristics of the seeds, their growing conditions, or the post-harvest handling processes.

The presence of pathogenic organisms such as *Escherichia coli, Staphylococcus*, and *Salmonella* in melon and bush mango seed, two commonly used ingredients in various dishes, can have serious health implications. Certain strains of *E. coli,* especially *E. coli* O157:H7, can cause severe gastrointestinal infections [36]. Symptoms may include abdominal cramps, diarrhea (which may be bloody), nausea, and vomiting. In some cases, E. coli infections can lead to hemolytic uremic syndrome (HUS), a condition that can cause kidney failure, especially in vulnerable populations such as children and the elderly. *Staphylococcus* aureus can produce heat-stable toxins, including enterotoxins. Ingesting food contaminated with these toxins can result in rapid onset food poisoning [37]. Symptoms of Staphylococcus food poisoning include nausea, vomiting, abdominal cramps, and diarrhea. The onset is often quick, occurring within a few hours of consuming contaminated food. *Salmonella* infection (salmonellosis) can lead to a range of symptoms, including diarrhea, abdominal cramps, fever, and vomiting [38].

3.2 Proximate Composition of Melon and Bush Mango Seed

Melon seed exhibited a lower carbohydrate content of 7.11%, compared to bush mango seed 15.03%. The carbohydrates of bush mango seed ranged from 15.3% to 30.0% as reported by Racheal et al., [39] is similar to this present study. This present study is slightly lower than the study of Ojieh et al., [40] who reported melon to be low in carbohydrate (10.6%) compared to other legumes which have as high as 20.0-60.0% carbohydrate content [41]. This disparity may be attributed to inherent differences in the seeds' compositions or variations in environmental factors during cultivation.

Notably, melon contained a substantially higher lipid content at 58.24% compared to bush mango seed 28.24%. This consistent with the findings of Onojah et al., [42] who correspondingly reported a lipid percentage of 58.7%. The higher lipid content in melon aligns with its traditional use as a cooking oil source and could contribute to its caloric density. Crude fat content of 45.7% obtained for melon by Ojieh et al. [43] is slightly lower than the present study. This study agrees closely with that reported by Ige et al. (1984) for varieties of melon seeds which ranged between 47.9 and 51.1%. With the high amount of crude fat obtained for melon in this study, egusi melon could be regarded as an oil seed. The low lipid content in bush mango seeds may likely results from a combination of genetic, environmental, and physiological factors that govern seed development and nutrient allocation in the plant.

Protein contents contribute positively to the requirement for biomolecules needed for repair and maintenance of the body tissues as well as synthesis of vital hormones for the body [44]. Protein content in melon was also notably higher at 23.86%, while bush mango showed a lower protein content of 11.95%. This is lower with the finding of Onojah et al*.,* [42]. The protein content of melon seed is similar to that reported by Ojieh et al., [43] which is 23.4% for melon, while the protein content in bush mango seed in this study is slightly higher than the report of Racheal et al. [39] which is 4.2 to 7.8%.

Crude fiber contains indigestible cellulose which helps to absorb water, provide roughage and better functioning of the alimentary system. Crude fiber content, important for digestive health, was lower in bush mango seed at 12.66% compared to melon seed which is 19.012%. The crude fibre percentage ranged from 9.1 to 10.7% as reported by Racheal et al. [39] for bush mango seed which is slightly lower than that reported for bush mango seed in this study. The crude fibre content of melon (12.0%) obtained in the study conducted by Ojieh et al. (2007) was slightly lower than this present study. These variations in proximate composition highlight the nutritional diversity between the two seeds, offering consumers choices based on their dietary preferences and nutritional needs.

In this study Melon had a moisture content of 7. 31 % and bush mango seed had a moisture content of 10.53%. The moisture content in the present study were higher than the findings of Sadou et al*.,* [45]. correspondingly reported a percentage moisture of 4.9% and a lower moisture content of melon (4.6%) reported by Ojieh et al. [43]. For bush mango seed the report of Racheal et al. [39] which is 4.2 to 5.5% which lower than the present study.

Through food consumption, the body could easily become contaminated with heavy metals, since these elements are either absorbed from the soil or released during food processing. Their toxicity may affect mental and nervous systems and other vital organ Winifred et al*.,* [24]. The heavy metal analysis revealed variations in the concentration of lead, copper, and cadmium between melon and bush mango seed. Lead content in melon seed was higher at 0.21646mg/Kg compared to bush mango seed with a concentration of 0.17903mg/Kg. This is lower compared to the findings of Winifred et al*.,* [24] which had 0.2 to 0.4 mg/kg for melon seed, Copper content in melon seed was 0.24mg/Kg, while bush mango seed exhibited a slightly higher concentration at 0.08mg/Kg. Calcium content in melon seed was 0.46172mg/Kg, whereas bush mango seed showed a higher concentration at 0.14821mg/Kg. Cadmium content in melon seed was 0.00385mg/kg, significantly higher than bush mango seed minimal concentration of 0.00164mg/kg. This is in agreement with the findings of Winifred et al*.,* [24]. These findings underscore the importance of understanding the potential health risks associated with heavy metal exposure through these food items. The observed differences in heavy metal concentrations may be influenced by various factors, including soil conditions, agricultural practices, or processing methods. It is crucial to consider the implications of these variations for consumers, as certain heavy metals can accumulate in the body over time and pose health risks.

The presence of lead, copper, and cadmium in food can have significant public health implications, raising concerns about potential adverse effects on human health. Lead exposure, even at low levels, can impact the nervous system, especially in children [46]. It may lead to developmental delays, lowered IQ, and behavioral issues. Chronic exposure to lead is associated with cardiovascular and renal damage in adults. Excessive copper intake can cause gastrointestinal symptoms such as nausea, vomiting, and diarrhea. Prolonged exposure to elevated copper levels may result in liver damage. Cadmium is a known carcinogen, and chronic exposure has been linked to lung and prostate cancer. Accumulation of cadmium in the kidneys over time can lead to kidney damage and impaired function [47-50].

4. CONCLUSION

In conclusion, this study provided a comprehensive assessment of the microbial composition of melon and bush mango seeds sourced from local markets. The Total Heterotrophic Bacteria Count (THBC) exhibited considerable variation in both samples, highlighting the diverse microbial populations associated with these food items.

Finally, the proximate and heavy metal analysis presented varying nutritional compositions and heavy metal contents in melon and bush mango seeds providing essential data for both consumers and regulatory bodies. In essence, this study contributes significant insights into the microbiological and nutritional aspects of melon and bush mango seed, advocating for improved hygiene practices and quality control measures to ensure the safety and integrity of these widely consumed food products.

5. RECOMMENDATIONS

Advocate for improved hygiene practices at all stages of the supply chain, including cultivation, processing, and display in local markets. This is crucial for minimizing the risk of contamination.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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