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Bacteriological Quality Assessment on *Pounded Yam* and *Amala* Sold in Sabon Gari Market, Fagge Local Government, Kano State-Nigeria

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Abstract

The elevated bacterial content, apart from coliform, in terms of the total count in various samples exceeds the safe limits for ready-to-eat foods. It reveals that hygienic practices were compromised before, during, and after preparing, processing, storing, and vending these foods. Isolation of pathogenic bacteria, such as Shigella, Staphylococcus aureus, Salmonella, and Klebsiella pneumonia, reveals that infections may be caused by consumption of these basic foods. The presence of these enteric pathogens indicates possible fecal contamination due to inadequate handling practices such as poor hand hygiene, contaminated water use, and unsanitary utensil use. The presence of S. aureus points to a problem of post-processing contamination, possibly due to inadequate handling practices. The results demonstrate systemic errors in handling food safety in informal market marketplaces and emphasize the dangers consumers are exposed to when it comes to food safety, especially considering that no secondary heating is done. Overall, the study reveals the need for enhancing food hygiene education among vendors, regular monitoring of food and markets by public health authorities, and the need for enforcing food laws in open markets as a means of decreasing the levels of microbial contaminants in food and enhancing the health of consumers of ready-to-eat traditional foods.

Keywords: Assessment, *Amala*, Bacteriological quality, pounded yam.

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Introduction

The safety of food continues to be an issue of concern especially to developing countries. In developing countries such as Nigeria, food handling and processing practices are substandard. In Nigeria, *Pounded yam* and *Amala* are ready to eat foods considered staples, culturally significant, and easy to prepare. Unfortunately, poor handling, inadequate storage, as well as environmental contamination are some of the challenges that compromise the hygienic quality of these foods (Abdullahi, Maiha, and Kida, 2020). The sale of yam and cassava staple foods is now common with street-vending and open-market sales, increasing the risk of microbial contamination. In Nigeria, the Sabon Garri Market in Kano is a perfect example of a busy market where large volumes of cooked foods are sold without maintaining any hygienic practices. The environment for microbial proliferation is enhanced and made easy due to dust presence, improper waste disposal, and unsanitary food display (Womboh, Ajumobi and Ebute, 2022).

Yam is a tuber that goes bad quickly, and that makes it easier for harmful microbes to increase during storage and handling. When any sanitation control is missed during peeling, pounding, or serving yam, and even during preparation of yam flour, a contamination risk is created. In several studies, foodborne pathogens, like *E. coli, Salmonella,* and *Staphylococcus aureus*, have been reported from ready-to-eat products (Olaleye *et al*., 2024). Yam-based meals have become an important component of Nigeria's culinary culture. *Pounded yam* is a universal dish and an important component of the Nigerian diet, as it is served during festivities across all socioeconomic classes. On the other hand, *Amala* is a southwestern Nigerian staple food. Both dishes, however, are based on yam which is also culturally important, and are prone to foodborne bacterial contamination. Long storage, low temperature during cooking, and the use of water of poor microbiological quality have all been reported to be contributing factors (Theophile and Adeleke, 2023). In food microbiology, one of the important questions is how packaging and storage conditions influence the survival of bacteria. For example, some inappropriate packaging materials can trap moisture, creating conditions that are favorable for bacteria to develop. Research indicates that yam flour in low quality packaging cuts down on the shelf life of the product, and in sensory and bacteriological quality too (Olaleye *et al*. 2024; Babajide, Oyebanjo, and Oyewole, 2021).

In addition, the high carbohydrate concentration in yam and cassava products is troublesome as it can cause fungal and bacterial colonization. This is particularly concerning the possible presence of mycotoxins, whose long term consequences on health are particularly troubling (Akinnibosun and Ojo, 2023). Given the many people in Kano who go to the Sabon Garri Market, it is important to evaluate the *Pounded yam* and *Amala* sold there for possible bacterial contamination. Such work can help guide public health actions around issues like policy development, hygiene improvements, and consumer educational awareness (Obi *et al*., 2022). Building on the above, there is also the urgent need to understand and for the first time document the sample foods' bacteriological quality. This is essential, particularly, for the health protection of these consumers, while also contributing positively to Nigeria's general food safety documentation and surveillance (Usman and Hamza, 2023).

Material and Methods

Sampling site

This study was carried out in Sabon Gari market. Sabon Gari Market is in the Fagge Local Government Area of Kano State and is one of the biggest open market in the State. In this regard, the Market is a commercial center that draws buyers and sellers beyond the State.

Economic activities in this Market are vibrant, and it is well known for the sale of food, house ware, textiles and other consumables of varying types. In the food section of this Market, a lot of vendors prepare and sell ready to eat staple food, especially *Pounded yam* and *Amala*. They serve these to countless consumers every day. For many, these are affordably priced, easy to obtain, and culturally important meals. Unpacked foods in open Market conditions also tend to varying and climatic and hygienic conditions. Sabon Gari Market is representative of the typical urban Nigeria informal food vending scenario, which is the primary reason it was chosen as the study site. Its informal nature and the high level of patronage in the Market are important in identifying potential risk of microbial contamination in staple foods. These foods are important in the local diet.

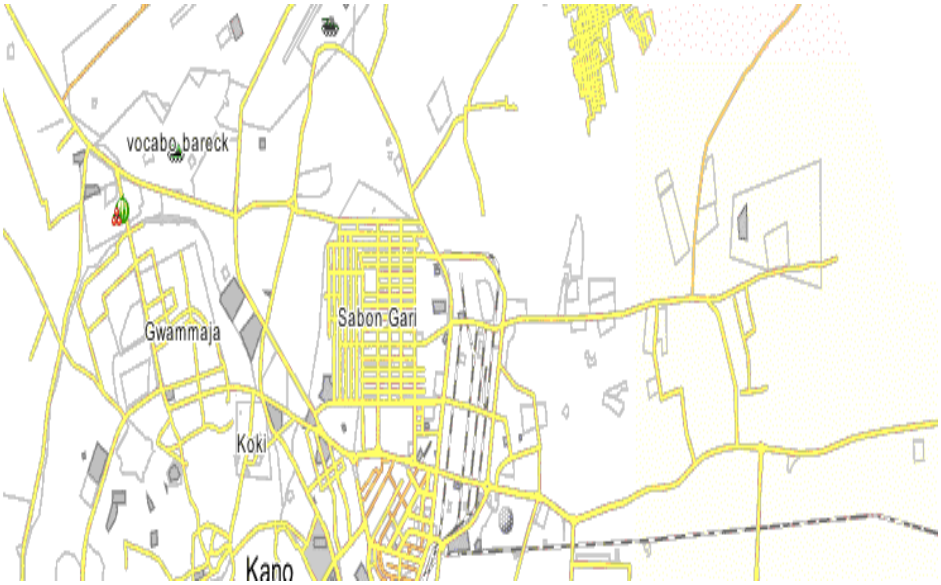


Fig1: Map of Sabon Gari, Kano State Nigeria

Sample Collection

Twelve (12) food samples were collected for this study. These included six (6) samples of *Pounded yam* and six (6) samples of *Amala* from three (3) different location and six (6) randomly selected vendors within Sabon Gari Market, one (1) samples of *Pounded yam* and one (1) samples of *Amala* were collected from each vendor. This approach allowed for a reasonable balance across different vendors and minimized bias during sample selection. All samples were collected within aseptic conditions, employing sterile, tightly sealed packing for each sample immediately upon purchase. Each sample was marked according to vendor, food type, and time of collection to maintain the chain of custody and precision in laboratory analysis. The samples were transported in ice packs to the Laboratory Unit of the Science Laboratory Technology (SLT) Department of Aliko Dangote University of Science and Technology, Wudil, Kano State. This transport method was designed to slow microbial growth within the samples (Fawole and Oso, 2001). This means the determined bacterial loads were a true reflection of the contamination level at the time of purchase.

Sample Preparation and Processing

In order to ensure sample sterility and prevent external contamination, all food samples were processed with utmost care once they had been delivered to the laboratory. A 1g portion of the sample was precisely and aseptically weighed using a digital balance, after which the sample was homogenized with 9 mL of sterile peptone water to create the initial stock

solution. At this point, it was possible to suspend the bacteria in the food to facilitate enumeration. The stock solution was assigned the designation of 1:10 dilution for the purpose of obtaining additional serial dilutions. One milliliter of the homogenate was aseptically transferred to 9 mL of sterile peptone water and the dilution was shaken to ensure uniformity, which was a necessary condition to carry out the procedure again. This was done in order to obtain a dilution factor of 10^{-5}, which makes it possible to obtain accurate bacterial loads. All prepared dilutions were stored under aseptic condition and used for plating without delay. This was made possible through the proper labeling of test tubes and all dilution stages which documented the order and sequence of designations, and all aseptic preparations made it possible. This was the first in a series of steps, and it the most important, as it standardizes the bacterial load for quantification and comparison across samples.

Media Preparation

All media used were prepared according to the manufacturer's instruction. After preparation, they were sterilized by autoclaving at 121ºC for 15 minutes.

Bacteriological Analysis

This section details the methods for the analysis of the samples from the study. For the identification of distinct bacterial strain, the characterization, and the quantification of each sample, the methods of Fawole and Oso (2001) and adaptations of Musa et al. (2025) were followed for each stage of the analysis, as the total plate count, the isolation on selective media, and the morphological and biochemical identification were performed. Total plate counts were performed for each of the diluted samples by aseptically inoculating 1 mL into sterile Petri dishes, followed by the addition of molten nutrient agar. The agar plates were swirled for even distribution, and solidified before being incubated for 24 hours at 37 °C. For the determination of CFU/ml, only plates with 30–300 colonies were selected, counted, and recorded (Oranusi *et al*., 2024).

Total Plate Count

To gauge the overall bacterial population in the food samples, the total plate count method was used. Appropriately diluted samples were taken and incubated at 37 °C for 24 hours before colony counting. The results were obtained in CFU/ml for the food samples. To limit estimations errors, plates with fewer than 30 and more than 300 colonies were discarded. For accuracy, the counts from duplicate plates were combined to form an arithmetic mean. This approach guaranteed that the evaluations of bacterial load were statistically sound and consistent. The total plate count method offered an insight into the different food types' microbial quality and inter comparisons of *Amala* and *Pounded yam*, and variability's between food vendors. For the isolation and identification of the bacteria, this was used as the baseline method (Nawasi *et al*., 2025).

Coliform count

This was carried out according to the method described by (Patience *et al*., 2026). In this method, a set up consisting of nine (9) test tubes each containing 9ml of lactose broth and inverted Durham tube were autoclaved to expel air and to sterilized. Inoculation was made from the serially diluted samples from the 1:10 to 1:1000 dilutions. All the 9 test tubes were incubated at 37^0C for 24 hours and another 24 hours in the absence of gas. Following 24 and 48 hours of incubation the tubes were observed for gas production and the numbers of gas positive tubes were compared with the Most Probable Number (MPN) table to estimate the most probable number of coliforms per ml of the sample.

Isolation and Identification of Bacterial Species

Some selective media such as Eosin Methylene Blue agar, Salmonella Shigella, MacConkey and Mannitol Salt Agar were prepared, poured into petri dishes and allowed to solidify. Following the total plate counts, the discrete colonies were sub-cultured by being inoculated onto the surface of those media using a sterile wire loop by streaking method. They were then incubated at 37°C or 24hrs in an inverted position. After incubation, distinctive morphology properties of each colony were formed and noted down for further study (Cheesbrough, 2012).

Results

Bacterial Counts from *Amala* and Pounded yam Samples

Bacteriological quality assessment of *pounded yam*and *Amala* from Sabon Gari market revealed the samples to have high bacterial. The highest bacterial count was obtained in location B in Amala (B^2) ($6.40x10^6$cfu/ml) while Pounded yam sample of (B^2) has the lowest counts of ($1.40x10^5$cfu/ml). While the highest coliform counts was found location B^2 and A^1in sample *Amala* and *Pounded yam* respectively. The lowest counts was found in location B^2 sample *pounded yam* (Table 1).

Table 1: Bacterial Counts from *Amala* and Pounded yam Samples

		Bacterial Load and Coliform counts (CFU/ml)			
S/N	**Location**	***Amala***	**MPN/ml**	***Pounded Yam***	**MPN/ml**
1	A^1	$2.40\ X10^5$	9	$2.80\ X10^5$	11
2	A^2	$1.96\ X10^6$	4	$2.36\ X10^7$	7
3	B^1	$1.82X10^4$	4	$1.92\ X10^4$	3
4	B^2	$6.40\ X10^6$	11	$1.40\ X10^5$	<3
5	C^1	$2.21\ X10^5$	9	$1.75\ X10^5$	3
6	C^2	$1.98\ X10^5$	9	$2.10\ X10^5$	9

Keys; A^{1-2}= Location 1, B^{1-2}= Location 2, C^{1-2}= Location 3,

Morphological and biochemical characteristics of Bacterial Isolates

The bacteria isolates from *Pounded yam* and *Amala* samples were subjected to morphological and biochemical characterization for proper identification. The isolates identified include *Shigella spp, Stapylococcus aureus, Salmonell spp* and *Klebsiella pneumonia*. Their colonies appearances on selective and differential media, as well as their Gram reaction and biochemical profiles are presented below (Table 2).

Table 2: Morphological and biochemical characteristics of Bacterial Isolates from *Pounded Yam* and *Amala* Samples

Morphology	Microscopy	1	2	3	4	Isolates
Colourless Colonies on SSA	Gram Negative Rods shape in Short chain	+	-	-	+	*Shigella* sp.
Yellowish Colonies on MSA	Gram Positive Cocci in Cluster	+	+	-	_	*Staphylococcus aureus*
Pink Colonies on EMB	Gram Negative Short Rods	+	-	+	_	*Klebsiella Pneumoniae*
Colourless Colonies on MCA	Gram Negative Rods	+	_	+	_	*Salmonella* sp.

Keys; 1=Catalase test, 2=Coagulase test,3=Citrate test, 4=Indole test, SSA=, MCA=MacCon key agar, MSA=, Mannitol Salt Agar, EMB= Eosin Methylene Blue agar

Frequency of Occurrence of Bacterial species

The frequency of occurrence of the bacterial isolates from the analyzed *pounded yam* and *amala* revealed varying level of contamination among the identified species. Such as *Shigella spp, Staphylococcus aureus, Salmonella* sppand *Klebsiella pneumonia*. *Shigella* spp and *Klebsiella pneumoniea* showed the highest frequency of occurrence while *Staphylococcus aureus* and *Salmonella* spp had a comparatively lower frequency (Table 3).

Table 3: Frequency of Occurrence of Bacterial species

S/N	S/C	***Shigella* spp**	***S. aureus***	***K. pnemoniae***	***Salmonella* spp**
1	A^1	+	+	+	+
2	A^2	+	+	+	+
3	A^3	_	_	_	_
4	A^4	+	+	+	+
5	A^5	+	+	+	+
6	A^6	+	+	+	_
7	P^1	+	_	+	+
8	P^2	+	_	+	+
9	P^3	_	_	_	_
10	P^4	+	+	+	+
11	P^5	_	_	+	_
12	P^6	+	+	_	_
13	Total(%)	**9 (**28.13%**)**	**7**(21.88%)	**9(**28.13%**)**	**7**(21.88%)

Keys; += Present, – = Absent,%= Percentage

Discussions

In this study, it was found that the samples of *pounded yam* and *Amala* purchased from Sabon Gari Market each exhibited bacterial counts no lower than 10^5 CFU/g. This observation is

similar to that of Abdullahi, Maiha, and Kida (2020), where they highlighted the same bacterial counts in ready-to-eat food samples collected from Zaria. Their research revealed that foods that are cooked and sold in tightly packed open air stalls and markets are highly likely to contain bacterial loads, capturing the essence of the argument that they are highly exposed to bacteria and environmental pollutants. Womboh, Ajumobi, and Ebute (2022) also highlighted the same idea in their research, in which they studied pounded yam in Makurdi and recorded bacterial counts above the acceptable threshold for ready-to-eat foods. Considering that these authors share similar findings to the current study, this indicates that the issue of contamination of swallow meals is something that does not seem to be unique to the region, or indeed, to any region of Nigeria. Many of these studies indicate that there are still substantial gaps in the food hygiene practice of vendors. On the other hand, Babajide *et al*. (2021) noted lesser microbial counts on packaged pounded yam flour, indicating the impact of packaging to minimize contamination. The disparities indicate the manner of preparation and presentation is vital to the bacterial load. In contrast to packaged meals, the freshly prepared *Pounded yam* and *Amala* sold in street markets is exposed to the open atmosphere and does not have any form of protective packaging. The bacterial isolates characterized in this work, namely *Salmonella*, *Shigella*, *Staphylococcus aureus*, and *Klebsiella pneumoniae*, are also noted in the review of microflora in swallow meals by Akinnibosun and Ojo (2023). Their work underlined the common abundance of enteric bacteria in yam-based foods and the contamination routes associated with water, tools, and hand hygiene.

Olaleye *et al*. (2024) also pointed out the microbial contamination risks of pounded yam flour which is poorly packaged. Although they focused on the organisms developed during prolonged storage, there is a substantial overlap between their findings and this study that bolsters the assertion that yam-based foods are prone to microbial contamination in varying circumstances. Fermentation, as Theophile and Adeleke (2023) in their study 'processing of yam paste' noted, might mitigate some bacterial risks due to conditions hostile to pathogens. This contrasts to non-fermented *Pounded yam* and *Amala* dense bacterial communities in the current study. The processes employed to achieve the end product highly determines the microbial outcomes. The case of *pounded yam* and *Amala* in this study and their higher bacterial counts can be attributed to their water activity, as well as to the way they are handled, which are far more favorable to microbial growth." The outcomes of this study as described in this paper are in general agreement with the available data, thereby supporting the assertion that street-vended swallow meals in various locations in Nigeria are likely to be heavily contaminated by microbial life, often to unsafe levels. The differences in counts from various studies point toward the varying levels of local hygiene, as well as the food type and environmental factors." People who consume *pounded yam* and *Amala* are always at the verge of eating contaminated food. This open more assumptions about the microbial contamination and hygiene from market vending practices in Sabon Gari. Because of the absence of secondary cooking, the risk of infection is more than what one would find in food that goes through secondary cooking, and this is the case with street vended foods.

The presence of *Shigella* as a major isolate points to fecal contamination, which poses a grave danger to food safety. This suggests possible contamination from inadequate hand washing, use of dirty water, or insufficiently cleaned utensils. It suggests food hygiene practices in Sabon Gari Market are below the minimum acceptable standards set by international organizations like WHO or FAO. There are particular issues with *Staphylococcus aureus*, as its presence suggests mishandling along with potential cross-contamination during the serving process, which is a complete breach of sanitation practices. *Staphylococcus aureus* is infamous for enterotoxin-related food poisoning. This suggests

lapses of hygiene as minor as touching the food with bare hands can result into a scenario where the targeted person can be severely sick.

Conclusion

The research showed that *pounded yam* and *Amala* sold at Sabon Gari Market, located in Kano State, are contaminated with bacteria that can cause health hazards to the Nigerian populace. The high bacterial and coliform counts were noted from some of the samples, exceeding the acceptable limits for ready-to-eat foods. The presence of pathogenic microorganisms such as *Shigella* spp., *Staphylococcus aureus*, *Salmonella* spp., and *Klebsiella pneumoniae* indicates the unhygienic preparation, handling, and vending of these foods. The results indicate that Nigerian consumers of these foods are more likely to be infected by these microorganisms due to the lack of further heat treatment before consuming them.

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