Open Access Library Journal
2025, Volume 12, e13490
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Comparative Study and Evaluation of Microbes on Selected Commercial Dry White and Water Yam at Two Popular Ibadan Markets

Olatubosun Fisayo Ojo[1*], Adedotun Onoyinka Afolayan[2]

[1]National Open University of Nigeria (Ibadan Study Centre), Abuja, Nigeria
[2]National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Apata, Ibadan
Email: *physayoh@gmail.com

How to cite this paper: Ojo, O.F. and Afolayan, A.O. (2025) Comparative Study and Evaluation of Microbes on Selected Commercial Dry White and Water Yam at Two Popular Ibadan Markets. *Open Access Library Journal*, **12**: e13490.
https://doi.org/10.4236/oalib.1113490

Received: April 23, 2025
Accepted: May 26, 2025
Published: May 29, 2025

Copyright © 2025 by author(s) and Open Access Library Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

Microbial infections of yam could be at any stage in its growth, from the seedling stage through to postharvest. Thus, this research study has been designed to investigate, compare and evaluate various microbes (bacteria and fungi) that may be present on and associated with selected commercial dry white and water yam at two popular Ibadan markets. Yam chips were purposively obtained from two markets (Oja Oba and Bodija) and were milled in the laboratory using a sterile milling machine. The microbial result of the first, second, and third analysis of white yam flour showed that Oja Oba samples had total viable microbial count ranging from 2.9×10^4 to 1.7×10^4, 2.9×10^4 to 1.4×10^4 and 8.1×10^4 to 1.5×10^4 respectively compared to Bodija samples which range from 1.3×10^4 to 7×10^3, 1.8×10^4 to 7×10^3 and 3.6×10^4 to 9×10^3 respectively. For water yam flour samples analysis, Bodija samples showed the result counts of 4.2×10^4, 4.4×10^4 and 1.02×10^5 respectively while Oja Oba samples showed counts of 5.4×10^4, 6.3×10^4, and 1.62×10^5 respectively. Different bacteria and fungi were isolated namely *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas sp*, *Enterobacter sp*, *Flavobacterium sp*, *Rhizopus stolonifer*, *Aspergillus niger*, *Penicillum oxalicum*, *Monillia*, *Mucor*, *Aspergillus flavus*, *Pythium*. Thus, the result of this study has shown that dried yam flour samples from Oja Oba had a higher total viable microbial count compared to the samples from Bodija while the prepared control samples had a low microorganism population compared with all the collected market samples. The bacteria and fungi isolated from white yam and water yam samples irrespective of the market, were similar. *Bacillus spp*, *Rhizopus stolonifer*, *Aspergillus niger*, *Penicillum oxalicum*, *Aspergillus flavus* were found to commonly present in both water yam and white yam of the two markets and in addition, *Monillia* and *Pythium* were found only on water yam and white yam sample respectively in Bodija market.

The microorganisms commonly isolated from all the yam flour samples irrespective of variety and location were *Rhizopus stolonifer*, *Aspergillus flavus*, *Penicillium oxalicum* and *Aspergillus niger*.

Subject Areas

Agricultural Science

Keywords

Microbial Infections, Yam, Microorganisms, Ibadan Markets, Contamination

1. Introduction

Yam is one of the most consumed staple foods in West Africa, which belongs to the genus Dioscorea (Family Dioscoreaceae) and is the second most important tropical root/tuber crop in West Africa after cassava [1]. West and Central African yam cultivation and harvesting account for around 95% of global production, with Nigeria being the major producer [2]. Yam with its appreciable content of essential dietary nutrients, has been reported to have nutritional superiority when compared with other tropical root crops [3]. The important yam species in Nigeria include *Dioscorea rotundata* (white yam), *Dioscorea alata* (white yam), *Dioscorea cayenensis* (yellow yam), *Dioscorea bulbifera* (aerial yam or air potato), *Dioscorea esculenta* (Chinese yam) and *Dioscorea dumentorium* (trifoliate yam). *D. rotundata* popularly known as white yam is the most widely cultivated and consumed of the *Dioscorea spp*. in Nigeria [4] [5]. The tuber is around 1.6m tall and weighs 2 - 5 kg, depending on size. The tuber has rough skin that ranges from dark to light brown [6].

Nutritionally, yams are mainly carbohydrate food but contain about 1% - 2% dietary protein, which is high compared with other tropical root crops [7], but has varying levels of proteins, lipids, minerals and most vitamins except Vitamin C [8]. Consequently, yams have the potential to meet a significant portion of the protein needs for humans when consumed in substantial amounts [9]. In Nigeria, yams undergo various processing methods to create essential food items like pounded yam, "amala", boiled yam, roasted yam, dried yam chips/pellets, pounded yam, and fried yam chips [10]. These products serve as valuable sources of energy and dietary fiber as other tuber crops [9] [11]. Additionally, intermediate products resulting from these processes are either consumed directly by animals or used as fundamental components in snacks, or they can be further processed into flour [12]. Yams also contribute to generating income through industrial applications in addition to their direct use as a food source. Tuber yam, like various other primary foods, is prone to postharvest illnesses caused by diverse types of fungi and bacteria [13]. These microorganisms are linked to the degradation of yam tubers during storage. In Nigeria, pathogens constitute the major factor to rot in yam production. The impact of pathogen attacks on crops typically leads to losses ranging from around 20% to 30% [6]. Nevertheless, these disease agents diminish both the amount and caliber of yam harvest, rendering them unappealing to consumers. Yam is susceptible to infection starting from the early growth stages, continuing through the harvesting process, and extending into storage [14].

The aim of this research work is to investigate and evaluate various microbial communities (bacteria and fungi) associated with ware yams and flour with their respective contextual market samples from two important markets in Ibadan, so as to ascertain that the commercial yam products being sold for public consumption are safe.

2. Materials and Methods

2.1. Description of Study Site

Sampling in this study involved the collection of processed yams from Oja-Oba and Bodija markets in Ibadan city. Ibadan is the capital and most populous city of Oyo State, Nigeria. It is situated at 7.39˚N Latitude, 3.9˚E Longitude. Oja-Oba market is located along the Ibadan South Government Area of Oyo State. It is one of the biggest foodstuffs markets in Ibadan. Comprising numerous independent vendors, this marketplace engages in the competitive selling of essential food items such as yam and its derivatives, maize, cowpea (beans), rice, vegetables, palm and vegetable oils, cassava products, onions, tomatoes, pepper, millet, sorghum, fruits, and more. Trading serves as the primary distribution method within this market structure, positioned in close proximity to the University of Ibadan Campus and adjacent to the state secretariat, the Bodija market occupies a region within the Ibadan North Local Government Area of Oyo State. This open-air market is renowned for its reliable supply of various fresh and dehydrated food products. The market layout encompasses a series of well-organized buildings arranged in blocks. Each type of agricultural produce is allocated its own designated row of stalls, ensuring a structured arrangement. The experiment was carried out at the National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation (7˚23'31.5"N latitude and 3˚50'46.5"E longitude), Ibadan, Nigeria.

2.2. Collection of Samples

At the Oja-Oba market, samples of dried yam were randomly collected by purchasing the products from those sellers over the period of six weeks at two weeks intervals. The selected and purchased dried yam products were of the dried white yam type and the dried water yam type. At Bodija Market, samples of dried yam (water yam and white yam) were collected by purchasing them from those selling them along 7.4358˚N latitude and 3.9192˚E longitude for a period of six weeks at two weeks intervals. The samples collected include dry white, dry water yam, and their pulverized products. The control samples are fresh samples collected in IITA, peeled, and dried in a drying machine.

Samples:

The Different Yam Products Samples obtained are;

White yam (*Dioscorea rotundata*): Kiayomo, Ipokoro, Gbararo and Kunube;

Water yam (*Dioscorea alata*): Ewura;

Control white yam (*Dioscorea rotundata*);

Control water yam (*Dioscorea alata*).

2.3. Processing and Analysis of Samples

All the samples were grounded using a laboratory blending machine.

The control samples were freshly harvested materials. They were thoroughly washed to remove soil and other undesirable materials from the yam and then later peeled using a sharp knife. The peeled samples were sliced into smaller sizes and parboiled at 50˚C for 2 hours in a water bath, then left in the parboiling water overnight, after which they were drained and dried at 60˚C for a minimum of 3 days in a dryer.

2.4. Media Preparation and Sterilization

All microbiological media used were prepared according to the manufacturer's instructions.

PDA: 39 grams of the dehydrated powder was weighed and dispensed into a medium bottle containing 1000 ml of distilled water. The bottle was heated for 2 minutes in a water bath to allow the powder dissolve completely and then autoclaved for 15 minutes at 121˚C for sterilization. After sterilization, the medium was allowed to cool to 50˚C then 1 ml of lactic acid was added to it prior to pouring.

NA: 28 grams of the dehydrated powder was weighed and dispensed into a medium bottle containing 1 liter of distilled water. The medium was pre-heated for 2 minutes in a water bath before autoclaving for 15 minutes at 121˚C. After sterilizing the medium, medium was allowed to cool to 50˚C prior to usage.

2.5. Microbiological Analysis

The total viable microbial count of the yam flour samples was determined by the pour plate method procedure with modification [15]. 10 g of yam flour was diluted with 90 ml of sterile distilled water and homogenized with the use of a vortex machine for agitation to obtain the stock solution. 1 ml from the stock solution was taken using a sterile pipette tip and diluted serially to dilution factor 10^{-9}. 1 ml volume of each dilution was poured with 10 - 15 ml of nutrient agar (NA) for bacterial culture and potato dextrose agar (PDA) for fungal culture. The plates were left to gel and then incubated. All inoculated plates of Nutrient Agar were incubated at 28˚C ± 30˚C for 24 h while the inoculated PDA plates were incubated at 28˚C ± 30˚C for 72 h. The colonies were counted and recorded.

The bacterial colonies which developed on the plates were purified by sub-culturing onto fresh NA plates using the streaking technique and stored for cultural and biochemical test while PDA medium was used for fungi during sub culturing for further identification.

3. Result

In this study, the results obtained in the microbial analysis of dry white and water yam revealed different types of microorganisms. They are *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas sp*, *Enterobacter sp*, *Flavobacterium sp*, *Rhizopus stolonifer*, *Aspergillus niger*, *Penicillum oxalicum*, *Monillia*, *Mucor*, *Aspergillus sp*, *Aspergillus flavus*, *Pythium sp*. For total microbial counts, different white yam flour samples were milled namely Gbararo, Ipokoro, Kiayomo. In the first experimental setup, Oja Oba samples had the highest total viable microbial count ranging from 2.9×10^4 to 1.7×10^4 compared to Bodija samples having a count ranging from 1.3×10^4 to 7×10^3 (**Table 1**). Comparing the viable microbial count of peel (Kunube) of white yam samples in **Table 1**, Oja Oba samples had 7.1×10^4 compared to Bodija with 5.9×10^4. At the second experiment setup, the white yam samples result showed Oja Oba samples having higher total microbial counts of 2.9×10^4 to 1.4×10^4 than Bodija samples having 1.8×10^4 to 7×10^3. In **Table 3**, the peel (kunube) of Bodija shows to be significantly higher than that of Oja oba market from 2.56×10^5 to 1.39×10^5. **Table 3** showed that white yam of Bodija samples had less bacteria count ranging from 3.6×10^4 to 9×10^3 compared to Oja Oba of 8.1×10^4 to 1.5×10^4. For water yam samples from Bodija, experiments 1, 2, and 3 showed counts of 4.2×10^4, 4.4×10^4, 1.02×10^5 respectively (**Tables 1-3**) and Oja Oba; 5.4×10^4, 6.3×10^4, 1.62×10^5 respectively (**Tables 1-3**). Therefore, the result shows that water yam flour from Oja Oba had a higher total viable count compared to the one from Bodija in the study as shown in the table. The control sample prepared at the laboratory has a low microorganism population compared with all the collected samples (**Figures 4-6**).

The mean of total viable bacterial count obtained from the yam flour samples was subjected to analysis of variance (ANOVA) and Duncan Multiple Range Test to separate the means. The yam flour in Oja Oba market had significantly higher (p-value of 0.3886) and (p-value of 0.3611) total viable bacterial count compared to Bodija market in the first and second analysis respectively. The third statistical analysis showed that there was no really significance difference (p-value = 1) of total viable bacterial count in Oja oba market to Bodija market. The diversity of bacteria and fungi isolated from white yam and water yam at the markets are shown in **Tables 1-3**. The bacteria and fungi isolated from white yam and water yam samples irrespective of the market were similar. *Bacillus spp*, *Rhizopus stolonifer*, *Aspergillus niger*, *Penicillum oxalicum*, *Aspergillus flavus* were found to be commonly present in both water yam and white yam of the two markets (**Figures 1-3**) and in addition, *Monillia* and *Pythium were* found only on water yam and white yam sample respectively in Bodija market (**Figure 2** and **Figure 3**). The microorganisms commonly isolated from all the yam flour samples irrespective of variety and location were *Rhizopus stolonifer*, *Aspergillus flavus*, *Penicilliium oxalicum and Aspergillus niger*.

Table 1. Comparison in the different markets' results of the first analysis of the different yam samples.

LOCATION	SAMPLES	TOTAL VIABLE BACTERIA COUNT	BACTERIA ISOLATED	FUNGI ISOLATED
BODIJA	Ewura (Water yam)	4.2×10^4	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer, Monillia, Penicillium oxalicum, Aspergillus flavus*
OJA OBA	Ewura (Water yam)	5.4×10^4	*Bacillus subtilis, Bacillus cereus, Pseudomonas sp*	*Rhizopus stolonifer, Penicillium oxalicum*
BODIJA	Gbararo (White yam)	7×10^3	*Bacillus subtilis, Bacillus cereus*	*Aspergillus niger, Penicillium oxalicum, Pythium sp, Rhizopus stolonifer, Fusarium oxysporum*
OJA OBA	Gbararo (White yam)	1.7×10^4	*Bacillus subtilis, Bacillus cereus*	*Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer, Penicillium oxalicum*
BODIJA	Ipokoro (White yam)	1.3×10^4	*Pseudomonas sp, Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer, Aspergillus niger, Penicillum oxalicum, Aspergillus sp, Pythium*
OJA OBA	Ipokoro (White yam)	2.9×10^4	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer, Penicillium oxalicum, Aspergillus termarii*
BODIJA	Kiayomo (White yam)	9×10^3	*Bacillus subtilis, Bacillus cereus*	*Aspergillus niger, Penicillium oxalicum*
OJA OBA	Kiayomo (White yam)	2.5×10^4	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer, Penicillium oxalicum*
BODIJA	Kunube (White yam)	5.9×10^4	*Pseudomonas sp, Bacillus subtilis, Bacillus cereus*	*Aspergillus niger, Penicillium oxalicum*
OJA OBA	Kunube (White yam)	7.1×10^4	*Bacillus subtilis, Bacillus cereus*	*Aspergillus niger, Penicillium oxalicum, Aspergillus flavus*

Table 2. Comparison in the different markets' results of the second analysis of the different yam samples.

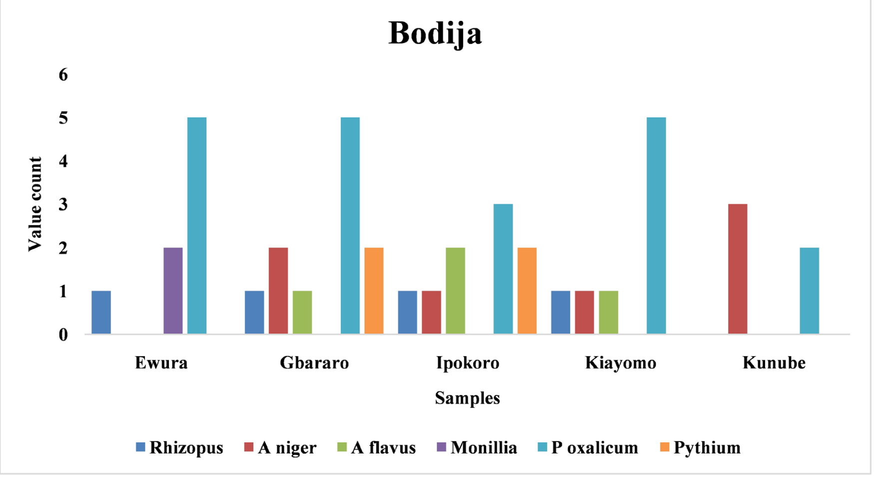
LOCATION	SAMPLES	TOTAL VIABLE BACTERIA COUNT	BACTERIA ISOLATED	FUNGI ISOLATED
BODIJA	Ewura (Water yam)	4.4×10^4	Bacillus subtilis, Bacillus cereus, Pseudomonas sp, Enterobacter sp	*Rhizopus stolonifer, Aspergillus flavus, Monillia sp*
OJA OBA	Ewura (Water yam)	6.3×10^4	Bacillus subtilis, Bacillus cereus, Pseudomonas sp, Enterobacter sp	*Rhizopus stolonifer, Aspergillus niger, Penicillium oxalicum, Pythium*
BODIJA	Gbararo (White yam)	6×10^3	Bacillus subtilis, Bacillus cereus, Enterobacter sp	*Rhizopus stolonifer, Aspergillus niger, Aspergillus flavus, Penicillium oxalicum, Fusarium oxysporum*
OJA OBA	Gbararo (White yam)	1.4×10^4	Bacillus subtilis, Bacillus cereus	*Aspergillus niger, Pythium, Aspergillus flavus, Penicillium oxalicum*
BODIJA	Ipokoro (White yam)	1.8×10^4	Bacillus subtilis, Bacillus cereus, Pseudomonas sp	*Rhizopus stolonifer, Aspergillus niger, Aspergillus flavus, Penicillium oxalicum*
OJA OBA	Ipokoro (White yam)	2.9×10^4	Bacillus subtilis, Bacillus cereus	*Rhizopus stolonifer, Aspergillus niger, Monillia, Penicillium oxalicum*
BODIJA	Kiayomo (White yam)	1×10^4	Bacillus subtilis, Bacillus cereus, Pseudomonas sp	*Rhizopus stolonifer, Aspergillus niger, Aspergillus flavus, Penicillium oxalicum*
OJA OBA	Kiayomo (White yam)	1.4×10^4	Bacillus subtilis, Bacillus cereus	*Rhizopus stolonifer, Aspergillus niger, Penicillium oxalicum*

Continued

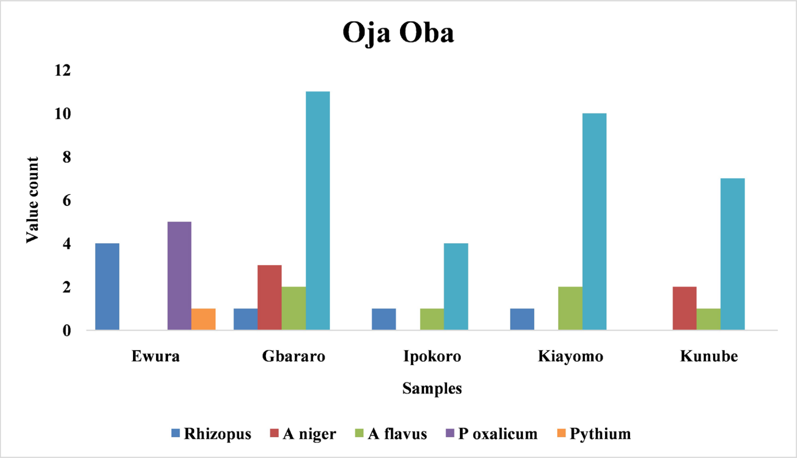
BODIJA	Kunube (White yam)	2.5 × 10⁴	Bacillus subtilis, Bacillus cereus	*Penicillium oxalicum, Aspergillus flavus*
OJA OBA	Kunube (White yam)	3.8 × 10⁴	Bacillus subtilis, Bacillus cereus, Flavobacterium sp	*Aspergillus flavus, Penicillium oxalicum*

Table 3. Comparison in the different markets' results of the third analysis of the different yam samples.

LOCATION	SAMPLES	TOTAL VIABLE BACTERIA COUNT	BACTERIA ISOLATED	FUNGI ISOLATED
BODIJA	Ewura (Water yam)	1.02×10^5	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer*
OJA OBA	Ewura (Water yam)	1.62×10^5	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer*
BODIJA	Gbararo (White yam)	9.0×10^3	*Bacillus subtilis, Bacillus cereus*	*Rhizopus stolonifer*
OJA OBA	Gbararo (White yam)	1.5×10^4	*Bacillus subtilis, Bacillus cereus, Pseudomonas sp*	*Rhizopus stolonifer, Aspergillus niger, Aspergillus flavus*
BODIJA	Ipokoro (White yam)	2.5×10^4	*Pseudomonas sp, Bacillus subtilis, Bacillus cereus, Enterobacter sp*	*Aspergillus flavus, Pythium sp*
OJA OBA	Ipokoro (White yam)	8.1×10^4	*Bacillus subtilis, Bacillus cereus, Pseudomonas sp*	*Mucor, Aspergillus flavus*
BODIJA	Kiayomo (White yam)	3.6×10^4	*Bacillus subtilis, Bacillus cereus, Flavobacterium sp, Pseudomonas sp*	*Rhizopus stolonifer, Aspergillus flavus*
OJA OBA	Kiayomo (White yam)	3.1×10^4	*Bacillus subtilis, Pseudomonas sp, Bacillus cereus*	*Rhizopus stolonifer, Penicillium oxalicum*
BODIJA	Kunube (White yam)	2.56×10^5	*Bacillus subtilis, Pseudomonas sp*	*Rhizopus stolonifer*
OJA OBA	Kunube (White yam)	1.39×10^5	*Bacillus subtilis, Bacillus cereus, Pseudomonas sp*	*Rhizopus stolonifer*

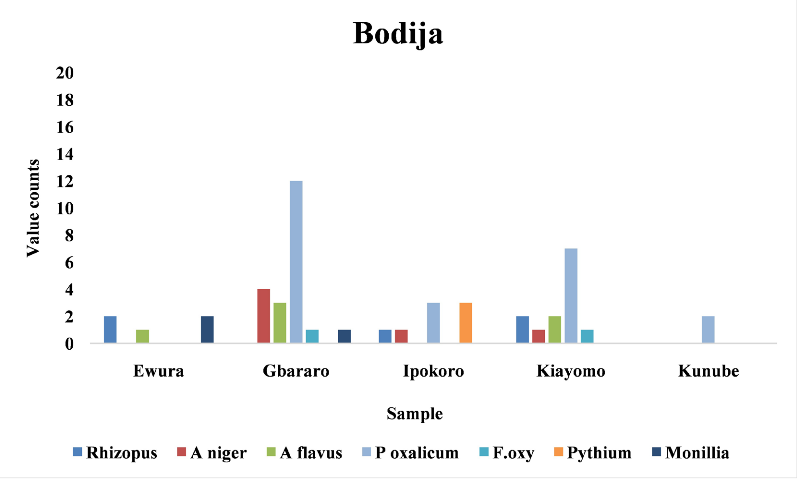


(a)

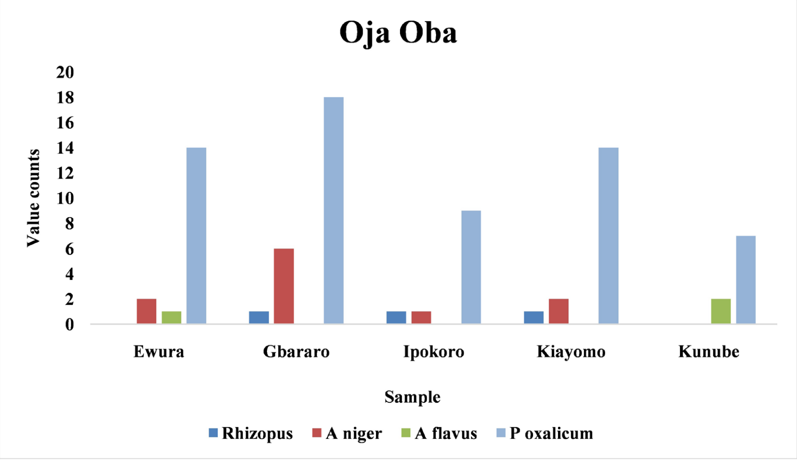


(b)

Figure 1. Diversity of fungi comparison in the different markets' results of the first analysis of the different yam samples.

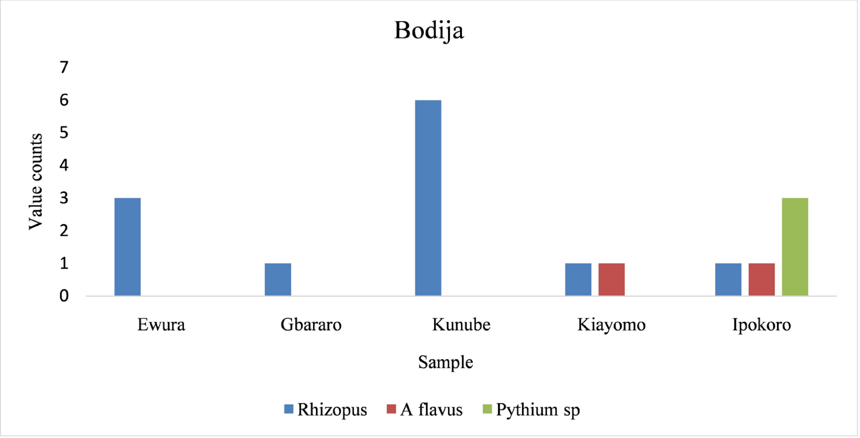


(a)

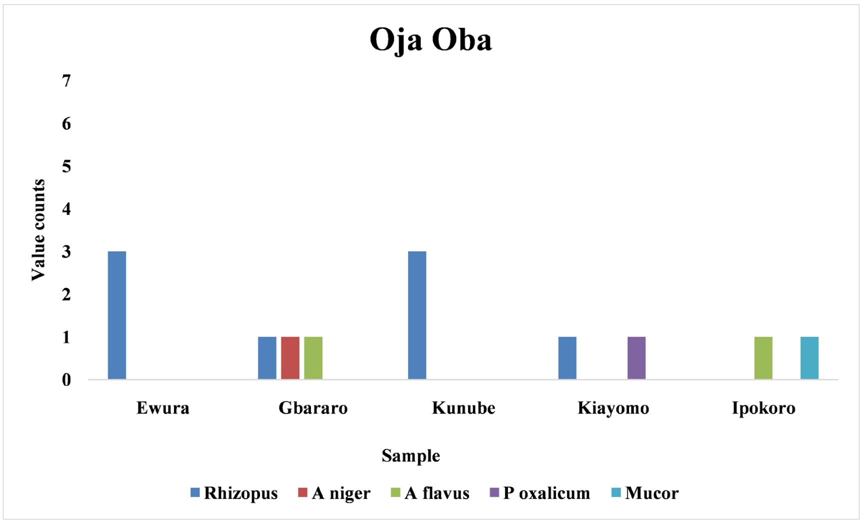


(b)

Figure 2. Diversity of fungi comparison in the different markets' results of the second analysis of the different yam samples.

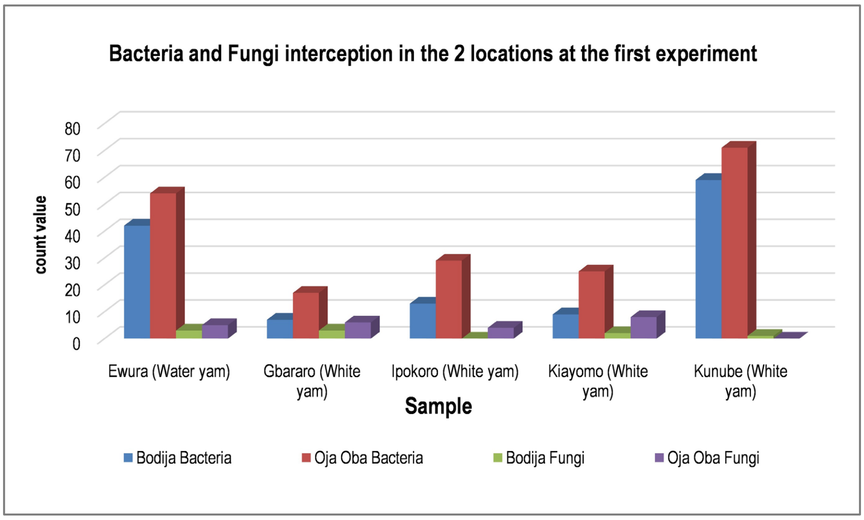


(a)

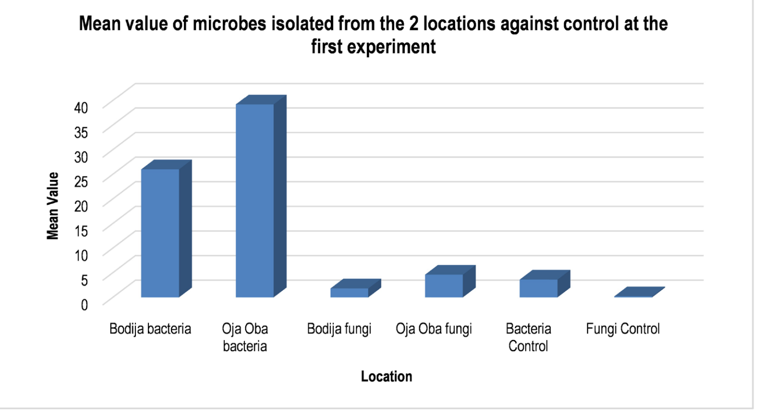


(b)

Figure 3. Diversity of fungi comparison in the different markets' results of the third analysis of the different yam samples.

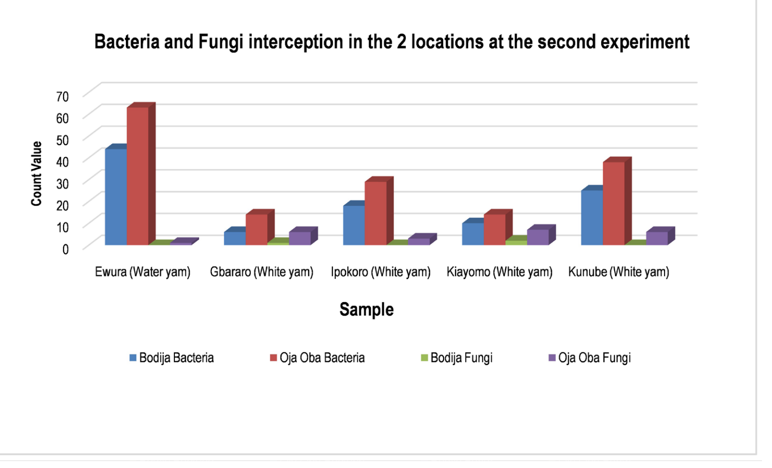


(a)

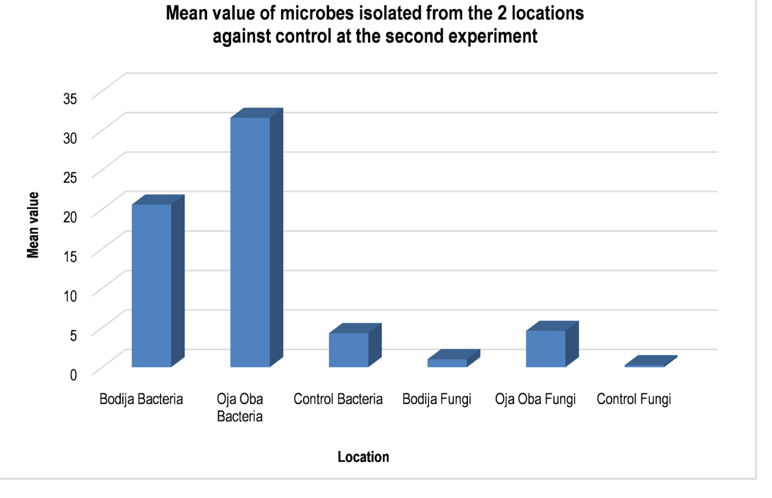


(b)

Figure 4. Showing the mean value of microbes isolated at the first analysis of the different yam samples.

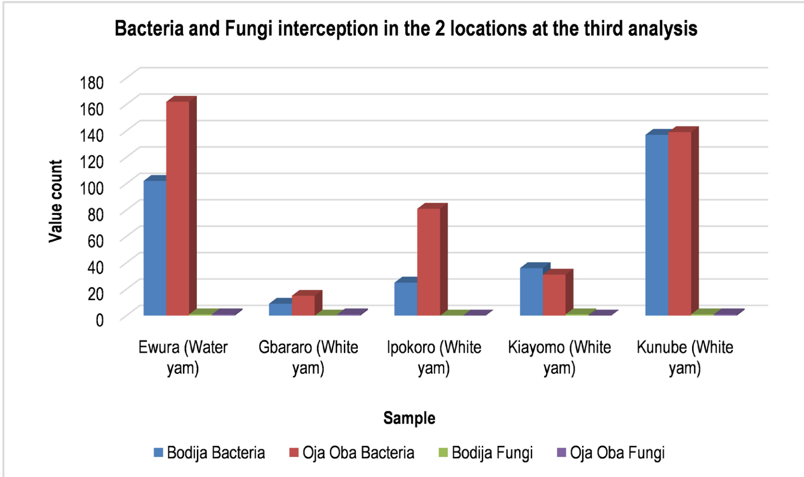


(a)

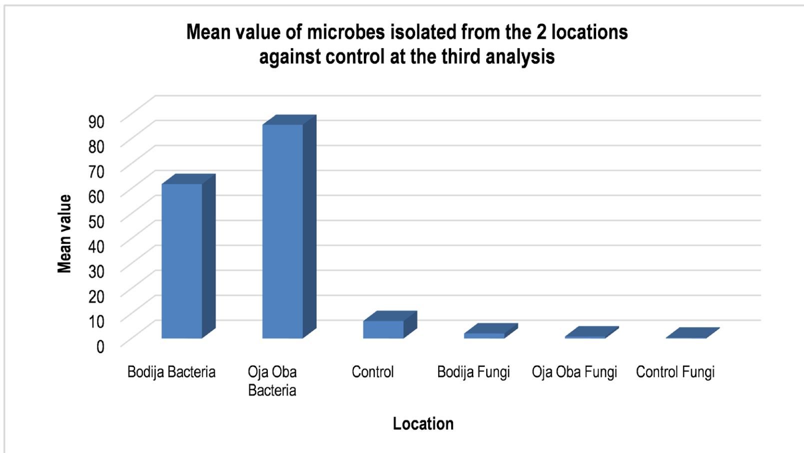


(b)

Figure 5. Showing mean value of microbes isolated at second analysis of the different yam samples.



(a)



(b)

Figure 6. Showing mean value of microbes isolated at the third analysis of different yam samples.

4. Discussion

In Nigeria, yam tubers can undergo various culinary transformations. They can be dried and ground into flour, which is then utilized to create a semi-solid dish known as "Amala." This dish can be paired with vegetables and leafy greens, offering a carbohydrate-rich option that contains vitamins and other nutrients. Yam cultivation is susceptible to several diseases, some of which are triggered by microorganisms. These microbial infections can occur at any point in the growth cycle, from the seedling stage to postharvest. During the post-harvest phase, specific fungal species have been linked to the decay of yam tubers while in storage. An examination of both dry white and water yam demonstrated the presence of diverse microorganisms (bacteria and fungi) as part of the natural flora. They are *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas sp*, *Flavobacterium sp*, *Enterobacter sp*, *Rhizopus stolonifer*, *Mucor*, *Aspergillus niger*, *Penicillium oxalicum*, *Mo-*

nillia, *Aspergillus sp*, *Aspergillus flavus*, *Pythium* (**Figure 1**). The control samples were fresh samples collected, peeled, and dried in a drying machine, which had a low microorganism population compared with all the collected samples (**Figures 4-6**). *Bacillus spp*, *Rhizopus stolonifer*, *Aspergillus niger*, *Penicillium oxalicum*, *Aspergillus flavus* were found to be commonly present on both water yam and white yam of the two markets and in addition, *Monillia and Pythium* were found only on water yam and white yam sample respectively in Bodija market (**Figure 2**). The microorganisms commonly isolated from all the yam flour samples irrespective of variety and location were *Bacillus cereus*, *Bacillus subtilis*, *Rhizopus stolonifer*, *Aspergillus flavus*, *Penicilliium oxalicum and Aspergillus niger*.

The predominant bacteria identified in the samples were Bacillus species, isolated from both yam samples obtained at both markets. This prevalence might be attributed to the spores' ability to endure various adverse environmental conditions, enabling their proliferation in a wide range of food products. Bacillus strains have been known to generate cereulide, a heat-resistant compound linked to a syndrome characterized by vomiting-like symptoms [16]. Similarly, reported some cases of food poisoning outbreaks due to consumption of yam flour meals [17]. Isolation of *Rhizopus*, *Aspergillus* and *Penicillium species* in this study are observed to be the most predominant fungi showing that these fungi may be the normal flora of both yam samples. They represent crucial genera of fungi known for their mycotoxin production, carrying significant significance in ensuring food safety due to their capacity to generate mycotoxins that pose diverse health risks [18]. Consequently, these fungi assume a pivotal role, particularly in processes like fermentation, as they possess the capability to produce amylolytic enzymes that facilitate starch breakdown, resulting in the production of acid and ethanol [19]. The potential for yam flours to be contaminated by these fungi holds significant importance within this study, as they are linked to the deterioration of yam chips and flour and other foodstuffs obtained from markets in Ibadan in similar reports [20].

Overall, the study observed a rise in both bacterial and fungal spore counts. The contamination of yam chips may have originated from unsanitary practices where raw yams were extracted from the soil, peeled, washed, soaked, and then laid out on unclean surfaces such as bare ground or swept cement floors for sun drying. This process could lead to contact with soil during drying and other forms of environmental contamination.

Likewise, the negative impact of microbial presence on well-preserved dried yam samples could stem from the choice of storage and packaging materials. This could result from elevated moisture levels in the samples and storage conditions, including temperature and relative humidity, which provide a suitable environment for microbial proliferation. The longer the storage duration, the greater the rise in bacterial and fungal growth. To ensure optimal storage, the samples should be kept at relative humidity levels of 36% - 56% and temperature ranges of 35˚C - 45˚C. The moisture content considered safe for storing flours or powdered food typically falls within the range of 12% to 14%, as advised by [21] [22]. However, this moisture range renders them susceptible to potential microbial contamination. The microbial load's growth and infiltration are also influenced by the choice of packaging material, especially when the packaging material's permeability to atmospheric gases like oxygen, carbon dioxide, and water vapor is conducive to their growth. Additionally, the storage conditions used can further impact this process. The influence of milling and unsanitary practices on yam flour cannot be dismissed, as these practices suggest multiple instances of microorganism contamination within the yam flour due to the actions of processors [23]. The unsanitary procedure involves crushing dried yam chips directly on the floor, which are then swept before being ground into flour. Throughout the milling process, it is of utmost importance for yam flour processors to recognize the significance of routinely cleaning their milling equipment and to refrain from collecting chips or flour that have fallen onto the floor to prevent inadvertent consumption [24]. Local weather conditions significantly influence the growth and spread of bacterial and fungal pathogens. High humidity and frequent rainfall create moist environments that promote spore germination and bacterial proliferation, increasing disease incidence in crops [25]. Conversely, prolonged dry periods or extreme temperatures can suppress microbial activity and limit infection rates [26]. Additionally, severe weather events such as floods or storms may facilitate the dispersal of spores and bacteria, elevating the risk of outbreaks. Thus, understanding local weather dynamics is essential for predicting and managing microbial diseases in agricultural systems.

To effectively manage microbial infections in yam, an integrated approach combining several strategies is essential. The use of certified, disease-free seed yams emerged as a critical intervention, corroborating previous reports that highlight the role of clean planting material in reducing primary inoculum [27]. Crop rotation with non-host species and rigorous field sanitation were shown to significantly decrease pathogen persistence in the soil [28]. Advances in molecular breeding have enabled the development of yam varieties with enhanced resistance to major diseases while it deployment a promising long-term solution for managing both fungal and viral diseases [29]. Chemical control, while still relevant, is now more strategically integrated with cultural and genetic measures to delay resistance development and reduce environmental impact [30]. Efforts should be made to organize sensitization initiatives and enhance awareness regarding food safety [31]. These programs can aid in fostering an understanding among individuals about the potential health hazards linked to unsanitary practices. This is particularly crucial given the rising incidence of food poisoning cases resulting from the consumption of yam flour-based dishes.

5. Conclusion

Over the years, the safety of foods containing flour has faced compromise not only due to pathogenic bacteria but also due to fungal contamination. These factors contribute to various acute and chronic health effects, posing a significant risk associated with the consumption of yam-based products. The negative impact of fungi and bacteria on plants and tubers has even led to shortages in available yam tubers for consumption. To address these concerns, government agencies should conduct regular inspections of markets and processing sites to ensure adherence to established standard operating procedures governing yam flour processing. This proactive approach will assist food regulators in Nigeria in comprehending the practices utilized by dry yam sample producers and sellers. By doing so, they can ensure compliance with best practices and ensure consumers' access to safer yam flour. Furthermore, it is essential to organize sensitization and awareness programs on food safety. These initiatives can help individuals comprehend the potential health risks associated with unsanitary practices, especially in light of the escalating cases of food poisoning attributed to the consumption of yam flour-based meals.

Therefore, this research has further demonstrated that yam products processed and available in the market are susceptible to microbial contamination, potentially posing health risks to humans if consumed without proper cooking. The study focuses on identifying the microbial communities (bacteria and fungi) present in yams and flour sold at two well-known markets in Ibadan, namely Bodija and Ojo-Oba markets. The primary objectives were to measure microbial loads, isolate, and identify bacterial and fungal pathogens. This is evident in the notably elevated microbial counts, ranging from 10^1 to 10^3 times higher, discovered in commercially processed dried water yam and white yam flour samples milled in the laboratory. Additionally, the research underscores the broad array of microorganisms known to be pathogenic to humans and contributors to food spoilage.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Waris, R., Tripathi, S., Shukla, A.C. and Agnihotri, P. (2021) An Overview of the Genus Dioscorea L. (Dioscoreaceae) in India. *Plant Science Today*, **8**, 72-78. https://doi.org/10.14719/pst.2021.8.1.878

[2] Akinwande, B., Abiodun, O., Adeyemi, I. and Akanbi, C. (2009) Effect of Steaming Method and Time on the Physical and Chemical Properties of Flour from Yam Tubers. *Nigerian Food Journal*, **26**, 97-105. https://doi.org/10.4314/nifoj.v26i2.47443

[3] González Ramírez, J.E. (2019) Yam's Potentials as Basis of Nutritional Security Programs in Underdeveloped Tropical Regions. *Biomedical Journal of Scientific & Technical Research*, **20**, 15149-15153. https://doi.org/10.26717/bjstr.2019.20.003474

[4] Abiodun A, A., Bolanle O, O. and Sola, O. (2012) Preliminary Studies on the Development and Evaluation of Instant Pounded Yam from Dioscorea Alata. *Journal of Applied Science & Environmental Management*, **16**, 287-290.

[5] Ilesanmi, O.S. and Adewale, I.O. (2020) Physicochemical Properties of Free and Immobilized Tyrosinase from Different Species of Yam (*Dioscorea spp*). *Biotechnology Reports*, **27**, e00499. https://doi.org/10.1016/j.btre.2020.e00499

[6] Oluwagbenga, A.O., Adedotun, A.A., Temitope, S.O. and Margaret, E.A. (2014) Studies on Fungi Isolated from Dioscorea Rotundata (YAM) Collected from Open Mar-

kets in Lagos Nigeria. *International Journal of Phytopathology*, **3**, 139-147. https://doi.org/10.33687/phytopath.003.03.0857

[7] Saranraj, P., Behera, S.S. and Ray, R.C. (2019) Traditional Foods from Tropical Root and Tuber Crops. In: Galanakis, C.M., Ed., *Innovations in Traditional Foods*, Elsevier, 159-191. https://doi.org/10.1016/b978-0-12-814887-7.00007-1

[8] Wondimu Fufa, T., Ogba Oselebe, H., Veronica Nnamani, C., Azubuike Afiukwa, C. and Aniedi Uyoh, E. (2021) Systematic Review on Farmers' Perceptions, Preferences and Utilization Patterns of Taro [*Colocasia esculenta* (L.) Scott] for Food and Nutrition Security in Nigeria. *Journal of Plant Sciences*, **9**, 224-233. https://doi.org/10.11648/j.jps.20210904.23

[9] Fisayo, O.O. and Onoyinka, A.A. (2023) Cyanide Content and Physical Properties of Commercial "Gaari" Samples from Different Markets in Ibadan, Oyo State, Nigeria. *African Journal of Food Science and Technology*, **14**, 1-7.

[10] Olatunde, G.O. (2024) Importance of Food and Culture in Nigeria with Special Reference to Yam. In: Aworh, O.C., Owusu-Darko, P.G., *et al*., Eds., *Nutritional and Health Aspects of Food in Western Africa*, Elsevier, 133-137. https://doi.org/10.1016/b978-0-443-27384-1.00013-9

[11] Kokoh, A.A., Konan, B.N.B., Gnoumou, J.I.K., Elleingand, E. and Koffi, E. (2022) Effect of Incorporation of Yam Flour and Moringa Powder in Wheat Bread on Glycemic Response. *Food and Nutrition Sciences*, **13**, 781-796. https://doi.org/10.4236/fns.2022.139056

[12] Ezeibekwe, I.O. and Ibe, A.E. (2010) Fungal Organisms Associated with Yam (Dioscorea Rotundata, Poir) Rot at Owerri, Imo State of Nigeria. *Journal of Molecular Genetics*, **2**, 1-5. https://doi.org/10.3923/jmolgene.2010.1.5

[13] Akintunde, F.C., Kabiru, U.A., Olasunkanmi, T.C. and Olisa, B.S. (2023) Molecular Characterization and Stress Tolerance Level of Nitrogen-Fixing Azotobacter Strain isolated from Oryza Sativa. *International Journal of Biological and Pharmaceutical Sciences Archive*, **6**, 1-8.

[14] Babajide, O.M., Oyewole, O.A. and Obadina, O.B. (2006) An Assessment of the Microbiological Safety of Dry Yam (Gbodo) Processed in South West Nigerian. *African Journal of Biotechnology*, **6**, 157-161.

[15] Akintunde, F.C., Chukwudi, U.S., and Anjorin, T.S. (2023) Mycobiota Incidence of Cowpea (*Vigna unguiculata* L. Walp) Seeds in Nigeria. *International Journal of Agriculture and Technology*, **3**, 1-5. https://doi.org/10.33425/2770-2928.1018

[16] Hoton, F.M., Fornelos, N., N'Guessan, E., Hu, X., Swiecicka, I., Dierick, K., *et al.* (2009) Family Portrait of *Bacillus cereus* and *Bacillus weihenstephanensis* Cereulide-Producing Strains. *Environmental Microbiology Reports*, **1**, 177-183. https://doi.org/10.1111/j.1758-2229.2009.00028.x

[17] Ojo, O.F. and Afolayan, A.O. (2023) Contamination of Retailed Yam Products at Two Popular Markets in Ibadan with *Pseudomonas Spp*, *Enterobacter Spp* and *Flavobacterium Spp*. *International Journal of Agriculture and Technology*, **3**, 1-7. https://doi.org/10.33425/2770-2928.1019

[18] Abu, M. and Adzigiwe, K.F. (2021) Possible Causes of Health Disorders in Stored Yam at Farm Gate. *Agricultural Sciences*, **12**, 960-976. https://doi.org/10.4236/as.2021.129062

[19] Zang, Z., Gong, X., Cao, L., Ni, H. and Chang, H. (2024) Resistant Starch from Yam: Preparation, Nutrition, Properties and Applications in the Food Sector. *International Journal of Biological Macromolecules*, **273**, Article 133087. https://doi.org/10.1016/j.ijbiomac.2024.133087

[20] Jimoh, K.O. and Kolapo, A.L. (2008) Mycoflora and Aflatoxin Production in Market Samples of Some Selected Nigerian Foodstuffs. *Research Journal of Microbiology*, **3**, 169-174. https://doi.org/10.3923/jm.2008.169.174

[21] Sanni, L., Maziya-Dixon, B., Akanya, J., Okoro, C.I., Alaya, Y., *et al*. (2005) Standards for Cassava Products and Guidelines for Export. IITA, 93.

[22] Standard Organization of Nigeria (2004) Standard for Edible Cassava Flour (Standards No. 344). Nigerian Industrial.

[23] Somorin, Y.M., Bankole, M.O., Omemu, A.M. and Atanda, O.O. (2011) Impact of Milling on the Microbiological Quality of Yam Flour in Southwestern Nigeria. *Research Journal of Microbiology*, **6**, 480-487. https://doi.org/10.3923/jm.2011.480.487

[24] Adedoyin, O.T., Ojuawo, A., Adesiyan, O.O., Mark, F. and Anigilaje, E.A. (2008) Poisoning Due to Yam Flour Consumption in Five Families in Ilorin, Central Nigeria. *Pan African Medical Journal*, **27**, 41-43.

[25] Ramkumar, Chaudhary, M., Sahu, P., Singh, K., Kumar, R., Shukla, A., *et al*. (2025) Effect of Humidity on Pest and Disease Incidence in Crops. In: Singh, A., Pandey, S. and Kumar, A., Eds., *Climate Change and Biotic Factors*, Apple Academic Press, 3-42. https://doi.org/10.1201/9781003568704-2

[26] Frey, S.D., Lee, J., Melillo, J.M. and Six, J. (2013) The Temperature Response of Soil Microbial Efficiency and Its Feedback to Climate. *Nature Climate Change*, **3**, 395-398. https://doi.org/10.1038/nclimate1796

[27] Agre, P.A., Edemodu, A., Obidiegwu, J.E., Adebola, P., Asiedu, R. and Asfaw, A. (2023) Variability and Genetic Merits of White Guinea Yam Landraces in Nigeria. *Frontiers in Plant Science*, **14**, Article 1051840. https://doi.org/10.3389/fpls.2023.1051840

[28] Dou, Y., Yu, S., Liu, S., Cui, T., Huang, R., Wang, Y., *et al*. (2025) Crop Rotations Reduce Pathogenic Fungi Compared to Continuous Cropping. *Rhizosphere*, **34**, Article 101074. https://doi.org/10.1016/j.rhisph.2025.101074

[29] Oyedoyin, F.P., Olawuyi, O.J., Agre, P.A. and Asfaw, A. (2025) Molecular and Agro-Morphological Evaluations of Interspecific Hybridisation in Two Wild Yams (*Dioscorea spp*.) for Genetic Improvement. *Ecological Genetics and Genomics*, **35**, 100345. https://doi.org/10.1016/j.egg.2025.100345

[30] Aighewi, B.A., Kumar, P.L., Aihebhoria, D., Amah, D., Maroya, N.G., *et al*. (2025) Rapid Propagation of Yam Using Leaf-Bud Cuttings: A Manual. International Institute of Tropical Agriculture, 52.

[31] FAOSTAT 2022. https://www.fao.org/3/cc2211en/online/cc2211en.html