PROXIMATE AND MICROBIAL ANALYSIS OF YELLOW, WHITE AND SPOILT GARRI SOLD IN OWERRI, IMO STATE, NIGERIA.

ABSTRACT

This study explored the proximate and microbial composition of garri, a widely consumed starchy food in West Africa, particularly in Nigeria, Ghana, and neighboring countries. Garri, derived from cassava, is esteemed for its extended shelf life, cost-effectiveness, and nutritional value, holding a significant place in West African diets. Samples of yellow and white garri, including spoilt variations, were procured from four distinct local markets (Obinze, Relief, Eke Ukwu, and Ihiagwa) and subjected to thorough analysis using standard methods. Proximate analysis encompassed key components such as ash content, moisture, fiber content, lipids, protein, carbohydrates, and energy in both white and yellow garri from different markets. White garri exhibited a higher ash content (1.70±0.58%) than yellow garri (1.27±0.24%). Moisture content was greater in white garri (15.74±0.23%) compared to yellow garri (12.55±0.57%). Fiber content was 9.12±0.23% in yellow garri and 8.018±0.09% in white garri. Lipid content was 0.33±0.46% in yellow garri and 0.09±0.18% in white garri. Protein content showed values of 0.50±0.89% for yellow garri and 0.66±0.38% for white garri. Carbohydrate content was 76.91±0.71% in yellow garri and 74.91±0.067% in white garri. Energy content (KJ/100g) was 960.59±0.93 for yellow garri and 1268.18±0.39 for white garri. Microbial analysis conducted on the samples from each market revealed bacterial load of various ranges. Fresh white garri bacterial loads ranged from 3.25±0.83 log10 CFU/g (Ihiagwa) to 3.93±0.67 log CFU/g (Eke Ukwu). Fresh yellow garri bacterial loads ranged from 2.27±0.43 log CFU/g (Ihiagwa) to 2.92±0.54 log CFU/g (Eke Ukwu). Statistical analysis indicated no significant difference ($P>0.05$) in bacterial loads between white and yellow garri. Spoilt white garri bacterial loads ranged from 5.27±0.56 log CFU/g (Ihiagwa) to 5.93±0.43 log CFU/g (Eke Ukwu), and a similar trend was observed for spoilt yellow garri (5.34±0.46 log CFU/g to 5.95±0.16 log CFU/g). The study identified bacteria isolates, including *Bacillus* spp, *Staphylococcus* spp, and *Streptococcus* spp. This study underscores the importance of educating producers and sellers on proper processing and handling procedures to enhance the microbial quality and safety of garri products. The high microbial load and presence of some pathogenic microorganisms in the garri samples should serve as great eye-opener to the consumers of raw garri.

Keywords: **Garri, Moisture, Proximate, Microorganisms, Fibre.**

1.0 INTRODUCTION

Garri is a popular and widely consumed processed product derived from cassava (Manihot esculenta Crantz) tubers, and it holds significant cultural, economic, and nutritional importance in Nigeria and other West African countries. The production and consumption of garri have deep historical roots, making it a staple in the diets of many communities in the region (Awoyale *et al.,*

2021). The production of garri involves several stages, including harvesting, peeling, washing, grating, fermentation, dewatering, and roasting. The cassava tubers are first harvested and peeled, after which they are washed to remove dirt and other impurities. The peeled and washed cassava is then grated to create a mash, which undergoes a fermentation process to reduce cyanogenic content and enhance flavour (Oluwafemi and Udeh, 2016).

Most of the cassava harvested from farms in Nigeria are being processed into Garri. The production of garri involves several stages, including harvesting, peeling, washing, grating, fermentation, dewatering, and roasting. The cassava tubers are first harvested and peeled, after which they are washed to remove dirt and other impurities. The peeled and washed cassava is then grated to create a mash, which undergoes a fermentation process to reduce cyanogenic content and enhance flavour. The fermented mash is pressed to remove excess water, and the resulting semisolid mass is sieved to obtain granules. These granules are then roasted, traditionally over an open flame, to produce the final product – garri. The roasting not only dries the granules but also imparts a distinct flavor and characteristic texture to the garri (Okafor *et al*., 2018; Okolo and Makanjuola, 2021).

Garri is renowned for its rich starch content, high fiber levels, and inclusion of essential vitamins, as highlighted by Adepoju *et al*. (2010). The significant fiber content in garri contributes to its satiating quality, potentially aiding in the prevention or reduction of constipation and bowel diseases (Adepoju *et al*., 2010).

Despite its nutritional benefits, the microbial growth, deterioration, and spoilage of garri pose substantial risks to public health and can lead to foodborne illnesses (Ogiehor *et al*., 2007). The production and processing of cassava to garri, along with post-processing practices such as spreading on floors and mats after frying, displaying openly in markets, and using various packaging materials for transportation, can introduce opportunities for contamination (Ogiehor *et al*., 2007; Ogugbue and Obi, 2011; Ogugbue *et al*., 2011).

Unhygienic practices in handling, sales, and transportation include the use of bare hands, which may contribute to microbial contamination through the deposition of bio-aerosols on exposed products and the transfer of infectious agents during these processes (Ogiehor *et al.,* 2007; Ogugbue and Obi, 2011; Ogugbue *et al*., 2011). It is imperative to address these hygiene

concerns in the production, processing, and marketing of garri to ensure its safety for consumption and to mitigate the potential health risks associated with microbial contamination.

Proximate composition refers to the basic components of a food product, including moisture, protein, fat, fibre, ash, and carbohydrates. Over the years, research efforts have been directed towards characterizing the proximate composition of various species of garri and derived products to unravel the effects of processing methods, environmental factors, and genetic diversity on their nutritional profiles (Nzuta*et al*, (2022), Okonkwo*et al*., 2021).

Consuming "Garri" dry as snacks or with cold water can pose health risks primarily due to potential microbial contamination. Microorganisms, such as bacteria, viruses, fungi or toxins, may be present in the "Garri," and if ingested, they can lead to various health issues.Thus, there is a need to ascertain and evaluate the microbiological quality of garri produced and sold within Owerri to ascertain their safety.

2.0 MATERIALS AND METHOD

2.1 Sample Collection

Yellow and white garri including spoilt yellow and spoilt white garri samples were purchased from different local markets (Obinze, Relief, Eke Ukwu Owerri, and Ihiagwa) in Owerri for this research. A total of 160 garri samples were collected, 10 each for the various garri specifications (Fresh yellow, fresh white, spoilt yellow, spoilt white) across the four markets. These samples were collected randomly from 10 different selling points at each of the markets without any bias. The samples were collected aseptically into sterile polyethylene bags and were transported to the laboratory for analysis within two hours of collection.

2.2 Sample Preparation and Inoculation

The method reported by Obi *et al.* 2022 was used. About 1 g of each garri sample was suspended in 9mls of distilled water in a test tube, the samples were homogenized and a ten (10) fold serial dilution technique was employed by dispensing 1ml of the suspension into another 9 ml of distilled water up to the 10^{th} test tube. 1ml of the diluents was taken and placed on an already prepared Nutrient Agar petri dish. The nutrient agar was incubated at 35°C for 24 hours. The growth was observed by colony appearance on the incubated nutrient agar and the bacteria colony was counted and the samples were subcultured to obtain pure isolates. Each bacteria

colony that appeared on the culture plates was counted with the aid of a colony counter and recorded as a colony-forming unit (cfu/g).

All isolates were sub-cultured and transferred to a slanted media to obtain a pure culture where a gram staining and other biochemical tests such as catalase test, coagulase test, methyl red test, indole test, citrate utilization, and Sugar fermentation test were conducted to identify the isolates based on the method described by Cheesbrough (2004).

Proximate Analysis of Garri

A portionof the garri samples was analyzed for proximate contents: moisture, lipid, ash, proteins, fibre and carbohydrates using the Association of Official Analytical Chemists procedures (AOAC, 2005).

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of yellow and white garri. White garri had higher contents of Ash (1.7±0.58%), Moisture (15.74±0.23%), Protein (0.66±0.38%) and Energy (1268.18±0.39 Kg/100g) than yellow garri with Ash (1.27±0.24%), Moisture (12.55±0.57%), Protein (0.50±0.89%) and Energy (960.59±0.93 kj/100g). Fibre, lipid and carbohydrates contents were higher in yellow garri with values of 9.12±0.23%, 0.33±0.46% and 76.91±0.7% respectively while white garri had 8.01±0.09%, 0.09±0.18% and 74.91±0.67 for fibre, lipid and carbohydrates respectively.

Table 1: Proximate Composition of Garri Sample

Parameter	Ash (%)	Moisture (%)	Fibre (%)	Lipid (%)	Protein (%)	CHO (%)	Energy (KJ/100)
Yellow Garri	1.27±0.24	12.55±0.057	9.12±0.23	0.33±0.46	0.50±0.89	76.91±0.71	960.59±0.93
White Garri	1.70±0.58	15.74±0.23	8.018±0.09	0.09±0.18	0.66±0.38	74.91±0.67	1268.18±0.39

Table 2 shows the total heterotrophic count (log cfu/g) of isolates from various garri samples across the four markets. Eke Ukwu Owerri market had the higest number of isolates for both fresh and spoilt garri varieties with values of 3.93±0.67 and 2.95±0.87 for fresh white garri and fresh yellow garri respectively while spoilt yellow and spoilt white garri had 5.95±0.16 and 5.93±0.43 respectively. Relief market had 3.81±0.67 and 2.92±0.2 for fresh white and fresh yellow garri respectively while 5.94±0.49 and 5.87±0.51 for spoilt yellow and spoilt white respectively. Obinze market had fresh white (3.46±0.45) fresh yellow (2.47±0.43) spoilt yellow (5.50±0.98) spoilt white (5.77±0.78). ihiagwa market had the least microbial load with fresh white garri (3.25±0.83), fresh yellow (2.27±0.43), spoilt yellow (5.34±0.46) and spoilt (5.27±0.56).

Table 2: Total heterotrophic count (log cfu/g) of isolates from various Garri Samples Across the four markets.

Market	**Garri sample**	**Log 10 CFU/g**
Obinze	Fresh white	3.46±0.45
	fresh Yellow	2.47±0.43
Relief	Fresh white	3.81±0.67
	fresh Yellow	2.92±0.54
Eke Ukwu	fresh white	3.93±0.67
	fresh yellow	2.95±0.87
Ihiagwa	Fresh white	3.25±0.83
	fresh yellow	2.27±0.43
Obinze	Spoilt Yellow	5.50±0.98
	Spoilt White	5.77±0.78
Relief	Spoilt Yellow	5.94±0.49
	spoilt white	5.87±051
Eke Ukwu	Spoilt Yellow	5.95±0.16
	Spoilt White	5.93±0.43
Ihiagwa	Spoilt Yellow	5.34±0.46
	Spoilt White	5.27±0.56

Table 3 shows the distribution of isolates across the various market. Obinze market had two *Bacillus* spp, relief market had two bacterial isolates, 4 *Bacillus* spp and a *S. aureus*. Eke Ukwu had 4 *Bacillus* spp, 3 *S. aureus* spp and 2 *Streptococcus* spp while Ihiagwa market had only *S. aureus* spp

Table 3: Distribution of Isolates Across the Markets

	OBINZE Market				Relief				Eke Ukwu				Ihiagwa			
Isolate	FW	FY	SW	SY	FW	FY	SW	SY	FW	FY	SW	SY	FW	FY	SW	SY
Bacillus spp	+	+ -	-	-	+	+	+	+	+	+	+	+	-	-	-	-
S. aureus	-		-	-	-	-	-	-	+	-	+	+	+	-	-	-
Streptococcus spp	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-	-

Figure 1 shows the distribution of isolates across the garri samples. Fresh white garri had 3 *Bacillus* spp and a *S. aureus*. Fresh yellow garri had only *Bacillus* spp. Spoilt white garri had 2 *Bacillus* spp, 2 *Streptococcus* spp and a *S. aureus*. Spoilt yellow garri had 2 *Bacillus* and 2 *S. aureus* spp and a *Streptococcus* spp.

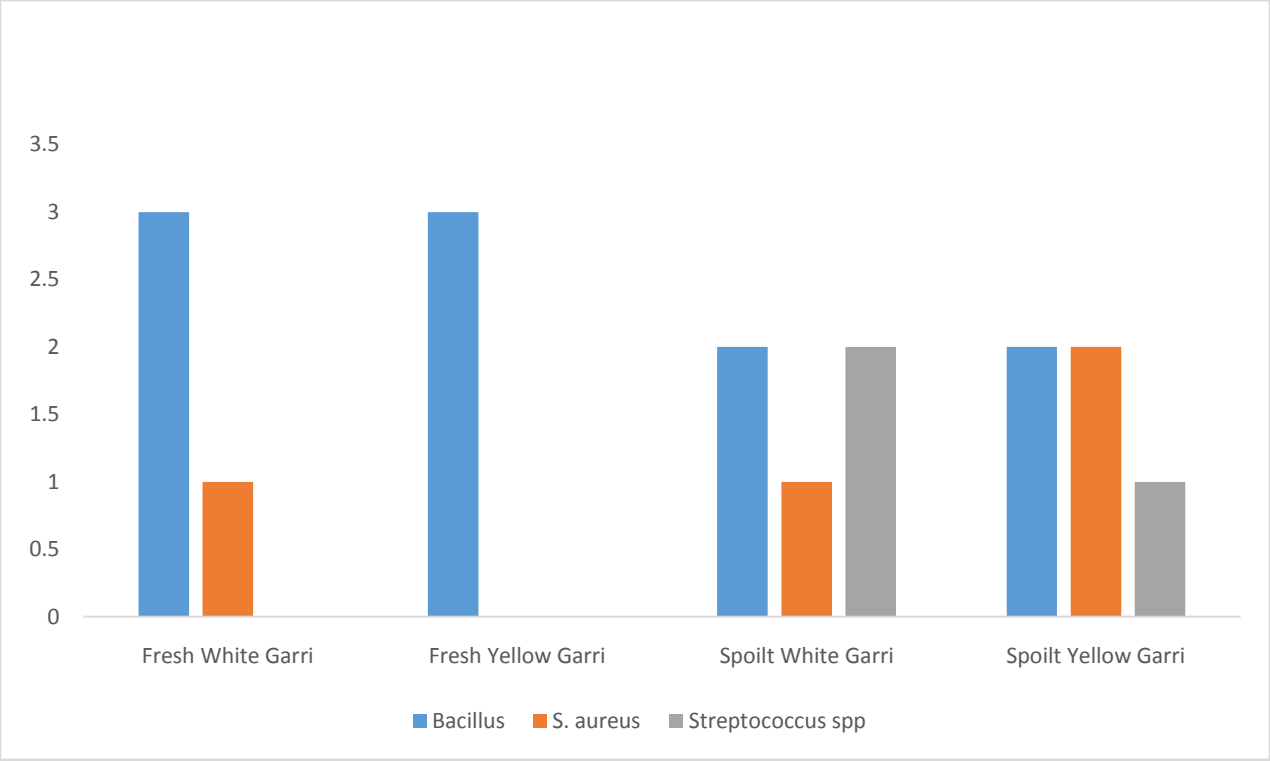

Fig 1:Distribution of Isolates in the Various Garri Samples

Figure 2 shows the percentage distribution of isolates *Bacillus* spp had 59% occurrence while 23 % and 18 % occurrence were recorded for *S. aureus* spp and *Streptococcus* spp respectively.

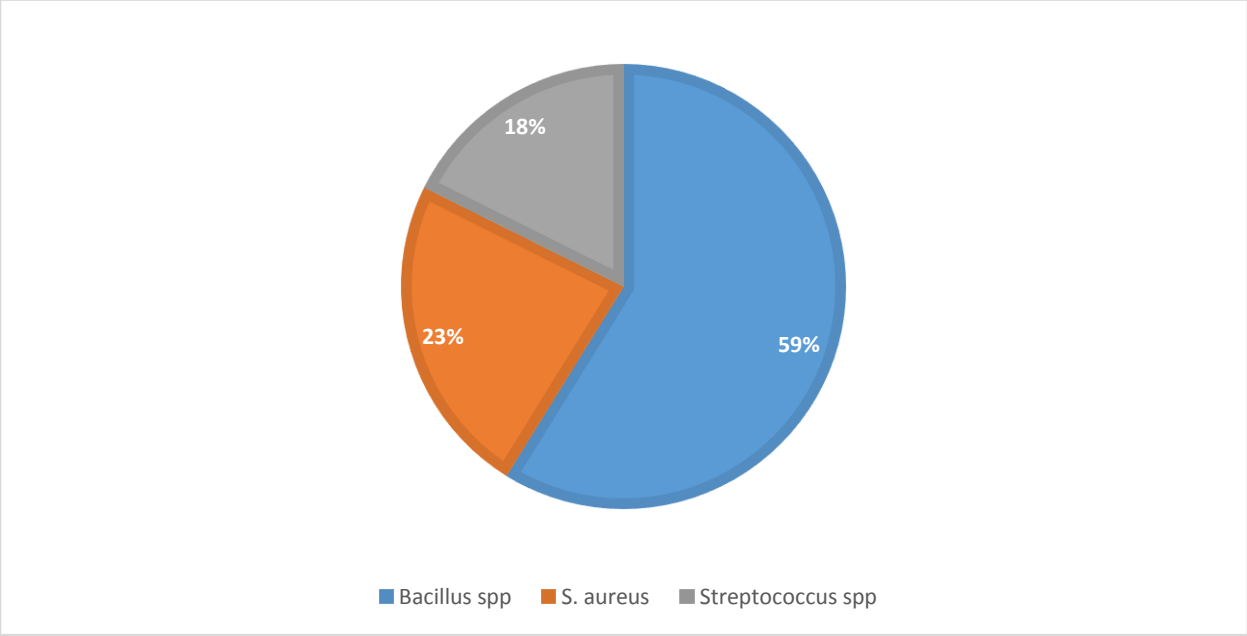

Fig 2: Percentage Distribution of Isolates

Garri stands as a fundamental dietary staple in Nigeria and several other African nations, constituting a substantial 70% of the total cassava production in Nigeria (Olopade *et al.*, 2014). Given its widespread consumption across households in Nigeria and the broader West African region, it is imperative to uphold stringent sanitary conditions to prevent potential contamination with microorganisms, thereby mitigating associated health risks.

Notably, the moisture content observed in garri samples aligns with established standards, and it is relatively low. This adherence to standard specifications may play a significant role in maintaining a low microbial load in garri. The controlled moisture levels likely contribute to the preservation of garri's overall quality and safety, reflecting the importance of adherence to proper processing and storage practices to ensure the microbiological integrity of this essential food product (Olopade *et al*., 2014). Excessive moisture contents attract high bacterial growth because of increased water activity. Following the Codex Alimentarius Commission for garri, the ash contents obtained were within the permissible limit (CODEX STAN 151 - 1989).Moisture is an important parameter in the storage of cassava flour. Very high levels greater than 12% allow for microbial growth and thus low levels are favourable and give a relatively longer shelf life (Rojas *et al*., 2007).

Crude ash content is usually indicative of inorganic constituents (minerals such as K, Zn and Ca) and generally including cassava, it ranges from 1% to 2%. Ash contents represent the total mineral content in food after it has been burnt at a very high temperature. The ash contents reported in previous studies: 1.90 – 2.84% (Eleazu, *et al*., 2012) and 1.44 – 2.35% (Kanwate*et al.,* 2019) are relatively higher as compared to the result obtained in the current study. The differences in reported ash contents could be attributed to differences in dry matter contents, genotypic form of the raw cassava roots and their proximate composition. It has been reported that higher dry matter contents were associated with lower ash contents (Omowonuola*et al*., 2017)

This study underscores a prevalent poor sanitary state in the production and handling of garri within the examined areas, creating conditions conducive to contamination and infestation by microorganisms. The bacterial isolates identified in this study hold medical significance, as they have been linked to various human ailments (Prescott *et al*., 2002).

Staphylococcus aureus, recognized as a typical commensal in human microbiota and a constituent of normal human flora (Prescott *et al*., 2002; Mohammed *et al.,* 2019), was isolated in the garri samples. Its presence indicates potential contamination during processing and handling, likely due to direct contact or airborne transmission methods such as coughing or sneezing by producers (Okolo and Makanjuola, 2021). Given the association of *Staphylococcus aureus* with foodborne illnesses, especially when transmitted through bare hands, its presence raises concerns about the safety of the garri samples.

The identification of *Streptococcus* sp., and *Bacillus* sp. in the garri samples is noteworthy, as these bacteria have been implicated in food infections and intoxications leading to various forms of diarrheal diseases, particularly affecting vulnerable populations such as young children, the elderly, and individuals with compromised immune systems (Prescott *et al.,* 2002; Olopade *et al*., 2014; Okolo and Makanjuola, 2021). Given that the processing of garri often involves minimal or no heat treatment, the toxins produced by *Bacillus* sp. and *Staphylococcus aureus*, if present, can remain heat stable. Consequently, the consumption of contaminated garri poses a potential health risk to consumers (Ogiehor *et al*., 2007).

In addition to death and ill health caused by food poisoning, individuals, families, health care system and society, as well as commercial enterprises incure tremendous economic lost. These lost include, loss of income due to the cost of medical care, the cost of investigating food contamination outbreaks, loss of income due to closure of business, legal costs and fine (Baine, 2000). Hence taking “Garri” dry as snacks or with cold water as witnessed by poor and middle class citizens in Nigeriais exposure to health risk due to the microbial status."Garri," being a starchy food product, can provide an environment conducive to the growth of microorganisms, including bacteria and fungi (Egbuobi*et al*., 2015).

The findings of this study underscore the importance of improving sanitary conditions throughout the production and handling of garri to minimize the risk of microbial contamination and safeguard the health of consumers. Addressing these concerns is crucial for ensuring the safety and quality of this widely consumed staple food.

CONCLUSION

The findings of this study uncover a concerning scenario of elevated microbial load and the presence of various bacterial isolates in garri produced and marketed in Owerri, Imo State. The abundance of these microorganisms poses potential threats to human health, raising apprehensions about the safety of garri consumption. These microbial issues may originate from suboptimal processing conditions, inadequate handling techniques, limited technical expertise among handlers, compromised hygiene practices, and inadequate safety measures for finished products.

To address these concerns, it is strongly recommended that garri be sold in well-packaged bags rather than being exposed to the air in basins or bowls, as commonly observed in various production areas and markets. Packaging plays a crucial role in preventing contamination during storage and transportation, thereby enhancing the overall safety of the product.

Furthermore, the implementation of stringent measures such as quality control, quality assurance, good manufacturing practices (GMP), and hazard analysis critical control point (HACCP) principles is essential. These measures can significantly contribute to ensuring the safety of garri throughout its production and consumption processes. Rigorous application and enforcement of these standards will serve to mitigate the risks associated with microbial contamination, ultimately safeguarding the health of the numerous consumers of garri in Owerri, Nigeria.

The study underscores the urgency of adopting and enforcing robust safety measures in the production and marketing of garri. Implementing these recommendations will not only enhance the safety of the product but also contribute to the overall well-being of the local population that relies on garri as a staple food.

With the findings from this research which revealed genre pathogenic microorganisms, members of the public should avoid or minimize their rate of consumption (drinking) of raw garri and adopt better preparation methods.

REFERENCES

Adepoju, O. T., Adekola, Y. G., Mustapha, S. O., & Ogunola, S. I. (2010). Effects of processing methods on nutrient retention and contribution of cassava to nutrient intake of Nigerian consumers. African Journal of Biotechnology, 7(24), 4591-4594.

Association of Official Analytical Chemists (AOAC). (2005). Official methods of analysis of the Association of Analytical Chemists International (18th ed.). AOAC, Gaithersburg, MD.

Awoyale, W., Oyedele, H., Adenitan, A. A., Alamu, E. O., & Maziya-Dixon, B. (2021). Comparing the functional and pasting properties of garri and the sensory attributes of the Eba produced using back slopped and spontaneous fermentation methods. Cogent Food & Agriculture, 7(1), 188-197.

Baine, W.E (2000). Food borne Disease: A Focus for Health Education (2nd Edition) ASSA publishers pp.1-34

Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries: Part 2. Cambridge University Press, Great Britain, 62-70.

Codex STAN 151. (1989). (Rev. 1 -1995). Codex standard for gari, 1-6.

Egbuobi, R. C., Dike-Ndudim, J., Ojiegbe, G. C., Okorie, H. M., Nnodim, J. K., &Ogamka, A. I. (2015). Bacteriological quality of garri sold in owerri open markets, imo state, nigeria. African Journal of Food Science, 9(4), 252-256. https://doi.org/10.5897/ajfs2014.1204

Eleazu, C., &Eleazu, K. (2012). Determination of the proximate composition, total carotenoid, reducing sugars, and residual cyanide levels of flours of 6 new yellow and white cassava (*Manihotesculenta*Crantz) varieties. *American Journal of Food Technology, 7*, 642–649.

Kanwate, B. W., Ballari, R. V., &Kudre, T. G. (2019). Influence of spray-drying, freeze-drying and vacuum-drying on physicochemical and functional properties of gelatin from *Labeorohita* swim bladder. *International Journal of Biological Macromolecules, 121*, 135-141.

Mohammed, Y. M., & Adamu, K. M. (2019). Bacteria associated with some freshwater fishes in Dangana Lake Lapai, Nigeria. Jewel Journal of Scientific Research, 4(1&2), 83–90.

Nzuta, R. A., Elechi, J. O., Isa, I. S., Kittika'a, H. J., & Thomas, C. T. (2022). Flour and Cassava (Manihotspp) Cultivars in Nigeria: Understanding their Chemical Functionalities and Acceptability in Food Systems. *International Journal of Scientific Research in Chemical Sciences, 9*(2), 20-29

Obi, P. U., Mohammed, Y. M., Okeke, K. S., Ibrahim, N. J., Ajayi, M. A., Benedict, A. U., & Umar, M. (2022). Microbial Analysis and Sensory Attributes of Garri Produced and Marketed in Bida Niger State, Nigeria. Journal of Applied Science and Environmental Management, 26(6), 1007-1013.

Ogiehor, I. S., Ikenebomeh, M. J., & Ekundayo, A. O. (2007). The bioload and aflatoxin content of market garri from some selected states in southern Nigeria: public health significance. African Health Sciences, 7(4), 223-227.

Ogugbue, C. J., & Obi, G. (2011). Bioburden of garri stored at different packaging materials under tropical market conditions. Middle East Journal of Scientific Research, 7, 741-745.

Ogugbue, C. J., Mbakwem-Aniebo, C., & Akubuenyi, F. (2011). Assessment of microbial garri contamination of post-processed garri on sale in markets. African Journal of Food Science, 5, 503-512.

Okolo, E., & Makanjuola, A. T. (2021). Microbial evluation of garri sold within Ahmadu Bello University Main Campus, Samaru, Zaria, Kaduna State. Science World Journal, 16(3), 259-265.

Okonkwo, C. E., Olaniran, A. F., Adeyi, O., Adeyi, A. J., Ojediran, J. O., Adewumi, A. D., &Erinle, O. C. (2021). Drying characteristics of fermented- cooked cassava chips used in the production of complementary food: Mathematical and Gaussian process regression modeling approaches. *Journal of Food Process Engineering, 44*(7), e13715.

Oluwafemi, G. I., & Udeh, C. C. (2016). Effect of fermentation periods on the physicochemical and sensory properties of garri. IOSR Journal of Environmental Science, Toxicology and Food Technology, 10(1), 37-42.

Olopade, B. K., Oranusi, S., Ajala, R., & Olorunsola, S. J. (2014). Microbiological quality of fermented Cassava (Garri) sold in Ota Ogun State Nigeria. International Journal of Current Microbiology and Applied Sciences, 3(3), 888-895.

Omowonuola, A. O. A., Mary, E. M., Fidelis, A. F., Olalekan, A. S. A., & Sunday, A. A. (2017). Quality characteristics of fermented cassava flour (Lafun) produced using backslopping method. *EC Nutrition, 7*(2), 52-57.

Prescott, L. M., Harley, J. P., & Klein, D. A. (2002). Food and Industrial Microbiology. In Microbiology (5th ed.). The WCB McGraw-Hill Companies, Boston, USA.

Rojas, C. C., Nair, B., Herbas, A., &Bergenståhl, B. (2007). Proximal composition and mineral contents of six varieties of cassava (*Mannihotesculenta*, Crantz), from Bolivia. *RevistaBoliviana de Química, 24*(1), 71-77.