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MICROBIAL EVALUATION OF GARRI SOLD WITHIN AHMADU BELLO UNIVERSITY MAIN CAMPUS, SAMARU - ZARIA, KADUNA STATE

E. Okolo* and A.T. Makanjuola

[1]Department of Microbiology, Faculty of Science, Federal University Lokoja, Kogi State, Nigeria
[2]Department of Microbiology, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

*Corresponding Author Email Address: estherokolo25@gmail.com

ABSTRACT
Garri is a commonly consumed cassava product in Nigeria. Poorly processed/stored garri could pose serious health risk to consumers. This study evaluated the microbial loads of garri sold within Ahmadu Bello University main campus, Samaru, Zaria, Kaduna State. Thirty garri samples were randomly collected from three major markets within Ahmadu Bello University, main campus, Samaru and subjected to proximate, functional and microbiological analyses using standard techniques. The ranges for proximate compositions were 2.46 – 2.88 % (moisture), 1.35 – 1.62 % (ash), 6.85 – 8.20 % (lipid), 2.47 – 3.45% (proteins), 1.32 – 1.54 % (fibre) and 84.14 – 86.36 % (carbohydrate). Mean swelling and water absorption capacities were within the ranges of 2.98 – 3.10 % and 4.66 – 5.03 % respectively. A range of 4.60 – 5.00 was observed for pH. There were no significant differences at $p>0.05$ among the proximate, functional and pH values except for the mean total aerobic plate counts (9.5×10^3 CFU/g – 6.7×10^4 CFU/g) and total fungal counts (1.0×10^3 CFU/g – 2.0×10^3 CFU/g) that were significantly different. The bacterial isolates were *Micrococcus* sp., *Escherichia coli*, *Klebsiella* sp., *Lactobacillus* sp., *Enterobacter* sp., *Staphylococcus aureus*, *Enterococcus* sp. *Pseudomonas* sp., *Streptococcus* sp., *Shigella* sp. and *Bacillus* sp. while the fungal isolates were *Rhizomucor* sp., *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* sp., *Mudurella* sp. and *Candida* sp. Some of the isolates are of public health concerns and thus, there is need for *garri* processors/retailers to maintain stricter environmental and personal hygiene to reduce microbial contaminations.

Keywords: Garri, swelling capacity, proximate, bacterial count, fungal count, public health.

INTRODUCTION

Garri is a well-known processed product of cassava (*Manihot esculenta Crantz*) tubers. It is one of the commonly consumed cassava products in Nigeria and other West African countries (Tonukari, 2004). Other products derived from roots of cassava plants are 'starch', 'lafun', 'tapioca', 'fufu', and 'attieke' (Awoyale *et al*., 2021). *Garri* is the most preferred cassava product because it is less expensive, less bulky, easy to cook and not readily perishable (FAO, 2010; Samuel and Ugwuanyi, 2014; Oluwafemi and Udeh, 2016). Adebayo *et al*. (2012) observed that almost all the cassava roots harvested from plantations in Nigeria were processed into garri. Processing of cassava roots to obtain garri is done in different ways depending on the locality and usage but the general process for commercial production of garri involves harvesting the matured cassava roots, peeling the roots, washing the peeled roots, grinding the washed roots, de-watering the mash, fermenting the mash, wet sieving the fermented mash, dry-frying/roasting, open air-cooling on floor or mat and packaging for sale (Adebayo *et al*., 2012; Okafor *et al.,* 2018). Consumption of garri varies with localities and transverses the low, middle and high class both in urban and rural areas (Tamang *et al*., 2016). They are generally consumed soaked in water along with dried fish or groundnut or coconut or beans cake/puddin ('akara'/'moimoi') or soaked in hot water to make 'eba' and taken with soup.

The processing conditions, retailing containers, storage containers and conditions could serve as veritable critical point of contamination of garri (Koledoye *et al*., 2012; Bamidele *et al.,* 2014; Akindele *et al.,* 2018). Microorganisms of public health importance such as *Staphylococcus aureus, Escherichia coli*, *Salmonella* sp., *Shigella* sp., *Aspergillus* sp., *Cladosporium* sp., and *Fusarium* sp. have been isolated from stored, retailed and ready-to-eat garri from some communities in Nigeria (Ogbonna *et al.,* 2017; Okafor *et al*., 2017). To date garri is still being consumed largely in students' communities without any form of thermal treatment which may expose them to serious health risk associated with microorganisms and their toxins (Orji *et al*., 2016; Okafor *et al*., 2017). Hence, the need to constantly evaluate the microbiological quality of garri sold within school environments to ascertain their safety. This study was aimed at investigating the microbial contents of garri sold within Ahmadu Bello University main campus, Samaru, Zaria, Kaduna State.

MATERIALS AND METHODS

Study Area

The study was carried out in Ahmadu Bello University (A.B.U) Main Campus, Samaru, Zaria, Kaduna State. Geographically, Samaru is located within latitude 11° 12" N and longitude 07° 37" E, at an altitude of 550-700 meters (Ugochukwu *et al.,* 2015)

Sample Collection

Thirty (30) samples of garri were randomly purchased; ten each from three major markets (A.B.U Community Market (ACM), Danfodio Market (DM), Isca/Ramat Market (IRM)) within Ahmadu Bello University main campus, Samaru, Zaria. The samples were placed in sterile plastic bags and labelled appropriately before conveying them to the microbiology laboratory for analysis.

Proximate Analysis of Garri Samples

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

Moisture content: Petri dishes were washed and placed in hot air oven at 100°C to dry, allowed cool and weighed (M1). Thereafter 2 g of the garri samples were added to the petri dishes and weighed again (M2). The dishes containing the samples were placed in the oven for 3hours, allowed to cool and weighed again (M3). The moisture content of the samples was determined as the average weight difference using equation 1 (AOAC, 2005)

Moisture content (%) = $\frac{M2-M3}{M2-M1}$ × 100 -- (1)

Ash content: Clean crucibles were oven dried, cooled in a desiccator and weighed (A1). 2 g of the garr*i* sample was placed in the pre-weighed crucible and weighed again (A2). The crucible with its content was transferred into the Muffle furnace for about 550°C. Thereafter, it was removed, cooled in a desiccator and weighed (A3). The ash contents were determined as follows (AOAC, 2005).

Ash content (%) = $\frac{A3-A1}{A2-A1}$ × × 100 --- (2)

Fibre content: 2g of the garri sample was placed in a beaker containing 1.2 ml of H_2SO_4 per 100ml of solution and boiled for 30minutes. The residue was filtered and washed with hot water before transferring into a beaker containing 1.2 g of NaOH per 100ml of the solution and boiled for 30 minutes, allowed to cool and weighed (F1). The residue was washed again with hot water and dried in an oven and weighed (F2). The weighed sample was incinerated in a furnace at 550^{0}C, removed, cooled and reweighed (F3). The fibre contents were evaluated using equation 3 (AOAC, 2005).

Fibre content (%) = $\frac{F2-F3}{F2}$ × × 100 -- (3)

Lipid (fat) content: A clean 250 ml boiling flask was oven dried, transferred into a desiccator and allowed to cool. Empty filter paper was weighed and labelled (L1). Then 2g of the sample was weighed into the labelled thimbles (filter paper) (L2). The boiling flask was filled with methylated spirit, assembled in the soxhlet apparatus and allowed to reflux for 8 hours. The flask is dissembled, transferred to oven to dry, cooled in a desiccator and reweighed (L3). The fat content was evaluated using equation 4 (AOAC, 2005).

Fat content (%) = $\frac{L2-L3}{L2-A1}$ × × 100 --- (4)

Protein content: 2g of the sample was weighed out and placed into a Kjeldahl flask. A catalyst (cupper) and 15 ml sulphuric acid (H_2SO_4) were added to the flask. The flask was heated in a fume cupboard until the solution assumed a green colour. The flask was cooled and the black particles at the mouth and neck of the flask were carefully washed down using distilled water. The flask was allowed to cool before transferring the digest with several washings into 100 ml conical flask with distilled water. 10 ml of the digested sample was transferred into the body of the Markham distillation apparatus previously steam heated for 15minutes using a small funnel before washing down the digest with distilled water followed by 10 ml of 40 % NaOH solution. Under the condenser a 100 ml conical flask containing 10 ml boric acid was placed. The set up was steamed for about 5–7 minutes to collect ammonium sulphate (about 30 – 40 ml). The receiving flask was removed and washed down the tip of the condenser into the flask. The solution in the receiving flask was titrated using N/100 (0.01N) hydrochloric acid. The nitrogen contents was calculated and from the result the protein content of the samples were evaluated using equation 5 (AOAC, 2005)

Protein(%)=

$$\frac{Final\ reading - Initial\ \ reading\ balnk(0.2) \times Standard\ Nitrogen\ number\ (1.4)}{Initial\ weight(0.5)\ x\ standrad\ protein\ number\ (6.25)}$$

--------- (5)

Carbohydrate content: The carbohydrate content were determined by subtracting the sum of all the calculated proximate contents from 100 % using equation 6 (AOAC, 2005).

Carbohydrate content (%) = *100 – (% moisture + % ash + % protein + % lipid)* --------(6)

Functional Properties of the Garri Samples

Swelling capacity: The method described by Sanni *et al*. (2001) was adopted. The *garri* samples were carefully added to a clean 100 ml measuring cylinder up to a 20ml mark. Distilled water was then added up to the 50 ml mark. The mouth of the measuring cylinder was then sealed tightly (water-proof) and the content was thoroughly mixed by inverting the cylinder for 2 minutes. It was re-inverted and allowed to stand for 3 minutes after which the final reading of the volume occupied by the distilled water was taken. To estimate the percentage swelling capacity, the following formula (equation 7) was used.

Swelling capacity (%) = $\frac{Volume\ of\ the\ gari\ in\ water}{Initial\ volume\ of\ gari}$ × 100 …..(7)

Water absorption capacity: The method previously described by Nuwamanya *et al*. (2011) was followed with slight modification. An aqueous suspension was made by dissolving 1 g of the garri sample in 10 ml of water. The suspension was manually agitated for 3 minutes and allowed to stand for 10 minutes before centrifuging for 10 minutes at 3000 rpm. The free water (supernatant) was carefully decanted from the wet *garri.*

Determination of pH: The pH of the *garri* samples was determined using a pH meter following the procedure reported by Ogiehor and Ikenebomeh (2005). 1 g of each *garri* sample was homogenized in 10 ml of distilled water and the suspension was collected and determined using a reference glass electrode pH meter (Jenway Model 3510).

Enumeration and isolation of total aerobic bacteria and fungi

Microbial evaluation of the samples was done according to the method of Aneyo *et al*. (2016). Exactly 1 g of the garri sample was transferred into 9 ml of sterile saline solution in a test tube and mixed thoroughly. A serial dilution of the stock solution was then carried out up to 10^{-6} using pour plate technique (Cheesbrough, 2004). Exactly 1 ml aliquot from 10^{-2} to 10^{-4} dilutions was aseptically inoculated into nutrient agar (NA) (Oxoid, UK), 10 % tartaric acid amended potato dextrose agar (PDA) (Oxoid, UK), macConkey agar (MA) (Oxoid, UK) and *Salmonella-Shigella* agar (SSA) (Oxoid, UK). The inoculated NA, MA and SSA plates were incubated at 37 °C for 24 hours, while the PDA plates were incubated at room temperature (28 ± 2 °C). The colonies on the incubated plates were counted using a colony counter and the number of organisms per gram (CFU/g) of diluted sample was calculated using the following formula (Clarence *et al.,* 2009):

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Number of organisms (CFU/g) =

$$\frac{Number\ of\ colonies \times Dilution\ factor}{Volume\ of\ dilution\ cultured} \quad - \quad (7)$$

The colonies were sub-cultured on fresh nutrient media to get pure culture which were stored on sterile agar slants (4 °C) for phenotypic characterization and identification. Bacterial identification was based on the cultural, morphological, Gram's reaction and other biochemical tests: catalase, coagulase, oxidase, motility, methyl red, Voges Proskauer, citrate utilization, urease, indole, endospores and triple sugar iron tests (Cheesebrough, 2004) with reference to Bergey's Manual of Determinative Bacteriology (Holt, 1994). Identification of fungi was based on the microscopic morphology of the fungal isolates as seen under the microscope at x10 and x40 objectives and macroscopic colonial morphology of fungi observed on the plates such as colony texture, size, pigmentation, colour on the reverse side of the plates and colony margins (Samson and Reenen-Hoekstra, 1988; Watanabe, 2010; Kidd *et al*., 2016).

Data analysis

The data obtained from this study was analysed with the help of Microsoft Excel Windows 7 using descriptive statistical tools. Differences in the mean values were compared using ANOVA at $p<0.05$ level of significance.

RESULTS

The results of the mean proximate composition of the *garri* samples from the different markets are shown in Table 1. It was observed that the proximate compositions of the *garri* samples ranged between 2.46 – 2.88 % (moisture), 1.35 – 1.62 % (ash), 6.85 – 8.20 % (lipid), 2.47 – 3.45 % (proteins), 1.32 – 1.54 % (fibre) and 84.14 – 86.36 % (carbohydrate). Although, there was no statistical significant difference between the mean values of the three markets investigated, the highest values were 2.46 % moisture (ACM), 1.37% ash (ACM), 6.85 % lipid (DM), 2.47 % proteins (DM), 1.37 % fibre (IRM) and 84.14 % carbohydrate (IRM) as shown in Table 1.

Table 1: Mean Proximate Composition of *Garri* Samples from different Markets

	Sampling sites*		
Parameter	**ACM**	**DM**	**IRM**
Moisture (%)	2.46[a]	2.88[a]	2.61[a]
Ash (%)	1.37[a]	1.45[a]	1.62[a]
Lipid (%)	7.40[a]	6.85[a]	8.20[a]
Proteins (%)	2.82[a]	2.47[a]	3.45[a]
Fibre (%)	1.54[a]	1.32[a]	1.37[a]
Carbohydrate (%)	85.97[a]	86.36[a]	84.14[a]

Key: ***ACM**: A.B.U Community Market; **DM**: Danfodio Market; **IRC**: Isca/Ramat Market; Values with similar alphabet across a row are not significantly different at p=0.05

The mean swelling capacity and water absorption capacity of *garri* samples from different markets ranged from 2.98 – 3.10 % and 4.66 – 5.03 % respectively (Figure 1). The highest and lowest mean swelling capacity were from DM (3.10 %) and IRM (2.98 %) while that for water absorption capacity were from IRM (5.03 %) and DM (4.66 %) (Figure 1). There was no significant difference in each of the mean swelling capacities and water absorption capacities in all the locations investigated. The results further revealed an acidic pH range of 4.60 – 5.00 , with the highest and lowest from *garri* samples collected from IRM (5.00) and ACM (4.60) respectively (Figure 2). The pH values obtained were also not significantly different at $p>0.05$.

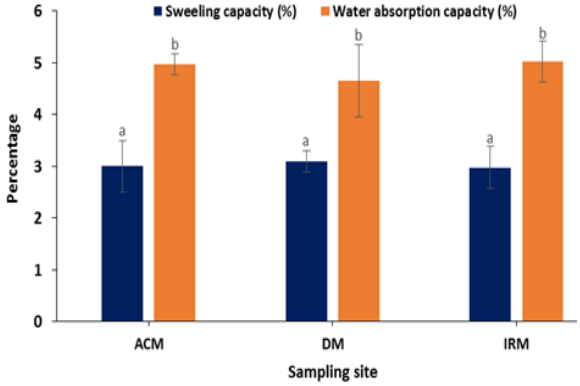

Figure 1: Mean swelling capacity and water absorption capacity of *garri* samples from different markets (**ACM**: A.B.U Community Market; **DM**: Danfodio Market; **IRC**: Isca/Ramat Market); Values with similar alphabet across a row are not significantly different at p=0.05.

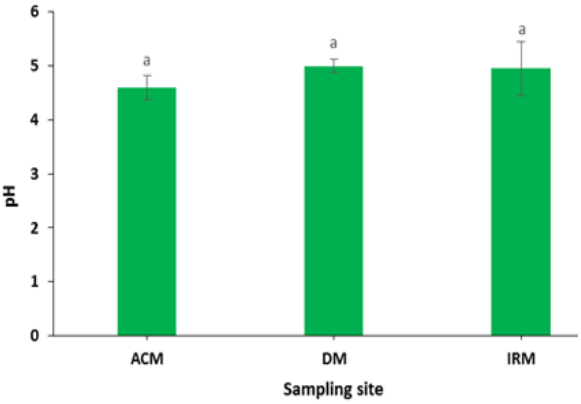

Figure 2: Mean pH of *garri* samples from different markets (**ACM**: A.B.U Community Market; **DM**: Danfodio Market; **IRC**: Isca/Ramat Market); Values with similar alphabet across a row are not significantly different at p=0.05

The total microbial count obtained from analysis of the *garri* samples are shown in Table 2. From the observation, the total bacterial count was higher than their fungal equivalents in all the three sampling locations. The range for Total bacterial count was 9.5×10^3 CFU/g – 6.7×10^4 CFU/g while the total fungal count was 1.0×10^3 CFU/g – 2.0×10^3 CFU/g. Isolates from ACM and DM locations were not significantly different from each other at $p>0.05$ but were significantly different from IRM location for bacterial and fungal isolates.

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Table 2: Total heterotrophic microbial counts of *garri* samples from different markets

Sampling site*	Total bacterial counts (× 10^4 CFU/g)	Total fungal counts (× 10^3 CFU/g)
ACM	6.70[a]	2.00[a]
DM	3.70[b]	2.00[a]
IRM	0.95[c]	1.00[b]

*(**ACM**: A.B.U Community Market; **DM**: Danfodio Market; **IRC**: Isca/Ramat Market); Values with similar alphabet in a column are not significantly different at p=0.05

Characterization of the bacterial isolates of the *garri* samples revealed the presence of *Micrococcus* sp., *Escherichia coli*, *Klebsiella* sp., *Lactobacillus* sp., *Enterobacter* sp., *Staphylococcus aureus*, *Enterococcus* sp., *Pseudomonas* sp., *Streptococcus* sp., *Shigella* sp., and *Bacillus* sp. (Table 3). The fungal isolates were *Rhizomucor* sp., *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* sp., *Mudurella* sp., and *Candida* sp. (Table 4). Bacterial was isolated from the three sampling locations while *Aspergillus* sp. was the only genus of the fungal isolates which occurred in the three sampling locations studied.

Table 3: Morphological characteristics and biochemical reaction of the bacterial isolates

	Isolates code										
Parameter	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Shape	Cocci	Rods	Rods	Rods	Rods	Cocci	Cocci	Rods	Cocci	Rods	Rods
Cell	Cluster	Singly				Cluster			Chain		Singly
Gram stain	(+)	(-)	(+)	(+)	(-)	(+)	(+)	(-)	(+)	(-)	(-)
Catalase	(+)	(+)	(+)	(-)	(+)	(+)	(+)	(+)	(-)	(+)	(+)
Coagulase	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(+)	(+)
Methyl red	(-)	(+)	(-)	(-)	(+)	(+)	(-)	(-)	(-)	(+)	(-)
VogesProskauer	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)
Urease	(+)	(-)	(+)	(-)	(+)	(+)	(-)	(-)	(-)	(-)	(-)
Citrate	(-)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	(-)	(-)	(-)
Endospores	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)
Triple sugar iron	K/NC	K/KG	A/AG	K/A	A/KG	A/A	A/A	A/AG		A/A	A/A
Motility	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)
Indole	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Oxidase	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(+)
Isolate	***M***	***E***	***K***	***L***	***En***	***S***	***Ent***	***P***	***Str***	***Shi***	***Ba***

M: Micrococcus sp., **E**: Escherichia coli, K: Klebsiella sp., **L**: Lactobacillus sp., **En**: Enterobacter sp., Staphylococcus aureus, **Ent**: Enterococcus sp., **P**: Pseudomonas sp., **Str**: Streptococcus sp., **Shi**: Shigella sp., **Ba**; Bacillus sp.

Table 4: Macroscopic and microscopic characteristics of fungi isolates of *garri* from different markets

Sample	Macroscopic characteristic	Microscopic characteristic	Inference
A_1	Cotton-like colonies, white at first turns grey to yellowish brown.	Aseptate, irregular, sporangiophores, with spherical to pyriform-shaped columellae,	*Rhizomucor* sp.
A_2	Very common colours of colony (black and white)	Hyphae divided and transparent with columnar head	*Aspergillus* sp.
A_5	Waxy-colony with white to bright yellowish top colour and a pale to yellowish bottom	Conidiophores with pyriform in shape, solitary or arranged in clustered miroconidia.	*Trichophyton* sp.
A_6	Colonies were fast growing, flat, white to cream, dry and finely suede-like with no reverse pigment.	Hyphae were hyaline, septate, branched and broke up into chains of smooth subglobose to cylindrical arthroconidia.	*Geotrichum* sp.
A_7	Flat, leathery white to yellow-brownish, folded colonies	Flask-shaped-phialides, spherical, pyriform conidia one conidiophores	*Mudurella* sp.
A_8	White to creamy colonies	Pseudo-hyphae smooth oval globose bastoconidia	*Candida* sp.

Table 5: Occurrence of bacteria and fungi isolatess from *garri* obtained from different markets

Sampling site (Markets)	Bacterial isolates	Fungal isolates
ACM	*Micrococcus* sp.	*Aspergillus oryzae*
	Escherichia coli	*Trichophyton* spp.
	Klebsiella sp.	*Aspergillus carbonarius*
	Lactobacillus sp.	*Rhizomucor* sp.
DM	*Enterobacter* sp.	*Candida* sp.
	Staphylococcus aureus	*Aspergillus awamori*
	Enterococcus sp.	*Trichophyton* sp.
		Madurella mycetomatis
IRC	*Pseudomonas* sp.	*Geotrichum candidum*
	Streptococcus sp.	*Aspergillus oryzae*
	Shigella sp.	
	Bacillus sp.	

DISCUSSION

It was found that the proximate composition of the garri samples varied with the sampling sites and ranged from 2.46 – 2.88 % (moisture), 1.35 – 1.62 % (ash), 6.85 – 8.20 % (lipid), 2.47 – 3.45 % (protein), 1.32 – 1.54 % (fibre) and 84.14 – 86.36 % (carbohydrate). According to the report on garri specifications, it was documented that garri should be enriched with vitamins, proteins and other essential nutrients (Anon., 2014). The relatively low content of protein in this study suggests a need for protein enrichment of garri before consumption. Studies have shown that most consumers of this cassava products (garri) supplement it with protein sources such as smoked fish, beans and milk in line with the enrichment specifications documented earlier (Anon., 2014). Hence, consumers of garri are encouraged to maintain the enrichment practices with some common protein foods. With respect to the moisture and ash contents, findings from this study were within the specified limits (≤ 7 % and ≤ 1.50 %) recommended for garri except for one of the locations (IRM) which was slightly above the recommended limit for ash content. Foods with high moisture content are highly prone to spoilage because most microorganisms proliferate under such condition. The relatively low moisture level of garri in this study will make them less prone to microbial spoilage. This finding is in line with earlier report that a well processed *garri* with low moisture content can be stored for a good number of months without microbial deterioration (Ismail *et al.,* 2015). Higher moisture content was reported by Ogbonna *et al.,* (2017). The differences observed in the level of moisture content can be attributed to variation in temperature, extent of dry-frying/roasting and storage condition of the finished product. The ash content of the garri samples in this study were relatively lower than 1.54 - 1.70 % and 1.5 - 2.4 % reported by Udoro *et al.* (2014) and Ogbonna *et al*. (2017) respectively for ash content of garri in their studies. The level of ash in food commonly indicates the quality of its mineral contents. The more the ash contents, the higher the mineral contents of the food sample. The level of carbohydrate, crude fibre and lipid content is in this study are similar to the values obtained from previous studies (Udoro *et al*., 2014; Ismail *et al.,* 2015; Ogbonna *et al*., 2017). The analysis of variance revealed no significant ($p>0.05$) variation in the crude fibre, carbohydrate, moisture and ash content of the garri samples.

The mean swelling capacity and water absorption capacity of the garri samples from different markets ranged from 2.98 – 3.10 % and 4.66 – 5.03 % respectively. Both functional properties indicate the rate of water absorption and retention by the particles of garri. There was no significant difference ($p>0.05$) in the levels of water retention and absorption in all the sampling locations suggesting a relatively similar functional properties. Similar findings were reported earlier (Udoro *et al*., 2014). Temperature of water have been identified as a key factor which determines the swelling and absorption properties of garri and thus might account for the slight variation in relation to previous reports (Udoro *et al*., 2014; Ogbonna *et al*., 2018). The pH results indicate that garri samples were within the acidic range (≤ 5.00). This is a reflection of the presence of high fermentation bacteria and fungi encountered in this study.

The total microbial counts obtained from the analysis of the garri samples showed that the total bacterial counts were higher than the fungal counts from the three sampling locations. This suggests a higher contamination by bacteria from the processors and the environment. This observation is in agreement with the total heterotrophic bacterial count obtained by Olopade *et al.* (2014). The range for total bacterial counts (9.5×10^3 CFU/g – 6.7×10^4 CFU/g) and total fungal counts (1.0×10^3 CFU/g – 2.0×10^3 CFU/g) were within the tolerable limits of 10^4 to 10^5 recommended by the International Commission on Microbiological Specifications for Foods (ICMSF, 1996). Although, the microbial load obtained appeared to be within the tolerable limit, the presence of *E. coli* is worrisome, considering that they are key coliform bacteria which indicate faecal contaminate of water/food. The other bacterial isolates were *Micrococcus* sp., *Klebsiella* sp., *Lactobacillus* sp., *Enterobacter* sp., *Staphylococcus aureus*, *Enterococcus* sp., *Pseudomonas* sp., *Streptococcus* sp., *Shigella* sp., and *Bacillus* sp. while the fungal isolates were *Rhizomucor* sp., *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* spp., *Mudurella* sp., and *Candida* sp. This study revealed a generally poor sanitary state of the production, handling and retailing of garri which paved way for the contamination and proliferation of the microorganisms. Some of the bacteria encountered in this study are medically importance because they have been implicated in diverse human ailments (Prescott *et al*., 2002). *Pseudomonas* species are opportunistic environmental pathogens that can cause serious ailment in individuals with suppressed immunity (Prescott *et al*., 2002). *Staphylococcus aureus,* a well-known commensal of human microbiota (Prescott *et al*., 2002) can contaminate food process and handled with bare hands as such their presence in the garri samples suggest possible contamination from direct contact or aerial-droplet mechanisms such as coughing or sneezing by garri processors/retailers or handler (Prescott *et al*., 2002). *S. aureus, Shigella* sp., *Enterobacter* sp. and *Bacillus* spp. have been implicated in food infections and intoxication leading to different forms of diarrhoeal diseases among other complications especially in young children, the elderly and the immunocompromised (Prescott *et al*., 2002). *Lactobacillus* sp., and *Enterococcus* sp. have been identified as good bacteria which can serve as probiotics to boost the microflora of the gut among other useful

benefits associated with probiotics (Prescott *et al*., 2002). Hence, their presence is good for the health of the consumers of *garri.* The fungi recovered from the *garri* samples are of public health importance. For example *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* sp.*, Mudurella* sp.*,* and *Candida* sp. have been implicated in difference mycotic infections ranging from superficial dermatophytosis to deep-seated organ infections (Prescott *et al*., 2002; Kabak *et al.,* 2006). Most of them produce mycotoxins that are heat resistant and can cause food intoxication to consumers (Kabak *et al.,* 2006). The presence these fungi in *garri* could be linked to poor handling and unhygienic spreading on of garri on the floor/ground/open basin in the markets for sale thereby giving room for the spores of these fungi which are ubiquitous in the surrounding to gain access to the commercial garri. The bacteria and fungi isolated from the garri samples in this research have been isolated and reported by other researchers such as Orji *et al.* (2016); Akindele *et al.* (2018); Okafor *et al*. (2018). Their results validate the isolation of the microorganisms encountered in this study.

Conclusion

This study has shown that *garri* sold in three major markets within A.B.U, Main Campus, Samaru, Zaria, are grossly contaminated by diverse fungi and bacteria of public health relevance. However, it relatively complied with acceptable standards with respect to proximate and functional properties. Considering the fact that *garri* has become a very important staple food among huge percentage of students in Nigeria and other tropical African countries, it is pertinent that these target populations are encouraged to reduce intake of garri without thorough thermal treatment to prevent food infections/intoxications. There is need for *garri* processors/retailers to maintain stricter personal hygiene and food safety consciousness in terms of using clean covered transparent containers as *garri* retailing containers so as to reduce direct and indirect contaminations by air-borne droplets and spores of the isolates in dust and air.

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