Microbial Profile and Physicochemical Composition of Yellow and White Garri Sold in Different Markets

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Abstracts:
Garri which is an important source of energy and fibre contains proteins and some essential vitamins and is particularly popular because of its ready-to-eat nature. A total of 16 samples of white and yellow garri were assessed and standard microbiological methods were used. The white garri samples obtained from the four markets had the highest heterotrophic bacteria count ranging from $8.9x10^{-6}cfu/g$ (Rumokoro market) to $9.8 x10^{-6}cfu/g$ (Alakahia market). Yellow garri samples had counts ranging from $1.18x10^{-7}cfu/g$ (Choba) to $9.5 x10^{-6} cfu/g$ (Rumuosi), both higher than the W.H.O directives on microbial limits of foods which states that THBC $\leq 5.0 \times 10^5$ colonies/gram of sample. White garri samples (Alakahia) had the lowest fungal count that ranged from $3.2x10^4 cfu/g$ to $5.05x10^4 cfu/g$ and yellow garri, $5.1x10^4cfu/g$ (Rumuosi) to $8.0x10^4cfu/g$ (Choba). Bacterial and Fungi isolates obtained from the garri samples which were isolated and identified during this study include Staphyloccocus aureus, Staphylococcus epidermidis, Escherichia coli, Micrococcus sp., Bacillus sp. and Klebsiella sp. Aspergillus niger, Aspergillus flavus, Candida sp., Saccharomyces sp. and Penicillum sp., Geotrichium sp., Fusarium sp. respectively. The result obtained from the proximate analysis carried out on both garri samples showed that yellow garri sample had a lower carbohydrate content of 72.22% than white garri sample which was 72.45%. Hence, it is recommended that garri should be stored in sack bags or air tight containers in the markets to avoid contamination. Regulatory agencies should be set up at strategic market places to ensure the enforcement of microbiological safety of garri by providing trainings on safety criteria, safe handling technique and microbiological limits of garri.

Keywords: White garri, yellow garri, pathogen, market

1. Introduction

Garri is the most popular form in which cassava is consumed by several millions of people in the African continent especially in the West Africa Sub Region (Ogiehor, 2002). Regardless of ethnicity and socio-economic class, it is the most common meal amongst the rich and the poor. Nigeria is the current leading cassava (Manihot esculenta Crantz) producing country in the world, but almost all the cassava produced are used for human consumption with less than 5% used in industries (FAO, 2002; Ajao and Adegun, 2009).

Garri is a roasted granular hygroscopic white or yellowish starchy food product, it is a dehydrated staple food with a high swelling capability and can absorb up to four times its volume in water. To prepare this food, fresh cassava roots are peeled, washed and grated. The resultant pulp is put in a porous sack (poly propylene bag) and weighed down with a heavy object or hydraulic press while it is fermenting. The dewatered and fermented lump of the pulp is pulverized, sifted and the resulting semidried mash is toasted in a pan (Nweke et al., 2002). The final granulated product may be white or yellowish product as the colour depends on production methods used.

Garri is an important source of energy and fibre and is particularly popular because of its ready-to-eat nature. It is classified/ grouped based on texture, length of fermentation, region or place where it is produced and colour imparted by the addition/ non-addition of palm oil. (Jekayinfa and Olajide, 2007). Garri is rich in starch. It is also having a very high fibre content and contains proteins and some essential vitamins. The high fibre content in garri makes it very filling, and also makes it good in preventing and/or reducing the likelihood of constipation and bowel upsets. Garri available in the market can be consumed directly without cooking by soaking in water without or with a variety of additives such as sugar, groundnut, fish, meat and stew, coconut, akara, milk prior to consumption or processed minimally using boiled water to form a stiff paste popularly called 'eba' and eaten with various types of African soups. (Ajao and Adegun, 2009).

There are different types of garri, depending on how it is processed and the region of Africa where it is produced. Red garri (Bendelgarri) is commonly found in the mid-Western part of Nigeria. Ijebu garri is made in the western part of Nigeria and is found great for 'soaking. Ghana garri as the name implies is garri made in Ghana. Ghana garri is starchy, very crispy and lasts very long in storage.

Garri is displayed and sold in the market in open basins, bowls and trays and on mats spread on the floor or on tables which potentiate contamination by various groups of microorganisms and may predispose public health hazards.

Various groups of moulds which include Aspergillus niger, Aspergillus flavus, Candida sp., Saccharomyces sp. and Penicillum sp., Geotrichium sp., Fusarium sp have been reported to be associated with garri as well as other microorganisms such as Staphyloccocus aureus, Staphylococcus epidermidis, Escherichia coli, Micrococcus sp., Bacillus sp. and klebsiella sp. during storage and distribution which if present can grow and affect the nutritional and sensory properties of the garri. The garri is stored in exposed basins and large sack bags in stores at the market place or in the homes and transferred to the market when needed. Due to the mode of sampling and sales, in the market aerial microorganisms can be deposited on the exposed garri either by active or passive mechanisms. In active mechanism, the bursting of ascus after absorbing water at a high pressure and releasing its spores could fall on the exposed garri. In passive mechanism, the organisms could be carried by wind and deposited on the exposed garri or by rain splash.

Garri production is laborious and cumbersome and production methods vary from one locality to another resulting in products of non-uniform quality. However, the practices that are associated with its production, processing and post processing handling of garri such as spreading on the floor, mats, display in open bowl in the markets, sale points, and use of various packaging materials to haul finished products from rural to urban areas may exacerbate microbial contamination (Ogiehor and Ikenebomeh, 2006). Markets that are close to waste sites and rivers where faeces are disposed, aerial contamination could also be a major problem as the air around such vicinity may be laden with coliforms emanating from such disposed organic matter. The microbial contaminants of garri result in serious health effects such as liver, cancer, kidney damage, typhoid, apergillosis, asthma and hypersensitivity and may serve as a source of food borne diseases (Islam et al., 1993; Maria et al., 2001; Venugopal, 2001, Omar et al.,2003). Information needed on what type of garri in respect to colour (white or yellow) is preferable in terms of microbial load and physicochemical parameters; and providing useful information as regards the public health concerns of the different brands of garri are the reasons why this study was carried out. The objective of the study is to determine the growth of microorganisms in different brands of garri in Rivers State and to evaluate the proximate composition and physicochemical parameters of the different brands of garri, to identify the pathogens of public health concern present in different brands of garri and finally to proffer solutions for proper handling and sales of garri in markets

2. Materials and Method

2.1. Area of Study

The garri used for this study were obtained from four different markets in Port Harcourt municipality. These samples obtained were from different sellers who sold garri in exposed basins and were transported to the lab in Ziploc bags and sampled within 24hrs.

Market	Location	Remarks
Choba	1km from the University of Port Harcourt	Situated near a poor drainage site with refuse dump close by and a park.
Alakahia	1km from the University of Port Harcourt	Situated in an unhygienic environment
Rumuosi	2km from the University of Port Harcourt	Situated near an express road. The environment is unhygienic
Rumuokoro	About 4km from the University of Port Harcourt	Situated in a dusty and dirty environment by a park and a busy express road.

Table 1: Markets Sampled and Their Location

2.2. Sample Collection

A total of 16garri samples used for this research were purchased randomly from different markets (Choba, Rumukoro, Alakahia and Rumuosi markets). The samples were collected aseptically into sterile polyethylene bags and were transported to the laboratory for analysis within two hours of collection. Samples were categorized according to the location of purchase Microbiological analysis of the different brands of the garri samples

Ten (10) grams of each garri samples were weighed into a beaker containing 90 ml of sterile peptone water and allowed to stand for 5 minutes with occasional stirring using a sterile glass rod. From the supernatant, ten-fold serial dilution was carried out by transferring 1 ml from the supernatant into 9 ml sterile diluents. To obtain dilution 10^{-2}, this was repeated into 9ml diluents to obtain dilution 10^{-3}, the process was repeated till dilution 10^{-5} was obtained. 0.1ml 10^{-4}-10^{-5} of each dilution was dispersed into the Plate count agar in duplicates while 0.1ml of 10^{-2}-10^{-3} into the selective media. Commercially made media were used for isolation, identification and characterization of microorganisms. The media used include: Nutrient agar, Manitol Salt agar, MacConkey agar, Potato dextrose agar. All media, diluents and glass wares used (Petri plates, bijou bottles, test tubes, pipette) were sterilized by autoclaving at 121^oC for 15mintues at 15 psi, unless stated otherwise

2.3. Isolation of Microorganisms

From the aliquot, 0.1 ml was plated onto nutrient agar using spread plate method for total viable heterotrophic count, mannitol salt agar for Staphylococcus count, MacConkey agar for coliform count and the plates were incubated at 37^oC for 24hrs. For total fungi count, 0.1 ml of the diluent was plated onto potato dextrose agar (PDA) and incubated at 26^oC for 2-5 days.

2.4. Purification of Isolates

Single colonies of bacteria were randomly picked from the different bacteriological media previously incubated based on their morphological characteristics and were sub cultured on freshly prepared media and incubated for 24hrs at 37ºC to obtain a pure culture. After the purification of isolates, nutrient agar slants were prepared in bijou bottles by dispensing 10 ml of the nutrient agar into bijou bottles and autoclaved at 121ºC for 15 min at 15 psi, slanted and allowed to solidify. After which a sterile wire loop as used to pick each inoculum and streaked onto the surface of the slanted nutrient agar and stabbed into the butt and incubated at 37ºC for 24hours.

2.5. Identification and Characterization of Isolates

Bacterial Isolates were identified based on their morphological and cultural characteristics on growth media which includes colony size, colour, opacity, consistency, colony pigmentation, elevation, odour, swarming), identification materials, reagents and protocols according to (Chessebrough, 2005)
Fungal isolates were done based on the colonial morphology (colour, size, texture) and the cell morphology (mycelia, hyphae) of the fungi was done using lactophenol blue. A piece of the mycelium from the Petri dishes was mounted on a clean grease free slide using a sterile wire loop and covered with a cover slip and a drop of lactophenol cotton blue was added and allowed for few minutes before examining with the microscope.

2.6. Physicochemical Parameters

2.6.1. Determination Of pH

The pH of the samples was determined following the procedures described by Ogiehor and Ikenebomeh (2005). 10g of each sample were homogenized in 10ml of distilled water in a beaker. The pH was determined by using a reference glass electrode pH meter.

2.6.2. Determination of Loose Density

This was calculated by weighing 10g of garri sample into a measuring cylinder without tapping and noting the final volume occupied.

2.6.3. Determination of Bulk Density

This was done by tapping the measuring cylinder containing the 10g of garri sample from the loose density determination on a table and noting the stable final volume.

2.7. Determination of Swelling Index

This was done as described by Ukpabi and Ndimele (1990). 50g each of garri samples were put into a 500ml measuring cylinder. 300ml of water was added to the garri sample and allowed to stand for 4 hours. The level of swelling was noted and the swelling index was calculated as the multiple of the original volume.
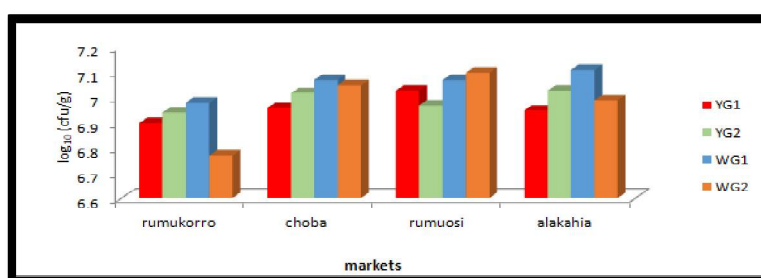PROXIMATE ANALYSIS This was done as described Okoli et al.,2012

3. Result

Figure 1: Total Heterotrophic Bacterial Count from Garri Samples Obtained from
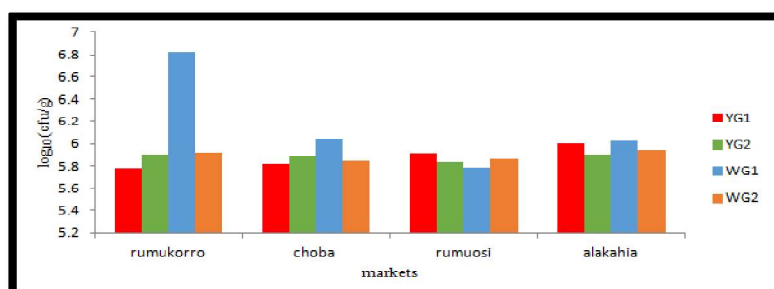*Different Markets Legend; YG-Yellow Garri, WG-White Garri*

Figure 2: Total Staphylococcus Count from Garri Samples Obtained from Different Markets
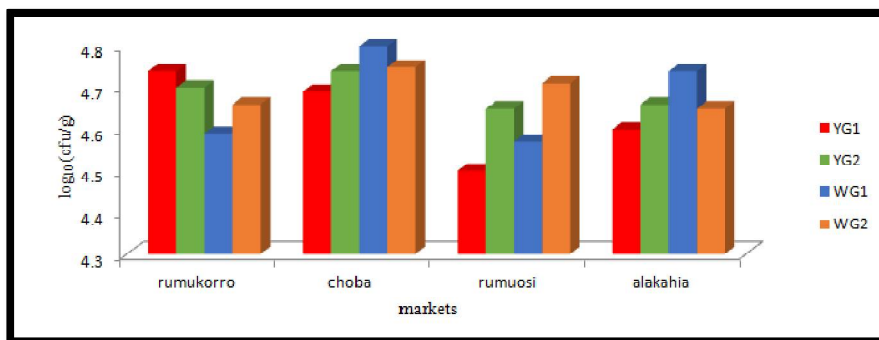*Legend; YG-Yellow Garri, WG-White Garri*

*Figure 3: Total Coliform Count from Garri Samples Obtained from Different Markets
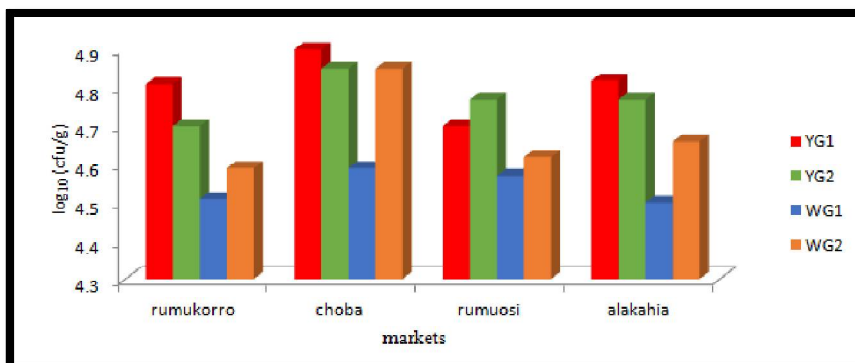Legend; YG-Yellow Garri, WG-White Garri*

*Figure 4: Total Heterotrophic Fungal Count from Garri Samples Obtained from Different
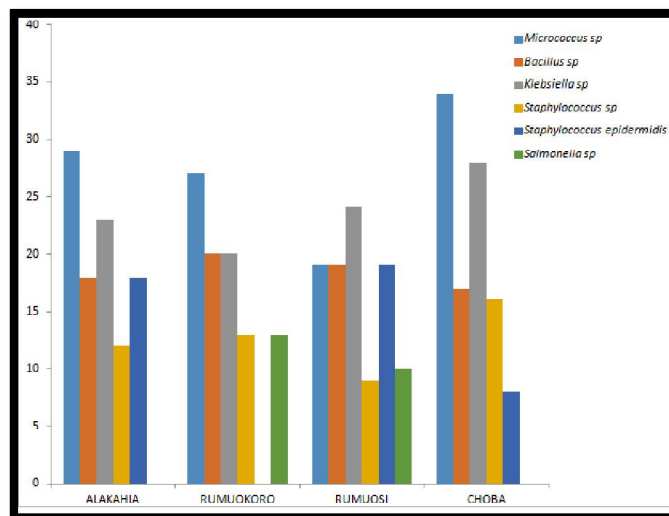Markets, Legend; YG-Yellow Garri, WG-White Garri*

*Figure 6: Showing the Frequency of Occurrence of the Different
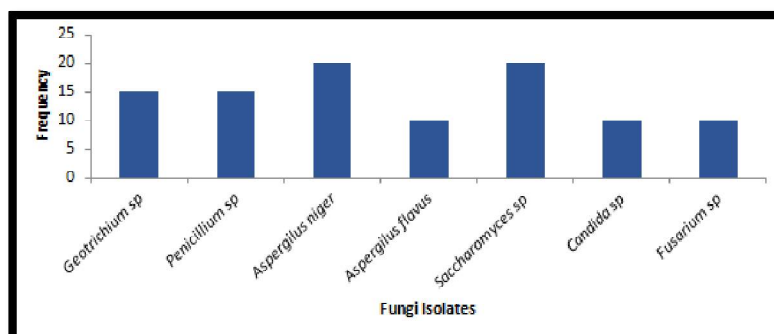Pathogens Found In the Garri Samples*

*Figure 6: Frequency of Occurrence of Fungi Isolated from Garri Samples
Obtained from All Four Markets*

S/no	Sample area	pH	Loose density (ml)	Bulk density (ml)
1	RKY1	5.9	16	14
2	RKW1	4.6	12	10
3	RKY2	4.9	15.5	13
4	RKW2	4.8	14	12
5	AY1	6.1	18	15
6	AW1	4.7	16	15
7	AY2	5.5	14.5	13
8	AW2	4.6	17	15
9	CY1	5.1	12	10
10	CW1	5.3	10	8
11	CY2	5.2	10	8
12	CW2	4.5	17	16
13	RSY1	4.9	14	10
14	RSW1	4.7	12	10
15	RSY2	5.1	14	8
16	RSW2	4.8	12	10

Table 2; Physicochemical Parameters of the Different Garri Samples
Keys: Rky = Yellow Garri (Rumukoro Market), Rkw= White Garri (Rumukoro Market)
Ay= Yellow Garri (Alakahia Market, Aw= White Garri (Alakahia Market)
Rsy= Yellow Garri (Rumuosi Market), Rsw= White Garri (Rumuosi Market)
Cy= Yellow Garri (Choba Market), Cw= White Garri (Choba Market)

S\N	Proximate composition	Garri samples (%)	
		White garri	yellow garri
1	Carbohydrate	72.45	72.22
2	Protein	1.7	1.75
3	Lipid	1.48	1.56
4	Ash	1.7	1.3
5	Moisture Content	11.87	12.27
6	Crude Fibre	10.8	10.9

Table 3: Proximate Composition of the Garri Samples

4. Discussion

From this study it is clear that garri samples (both yellow and white garri) harbour arrays of bacterial and fungal contaminants. The total heterotrophic bacteria count of the garri samples shown in Table 2 indicates that the white garri samples obtained from the four markets had the highest heterotrophic bacteria count which ranged from 8.9×10^{-6} cfu/g (Rumokoro market) to 9.8×10^{-6} cfu/g (Alakahia market) than that of yellow garri samples with counts which ranged from 1.18×10^{-7} cfu/g for (Choba market) to 9.5×10^{-6} cfu/g for (Rumuosi market). The findings of this study are higher than the findings of total heterotrophic count of fermented cassava flour obtained by Ijabadeniyi, (2007) who reported 1.5×10^6 cfu/g and that of Tsau-Wau, 2004 who reported 1.2×10^7 cfu/g to 2.7×10^3 cfu/g but were close to the count reported by some other researchers. It is also higher than the World Health Organization directives on microbial limits which states that Total Heterotrophic Bacterial Count should not exceed 5.0×10^5 colonies per gram of sample and coliform count should not exceed 5.0×10^3 colonies per gram of sample which from this study, some of the results were higher and the others were within the limit with white garri sample from (Choba market) having the highest count of 6.4×10^4 cfu/g followed by that of Rumuosi market 3.84×10^4 cfu/g and yellow garri samples count were 5.6×10^4 cfu/g and 3.55×10^4 cfu/g for (Rumukoro market) for (Rumuosi market) respectively for coliform.

These findings however revealed that the THBC ranged from 1.06×10^7 cfu/g - 9.8×10^6 cfu/g. Some of the microbial counts obtained from this study conformed to the microbiological limit showing partial negligence on the part of National agencies concerned with food inspection in the country.

The total Staphylococcus count of the garri samples is shown in Table 3. Food and Drug Agency (FDA) limit for Staphylococcus in foods is $<10^5$ CFU/g. The lowest Staphylococcus count was recorded for yellow garri samples, with bacteria counts that ranged from 1.00×10^{-6} cfu/g (Alakahia market) to 5.9×10^{-5} cfu/g (Rumukoro market) which is lower than that of the white garri samples which had counts that ranged from 6.1×10^{-5} cfu/g for (Rumuosi market) to 6.75×10^{-6} cfu/g for (Rumukoro market). These findings are within the permissible limit of FDA but corroborate the report of Ogiehor et al, 2007.

The level of contamination by mould and bacteria recorded in this study is mainly due to contamination as a result of local method of processing (Amadi and Adebola, 2008). This is also an indication of recommendation in food handling/hygiene technique. The practices that are associated with the production, processing and post processing handling of garri such as spreading on the floor, mat and the open display in bowls and basins in the market, measurement with the aids of bare hands, coughing and sneezing while selling and also the use of non-microbiologically determined

hessian bags for packaging and haulage may be responsible for its contamination as the growth of these microorganisms in the food results to changes in the organoleptic, microbiological and nutritive quality which subsequently results in spoilage. (Ogeihor and Ikenebomeh, 2005),

Data obtained on the analyses of the garri samples obtained at the four markets for bacterial contaminants include seven different bacterial genera with their highest percentage of occurrence: Bacillus sp. 20%, Staphylococcus aureus 16%, Staphylococcus epidermidis 19%, Micrococcus sp. 34%, Salmonella sp. 13%, Escherichia coli 7% and Klebsiella sp. 28%. The isolation of Staphylococcus aureus is of human origin and their presence could be from handlers, intrinsic and the environment. It has been known to cause various pus-forming infections in humans such as boils, carbuncles, impetigo, osteomyelitis, toxic shock syndromes. (Hartman et al., 2004). On the other hand, Staphylococcus epidermidis which was also isolated from the samples is a normal flora of the skin but can occasionally assume an opportunistic pathogenic role in causing human infection such as endocarditis (Anastasiades et al., 2009). The isolation of Salmonella sp. and E. coli from garri samples obtained Choba market may be connected with its proximity to an unkempt drainage / refuse dump very close to the market as also were the findings of Oje et al., (2000.) Bacillus cereus is an environmental contaminant which was also isolated from the sample. It has been reported to be pathogenic especially if found to be present at 105-107cfu/g. (Michelet et al, 2006).

White garri samples from Alakahia market had the lowest fungal count that ranged from 3.2×10^4 cfu/g to 5.05×10^4 cfu/g and yellow garri fungal counts ranged from 5.1×10^4 cfu/g Rumuosi market to 8.0×10^4 cfu/g Choba market as represented in Table 5. The International Commission on Microbiological Specifications for Foods (ICMSF) states that ready to eat foods with counts of $\leq 10^3$ CFU/g are acceptable, counts of 10^4-10^5 CFU/g are tolerable while counts of $\geq 10^6$ CFU/g are unacceptable (ICMSF, 1996). The average Total Fungi Count value of the garri sample is $<10^3$ CFU/g, within this range, food is safe for consumption. Therefore, we can say that the TFC of our garri sample is within the range of acceptable limit but higher than the value gotten by other researchers like Obadina et al, 2009 who reported 1.79×10^4 CFU/g. The fungal contamination of the garri samples could be as a result of the deposition of bioaerosols on the exposed garri in the markets. Airborne fungal spores are released into the atmosphere by explosive discharge mechanisms that require high humidity and moisture and these spores are carried by wind and transported vertically and horizontally (Aylor, 1995; Nagarajan and Singh., 1990) and may thus, be deposited on the exposed food items in the markets. Aspergillus sp. which was the most frequently isolated fungi in both yellow and white garri samples is among the most abundant and widely distributed organisms on earth (Klich, 2002). Members of this genus are saprophytic moulds living in the environment without causing diseases (Cheesborough, 2005). Aspergillus niger has the highest occurrence in both garri samples. Penicillium sp. is an uncommon pathogen in humans and has also been reported as a common opportunistic pathogen causing systemic penicilliosis in AIDS patients in Thailand, Southern China and other parts of Southern Asia (Cheesborough, 2005). Data obtained from the analysis of the gari samples from the four markets are represented in table 2 and the frequency of each fungal isolate is shown in figure 9. These isolates include Aspergillus niger 20%, Aspergillus flavus 10%, Saccharomyces cerevisae 20%, Geotrichium sp. 25%, Fusarium sp. 10%, Candida sp. 10% and Penicillium sp 15%.

The result obtained from the proximate analysis carried out on both garri samples shows that yellow garri sample had a lower carbohydrate content of (72.22 %), lipid (1.56 %), protein (1.75 %), ash (1.30 %), moisture content (12.27 %), crude fibre (10.90 %). The white garri samples had a higher carbohydrate content of (72.45 %), lipid (1.48 %), protein (1.70 %), ash (1.70 %), moisture content (11.87 %), and crude fibre (10.80 %). Moisture content levels of the garri samples were within standard range of 12.7 – 13.6%. The moisture content of yellow garri was 12.27% and white garri 11.87%. The low moisture content of white garri suggests longer storage lives and better cooking qualities, (Eleazu and Eleazu, 2012) The proximate composition values of the garri samples (both white and yellow) are comparable to that obtained by Oluwole et al. 2004. From the above result, there was a high significant statistical difference ($p>0.05$) between the two brands of garri.

For the physicochemical parameters, yellow garri had a higher swelling index than white garri. The pH's of the yellow garri samples ranged from 4.9–5.9 and were higher than that of the white garri samples which showed lower pH and ranged from 4.5–5.3 implying reduced level of cyanide as opposed to the observed pH and cyanide effect of white garri. The pH values of this study can also be comparable to that obtained by Cornelia et al (2017), whose values were 4.6 – 5.8. Yellow garri had a higher loose density of 12 - 18 than white garri which was 10 - 17, but had a lower bulk density of 8 – 15 and white garri 8–16. The loose density of garri is expected to be less than the bulk density as the bulk density method involved tapping on a hard surface which reduced the volume. The percentage moisture content of the white garri influenced the bulk density as high bulk densities imply reduced volume. (Cornelia et al, 2017)

Developing strategies to antagonize the growth and survival of microorganisms in foods in order to neutralize the potential of these organisms that serve as food borne disease vectors is of necessity. However, the exposure of garri in the market during its sale shows serious health implications especially as garri undergoes little or no cooking which could help in eliminating some of these microorganisms present in the garri before consumption.

5. Conclusion

According to the results obtained from this study, it can be concluded that airborne contaminants in the market areas contribute considerably to the microbial load of garri sold in market places. Also, the presence of Staphylococcus aureus and Escherichia coli in the garri samples is an indication of faecal contamination of the garri. There is therefore a need to maintain proper sanitary conditions so as to avoid health risks. The moisture content of garri samples analysed is low and within standard specification, this could have accounted for keeping the microbial load of garri low. The difference between the two brands of garri was very small indicating that both brands are good but can cause potential harm as a

result of poor hygiene and handling. It can be concluded from this research that yellow garri is better than white garri in terms of consumption and health implication as red oil introduces Vitamin A into the garri and neutralizes its cyanide level.

6. Recommendation

From the findings of this research, it is necessary that the following adjustments be made to prevent contamination and to obtain the best quality of the different brands of garri sold in markets. .Garri should be sampled and stored in the market with nylon bags and transparent plastic containers which would protect the product against any infiltration of moisture, insect infestation and leakage.In large scale cassava flour processing industries, garri should not be left exposed but packaged in bags just as rice and other food products are being packaged. Packaging materials should be changed to effectively provide complete protection of the dehydrated products against moisture, light, air, dust, micro flora, foreign odour and animal pests. The packaging materials also should provide strength and stability required to maintain the original properties of products through storage, handling and marketing. Effective HACCP and GMP will help reduce or eliminate product contamination and thus make the product safe for consumption. Also, the habit of drying half fried garri on concrete, rocks, mat etc should be disallowed to reduce the level of solid particle and microbial contamination thereby preventing health hazards such as liver cancer, aspergillosis and typhoid fever. Sanitary conditions of our factories, markets and communities should be improved. Regulatory and Inspection agencies should make it a duty to educate food/garri sellers on Effective Food Handling Techniques and proper personal/environmental hygiene. This would reduce contamination from faecal origin or from handlers' skin, nose or mouth (normal flora).

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