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Research Paper

Bacteriological Quality and Public Health Implications of Garri Sold In Saturday Market in Langtang North Town, Plateau State

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ABSTRACT
The purpose of this study is to investigate the bacteriological quality and public health implications of garri sold in Saturday market in Langtang North town, Plateau State. Six Garri samples were randomly collected from three retailer. On purchases, each sample was collected into sterile nylon (polythene) bags one cup each for the sample and appropriately labeled for each brand: Which is as follows. (1st Retailer): W1 -White Garri, R1-Red Garri; (2nd Retailer): W2- White Garri, R2-Red Garri; (3rd Retailer): W3-White Garri, R3-Red Garri. The samples were transported to the microbiology laboratory of the National Veterinary Research Institute (NVRI) VOM, Jos Plateau State for immediate processing and analysis. The result clearly indicated that the mean microbial count of white Garri and red Garri samples from three retailers in Monday market, Pankshin L.G.A of Plateau State. It reveals that the mean of the total bacterial count of W1 is $9.27\pm0.02\times10^4$, W2 is $5.85\pm0.05\times10^4$, W3 is $7.85\pm0.05\times10^4$, R1 is $3.58\pm0.03\times10^4$, R2 is $6.15\pm0.05\times10^4$ and R3 is $7.16\pm0.01\times10^4$ with W1 having the highest mean count. The mean of the total coliform count reveal that W1 is $9.84\pm0.06\times10^3$, W2 is $2.22\pm0.02\times10^4$, W3 is $4.03\pm0.02\times10^5$, R1 is $1.34\pm0.01\times10^3$, R2 is $1.93\pm0.03\times10^3$ and R3 is $2.53\pm0.03\times10^4$ with W1 having the highest mean count. The bacterial isolates reveal that W1 was contaminated with Escherichia coli, klebsiella aerogenes, staphylococcus epidermids. W2 with Escherichia coli, Staphylococcus epidermids, W3 with Escherichia coli, Staphylococcus epidermids, R1 with Micrococcus specie, Escherichia coli, Staphylococcus epidermids, R2 with Escherichia coli, Staphylococcus epidermids, Bacillus species and R3 with Escherichia coli, Proefeus vulgaris, Staphylococcus epidermids, micrococcus species. The Biochemical Characteristic of Bacterial Isolates of Garri revealed that Escherichia coli was positive in Indole test, Methyl Red test, motility test, negative in oxidase test, catalyse test, coagulase test and Acid/Gas in Glucose test, lactose test, sucrose test, mannitol test. Staphylococcus epidermids was negative in Indole test, Methyl Red test, motility test, oxidase test, coagulase test and Positive in catalyse test, Glucose test, lactose test, sucrose test and mannitol test. Bacillus spp was positive in motility test, oxidase test, catalyse test, Glucose test, lactose test, sucrose test, mannitol test and negative in Indole test, Methyl Red test, coagulase test. In conclusion, results obtained from this study have shown that air bone contaminants in market areas may contribute considerably to the microbial burden of Garri sold in Saturday market in Langtang North L.G.A, Plateau State. This is worsened by the unhealthy but accepted mode of selling and distributing Garri in open basins, trays and mats in Nigerian markets which may pose potential risk for public health.
Keywords: Bacteria, Garri, Health, Implications, Pankshin

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I. INTRODUCTION

Food security both in developed and developing countries has been a growing concern that has led to an unprecedented global interest in Agriculture (Ikon & Atadoga, 2020) because of the alarming concern of disease outbreak caused by consumption of contaminated food and food products. Market vending has become an important public health issue and a great concern to everybody. This is due to the widespread of food borne disease associated with garri handlers who lack adequate understanding of the basic food safety issues (Ikon & Atadoga, 2020).

Garri is a creamy white granular floor with a slightly fermented flavor and slightly sour taste, made from fermented gelatinized fresh cassava (*Mannihot esculeta*) tubers. It is estimated that 70% of the cassava produced in Nigeria is processed into garri. It is produced from Cassava Tubers and is the commonest stable food in Nigeria consumed by over 130 million people (Ikon & Atadoga, 2020). In garri preparation the cassava is peeled, washed, grated then followed by dehydration under pressure. Finally, frying, packaging and storage (Arasi & Adebayo, 2000).

Garri is widely known in Nigeria and other West African countries as a staple food eaten mostly by the Midwestern part of Nigeria as red garri and white garri. The western parts of the country eat it as Ijebu garri. It is commonly consumed either dry or soaked in cold water with sugar, coconut or roasted groundnut as compliments or as a paste made with hot water and called "Eba" which is eaten with variety of African soups or stews of various types by chewing or swallowing in morsels (Asegbeloyin and Onyimonyi, 2007).

There are several factors which influence the quality of garri. Through their processing and storage conditions respectively (Obadina *et al*., 2009). During processing, garri may be contaminated with micro-organisms, unless the growth and metabolism of this micro-organism are controlled micro-organisms are capable of altering the condition of food resulting in food spoilage and food poisoning. This can lead to death of people, thereby reducing the population.

The garri sold in open market is exposed to many factors which might introduce micro-organisms into the garri. Some of these factors are. The hygienic status of the retailers: Some of the garri retailers are unhygienic. They use bare hands which may be contaminated or infected with micro-organisms during handling and sales (Hong *et al*., 2009). The materials used for Garr selling: Some of these materials (display of product in open buckets, basins, wheelbarrow, bowls, mats, sack etc). are not usually clean. Some are contaminated (e.g sack and mats) while others may be rusted (e.g basin, buckets and wheel-barrow) (Obiazi, 2018). Exposure of the Garr to dust and air borne particles: The garri sold in open markets are not usually covered. This exposes the garri to dust which might contain some micro-organisms. Also, some of the garri sellers do hawk, and that also exposes the garri to dust and polluted air. Attitude of the buyers: Some of the buyers of garri use their hands to fetch the garri, not minding if their hands are clean or not (Okafor *et al*., 2018). It has also been reported that garri sold in markets contain high load of microorganism (Ikon & Atadoga, 2020) which might cause economic loss and food borne illness and public health threat as a result of these contaminations. The patronage of many consumers could constitute serious health implication as many chances have been given to contamination by organism of epidemiological importance such as *Salmonella, Escherichia coli, Klebsiella, Staphylococcus aureus, Staphylococcus epdidermidis Cryptosporidium, Campylobacter, L.grayi, L ivanovii* (Ikon & Atadoga, 2020).

However, these unhygienic practices which may lead to microbial contamination due to deposition of bioaerosols on exposed products, transfer of microbes from contaminated hands and utensils, frequent visit by animals and femites (which may carry infectious agents) can contribute to the post-process problems of this product (Orpin *et al*., 2020). In Nigeria, it has become a common practice to eat garri raw or as snacks especially among students who resort to it as faster alternative to preparation of cooked food, without considering the bacteriological implication. This study is carried out to assess the microbial quality of garri sold in Saturday markets of Langtang North LGA of Plateau State as well as to establish the hygienic status of garri taken as snacks by many Nigerians.

JUSTIFICATION OF THE STUDY

The assessment of some bacteria connected with garri sold in Nigeria (Ikon & Atadoga, 2020) and even the study area are both limited. Because no studies have been reported, this investigation was conducted to give details on the bacteriological quality of garri in Langtang North LGA of Plateau State, Nigerian.

THE STUDY'S OBJECTIVES

The following are the precise goals:

1. Calculate the mean bacterial load in garri.
2. Isolation and identification of microorganisms in garri
3. To determine the biochemical characteristics of the isolates.

II. MATERIALS AND METHODS

Study Area

The study area is in Langtang North. Langtang North is a Local Government Area in Plateau State, Nigeria. Its headquarters are in the town of Langtang. The geographical co-ordinates of Langtang are Latitude 9°08′00″N E and longitude 9°47′00E. It has an area of 1,188 km^2 and a population of 140,643 at the 2006 census. The postal code of the area is 941. It has a population of 140, 643 as of 2006population census. Language spoken in Langtang North is Taroh.

Apparatus

The apparatus used for the experiment are: microscope; incubator, refrigerator, universal bottles, bayou bottles, syringe, needle, were loop, micropipette, Petridishes, masking tape, conical flask.

Reagents

The reagents used are crystal violet, lugols lodine, Acetorie or acid-alcohol, safranin, methyl red, kovac reagent, Hydrogen peroxide and pepton water.

Sample Collection

Two brands of garri, based on colour are regularly sold in the Saturday market in Langtang North town at different prices per measure. These are the "white GARRI" and the "Red Garri" (or Bendel Garri) which is usually more expensive. Consequently, majority of people go for the cheaper white garri. Three samples of each brand of the were collected, giving a total of six samples, three white garri types and three red garri types, respectively. On purchases, each sample was collected into sterile nylon (polythene) bags one cup each for the sample and appropriately labeled for each brand: Which is as follows.

(1st Retailer):	W1	-	White Garri	
	R1	-	Red Garri	
(2ndRetailer):	W2	-	White Garri	
	R2	-	Red Garri	
(3rd Retailer):	W3	-	White Garri	
	R3	-	Red Garri	

The samples were transported to the microbiology laboratory of the National Veterinary Research Institute (NVRI) VOM, Jos Plateau State for immediate processing and analysis.

Sterilization of Materials

The glassware and the ware loops were properly washed, air dried, wrapped with Kraft paper and sterilized in hot air oven at 180^0c for 2 hours.

Preparation of Media Used

Each medium was prepared as at when needed according to the manufacturer's instruction on the labels of the media and autoclaved at 121^0c for 40minutes. Different media such as Macconkey Agar (MCA), Sabouraud Dextrose agar (SDA), Nutrient Agar (NA) were prepared separately.

Preparation of Macconkey Agar (MCA)

25g of macconkey agar powder was weighed on a balance machine, suspended in 500m1 of distilled water. It was heated to boil with gentle swirling to dissolve completely. The medium for the isolation was sterilized by autoclave at 121^{0c} for 40minutes. The medium was cooled to 40-50^{0c} and poured in the sterile petri-dishes.

Preparation of Sabouraud Dextrose Agar

32.5g of sabouraud distilled agar powder was weighed on a balance machine, suspended in 500m1 of distilled water. This medium was heated to dissolve completely and was sterilized in autoclave at 121^{0c} for 40 minutes. The medium was cooled to 40-50^{0c} and poured into sterile petri-dishes.

Preparation of Nutrient agar

10g of nutrient Agar powder was weighed on a balance machine, and was suspended in 500ml of distilled water, boiled to solve completely, the media sterilized in autoclave at 121^0c for 40minute. The medium was cooled to 40-50^0c and poured into sterile petri-dishes.

Preparation of Normal Saline

3.4g of normal saline was suspended in 400m1 of distilled water, 10m1 syringe was used to transfer the dilute normal saline into the bijou bottles ready for dilution.

CULTURE OF SAMPLE

1g of each sample (garri) was weighing on a weighing balance, dissolved properly in 10m1 of pepton water which was used to prepare ten folds serial dilution. Using pour plate method. The medium was allowed to solidify before drying in an incubator for 1 hour at 37^0c. The petridishe of the medium was labeled according to the labeled samples. After the drying, micropipette was used to inoculate the dilute. Sample into the prepared medium and was spread with rubber wire loop properly to ensure even distribution. The pour plates were incubated in an inverted manner at 37^0c for 24 hours. The plates were observed and the single colonies were picked for sub-culture in order to obtain pure culture.

MICROSCOPIC EXAMINATION

Microbial count

After incubation, the number of colonies on the petri-dish were counted using bacterial colony counting chambers. The total bacterial count, total Coliform count and total fungal count were taken.

Gram stain technique

Smear of each of the isolates were prepared by picking a small portion of discrete colony form the plates with the help of sterilized wire loop, into a drop of normal saline on glass slide, it was spread properly and allowed to dry. After making the smear, the slide were heat-fixed by carefully passing them over a Bunsen burner flame, about 3 times. The heat-fixed smear was then covered with crystal violet stain for 60 seconds. The stain was quickly washed off with clean water. The water was tipped off and the smear was covered with lugols lodine for 60 second. The lodine was washed with clean water. The smear was decolorized rapidly for about 20 seconds with 95% ethanol. The smear was quickly washed with clean water and then covered with dilute carbolfuschin for 30 second. The stain was washed off with clean water and the slide was allowed to dry at room temperature. The gram stained slide was examined first with x40 objective lens to check for the staining and distribution of the gram stained bacteria, then with oil immersion objective lens (x100) to look for the bacteria. Gram positive bacteria appeared purple while gram negative appear red or pink.

BIOCHEMICAL TEST

Indole test

The sterile wire loop was used to inoculate organisms in a test tube containing 5m1 of peptone water (medium) and incubated for 48hours at 37^0c. After incubation, 0.5m1 of kovac's reagent was added into the tube and allowed to stand for 15minute a rose spank colour indicated positive reaction. While the negative reaction result in the indole reagent retaining it's yellow color.

Catalase test

The test demonstrates the presence of catalase which is an enzyme that catalys the release of oxygen form hydrogen peroxide (H_2 0_2). A colony of 24 hours old culture was picked using a sterile loop and then emulsified in a few drops of hydrogen peroxide on a clean slide presence of effervescence indicated catalase positive reaction whereas negative reaction showed no effervescence.

Motility test

This test was carried out to determine the presence of or absence of flagella as organelle of movement in the bacteria isolated. Discrete colonies of overnight culture was placed on microscopic slide containing a drop of peptone water and covered with a cover slip after a minute. Then, it was viewed microspically with high power objectives. Motile organisms were seen swimming around indicating a positive reaction while non-motile organisms indicated negative reaction.

Methyl Red Test

In carrying out this test, a test organism was inoculated in a test tube containing 5m1 of prepared peptone water and was incubated for 48hours at 37^0c after incubation, 0.5m1 of methyl red was added into the test tubes and allowed to stand for 15 minutes. A reddish color on the addition of indicators signified a positive result while a yellowish color denoted negative result.

Coagulase test

In carrying out this test, a test organisms was inoculate in a test tube containing 1ml of rabbit plasma which was labeled negative control and positive control, and was incubated at 37^0c and the suspensions was observed at half an hour intervals for a period of four hours. Positive result was indicated by gelling of the plasma which remains in place even after inverting the rube, while negative result remains until four hours at 37^0c, the tube is kept at room temperature for overnight incubation.

Oxidase test

A piece of filter paper was soaked with 1% of the substrate tetraethyl-p phenylenediamine dihydrochloride, the paper was moisten with sterile distilled water. A bit of the isolate were obtained with sterile wire loop and smeared on the wetter portion of the filter paper. The development of an intense purple color within 30 second, was observed.

Sugar Fermentation

10m1 of pepton water was introduced into four (4) sterile test tubes respectively. 1g of respective carbohydrate such as glucose, lactose and mannitol were added into each of the test tubes that contain the pepton water and labeled accordingly. They were stirred to dissolve completely over a Bunsen burner after which 3 drops of phenol red were added into each of the test tubes, the tubes were plugged with cotton wool and sealed with foil before sterilization in autoclave at 115^0c for 15 minutes after the sterilization of medium, the culture organisms were inoculated into each of the tubes respectively and durham's tubes were inserted in an inverted position into each of the tubes. They were incubated at 37^0c for 24 hours. A change in the coloration of medium after 24 hours form purple to yellow indicated acid production due to the fermentation of sugar by the organisms while retention of the purple color indicated a negative reaction. Gas production was shown by the presence of bubbles on the surface of the medium and an upward movement of the inverted durhams tubes.

INCULCATION AND INCUBATION OF FUNGAL

The affected tissues were surfaced-sterilized with 10% ethanol using a cotton wool. Four small pieces form the margin of lesion of each sample were directly inculcated aseptically on prepared plates of Sabouraud Dextrose Agar (SDA) and incubated at 270c for 3-5 days.

Sub-culturing of fungals

When fungal growth from the tissue was visible, fungal were sub-cultured on SDA to obtain pure cultures for identification. Fungi were continuously sub-cultured until pure isolates were obtained. The pure fungal cultures were stored safely in the refrigerator at 40^0c to prevent any fungal growth in the plates.

Microbiological analysis of fungals

The fungal isolates were identified by wet mounting the fungal spores in lacto phenol cotton blue and then observed under x40 objectives. Features such as vesicle shape, length and color of the stripe, the foot cell, the type of conidia and the serration were some of the characteristics observed under the microscope, while macroscopic features such as colour of the organisms on plate.

STATISTICAL ANALYSIS

Statistical analysis was carried out using One-way Analysis of Variance (ANOVA). Data were analysed using SPSS Version 23 computer software. Data were expressed as the mean $\pm$ standard error of mean and values of $P< 0.05$ were considered significant.

III. RESULTS AND DISCUSSIONS

RESULTS

Table 1: Mean microbial load cfug^{-1}

S/N	Sample	TBC(cfu/g)	TCC(cfu/g)	TFC(cfu/)	p-value	LOS
1	W1	$9.27\pm0.02\times10^4$	$9.84\pm0.06\times10^3$	<3TFTC	0.05	ns
2	W2	$5.85\pm0.05\times10^4$	$2.22\pm0.02\times10^4$	<5TFTC	<0.0001	*
3	W3	$7.85\pm0.05\times10^4$	$4.03\pm0.02\times10^5$	<3	<0.0001	*
4	R1	$3.58\pm0.03\times10^4$	$1.34\pm0.01\times10^3$	<5	<0.0001	*
5	R2	$6.15\pm0.05\times10^4$	$1.93\pm0.03\times10^3$	<10	<0.0001	*
6	R3	$7.16\pm0.01\times10^4$	$2.53\pm0.03\times10^4$	<10TFTC	<0.0001	*

Note: Values are expressed as mean ± SEM; NS= Not significant, LOS= Level of Significance,
* = significant at P<0.05

KEY: W: White Garri, R: Red Garrri, TBC: Total Bacterial Count, TCC: Total Coliform Count, TFC: Total Fungal Count, TFTC: Two few to count; TNTC: Two numerous to count

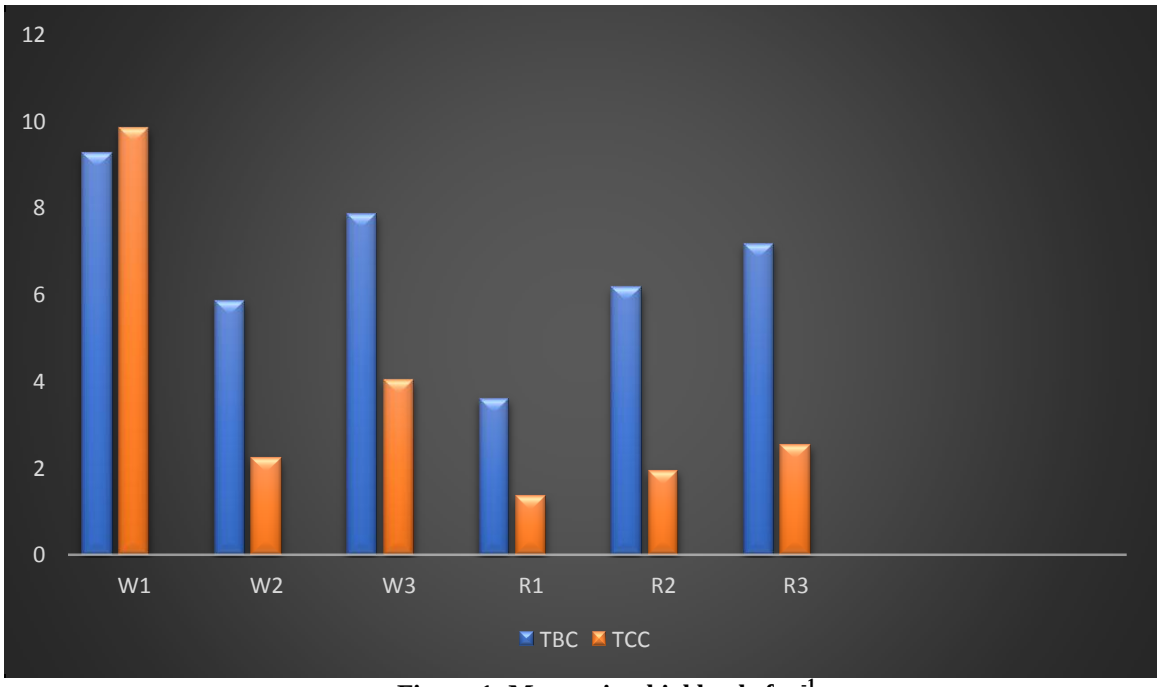

Figure 1: Mean microbial load cfug^{-1}

KEY: W: White Garri, R: Red Garrri, TBC: Total Bacterial Count, TCC: Total Coliform Count

The table 1 and figure 1 above shows the mean microbial count of white Garri and red Garri samples from three retailers in Monday market, Pankshin L.G.A of Plateau State. It reveals that the mean of the total bacterial count of W1 is $9.27\pm0.02\times10^4$, W2 is $5.85\pm0.05\times10^4$, W3 is $7.85\pm0.05\times10^4$, R1 is $3.58\pm0.03\times10^4$, R2

is $6.15\pm0.05\times10^4$ and R3 is $7.16\pm0.01\times10^4$ with W1 having the highest mean count. The mean of the total coliform count reveal that W1 is $9.84\pm0.06\times10^3$, W2 is $2.22\pm0.02\times10^4$, W3 is $4.03\pm0.02\times10^5$, R1 is $1.34\pm0.01\times10^3$, R2 is $1.93\pm0.03\times10^3$ and R3 is $2.53\pm0.03\times10^4$ with W1 having the highest mean count. The mean of the total fungal count reveal that W1 is <3, W2 is <5, W3 is <3, R1 is <5, R2 is <10 and R3 is <10 respectively.

Table 2: Microorganisms isolated from Garri samples

SAMPLE	BACTERIAL ISOLATES	FUNGAL ISOLATES
W1	*Escherichia coli, klebsiella aerogenes, staphylococcuus epidermids*	Penecillium species, Trychophyton species
W2	*Escherichia coli, Staphylococcuus epidermids*	*Aspergillus niger*, Penecillium species
W3	*Escherichia coli, Staphylococcuus epidermids*	Mucor species, *Aspergillus niger* Penecillium species
R1	Micrococcuss specie, *Escherichia coli, Staphylococcuus epidermids*	Mucor species, Penecillium species
R2	*Escherichia coli, Staphylococcuus epidermids*, Bacillus species	Penecillium species, *Aspergillus niger*
R3	*Escherichia coli, Proefeus vulgaris, Staphylococcuus epidermids*, micrococcus species	Penecillium species, Trychophyton species

Table 2 above show the microorganisms isolated from garri samples. The result reveal that the gari samples were contaminated by diverse microbial species. The bacterial isolates reveal that W1 was contaminated with *Escherichia coli*, *klebsiella aerogenes, staphylococcuus epidermids.* W2 with *Escherichia coli*, *Staphylococcuus epidermids,* W3 with *Escherichia coli*, *Staphylococcuus epidermids,* R1 with Micrococcuss specie, *Escherichia coli*, *Staphylococcuus epidermids*, R2 with *Escherichia coli*, *Staphylococcuus epidermids*, Bacillus species and R3 with *Escherichia coli*, Proefeus vulgaris, *Staphylococcuus epidermids*, micrococcus species. The fungal isolates reveal that W1 was contaminated with Penecillium species, Trychophyton species. W2 with *Aspergillus niger*, Penecillium species, W3 with Mucor species Aspergillus niger Penecillium species, R1 with Mucor species, Penecillium species, R2 with Penecillium species, *Aspergillus niger* and R3 with Penecillium species, Trychophyton species.

Table 3: Biochemical Characteristic of Bacterial Isolates of Garri

Isolates	Indole Test	Methyl Red test	Motility test	Oxidase Test	Catalyse Test	Glucose Test	Lactose Test	Sucrose Test	Mannitol Test	Coagulase Test
Escherichia coli	+	+	+	-	-	**AG**	**AG**	**G**	**AG**	-
Staphylococcuus epidermids	-	-	-	-	+	+	+	+	+	-
Klebsiella aerugenusa	-	-	+	-	+	**AG**	**AG**	**AG**	**AG**	-
Micrococcus spp	-	-	-	+	+	+	+	-	-	-
Proteus Vulgaris	-	-	+	-	-	**A**	-	-	**A**	-
Bacillus spp	-	-	+	+	+	+	+	+	+	-

KEY: + Positive, - Negative, A-Acid, G-Gas, AG- Acid and Gas

The table 3 above show the Biochemical Characteristic of Bacterial Isolates of Garri. The *Escherichia coli* was positive in Indole test, Methyl Red test, motility test, negative in oxidase test, catalyse test, coagulase test and Acid/Gas in Glucose test, lactose test, sucrose test, mannitol test. *Staphylococcuus epidermids* was negative in Indole test, Methyl Red test, motility test, oxidase test, coagulase test and Positive in catalyse test, Glucose test, lactose test, sucrose test and mannitol test. *Klebsiella aerugenusa* was Negative in Indole test, Methyl Red test, oxidase test, coagulase test, Positive in motility test, catalyse test and Acid/Gas in Glucose test, lactose test, sucrose test, mannitol test. *Micrococcus spp* was Negative in Indole test, Methyl Red test, motility test, sucrose test, mannitol test, coagulase test, and Positive in oxidase test, catalyse test, Glucose test, lactose test. *Proteus vulgaris* was Negative in Indole test, Methyl Red test, oxidase test, catalyse test, coagulase test, lactose test, sucrose test Positive in motility test, and Acid in Glucose test, mannitol test. *Bacillus spp* was positive in motility test, oxidase test, catalyse test, Glucose test, lactose test, sucrose test, mannitol test and negative in Indole test, Methyl Red test, coagulase test.

IV. DISCUSSIONS

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 post. These lost includes: loss of income due to the cost of medical care, the cost of investigating food contamination outbreaks, loss of income to closure of business legal costs and fine (Nichols *et al*., 2011). Hence taking "Garri" dry as snacks or with cold water is exposure to health risk due to the microbial status.

Mean Microbial Count of White Garri and Red Garri Samples

The table 1 and figure 1 above reveals that the mean of the total bacterial count of W1 is $9.27\pm0.02\times10^4$, W2 is $5.85\pm0.05\times10^4$, W3 is $7.85\pm0.05\times10^4$, R1 is $3.58\pm0.03\times10^4$, R2 is $6.15\pm0.05\times10^4$ and R3 is $7.16\pm0.01\times10^4$ with W1 having the highest mean count. The mean of the total coliform count reveal that W1 is $9.84\pm0.06\times10^3$, W2 is $2.22\pm0.02\times10^4$, W3 is $4.03\pm0.02\times10^5$, R1 is $1.34\pm0.01\times10^3$, R2 is $1.93\pm0.03\times10^3$ and R3 is $2.53\pm0.03\times10^4$ with W1 having the highest mean count. This difference in count may be attributed to difference in food safety adherence or personal hygiene by the food handlers (Sherifat and Wunmi, 2018). The garri samples contain total bacterial count and total coliform count within acceptable limit. Ready to eat foods with plate counts of $\leq10^3$ are acceptable, counts of 10^4 to 10^5 are tolerable while counts $\geq10^6$ are unacceptable (Ikon & Atadoga, 2020). This study reveal that the total bacterial count and the total fungal count in all the garri samples are within the range of 10^3 to 10^5 which are acceptable according to Ikon & Atadoga, 2020). The presence of coliform in most of the garri samples therefore make it poor quality and unsafe for human consumption but in this study, no coliform was present in the garri samples collected in the study area. This generally signifies that good sanitary conditions in the post-process handling of garri via food handlers and the environment. The ICMSF (1996) and the African Organization for Standardization recommended absence of coliform in ready to eat foods. Moreso, The total bacterial count identified recorded the highest mean count with white garri than the red garri having the least mean count which is an indication of the sanitary quality, safety and utility of foods; it may reflect the conditions under which the product is manufactured such as contamination of materials, the effectiveness of processing and sanitary conditions of equipment and utensils at the processing plants (Obiazi, 2018)

Microorganisms isolated from Garri samples

The fermentation of Garri is by mixed microbial cultures, this could have accounted for the diverse microbial population contaminating the product. Similarly post process contamination specifically associated with sieving of products after heat treatment and the spreading of products in the open to air dry, coupled with the practice of leaving Garri open for sales could have accounted for the diverse microbial population. The isolation of diverse microbial species from this ready to eat food (Garri) corroborate the findings of Nichols *et al*., (2011) and Ikon & Atadoga, (2020). The presence of *Escherichia coli* and *staphylococcuus epidermids* calls for serious concern considering the facts that Garri is sometimes eaten without further cooking coupled with the facts that some strains of these organisms are toxigenic and have been implicated in food borne intoxication (Ikon & Atadoga, 2020). *Escherichia coli* and *staphylococcuus epidermids* are of human origin, their presence therefore could be of potential risk to the public health or customers.

Moulds are common environmental contaminants due to their ability to produce spores, this could explain their presence in Garri. They have been implicated in ready to eat foods and in unregulated/mixed fermentation. Species of *Aspergillus niger*, Penecillium species and *Trychophyton* isolated in this study are known to produce deleterious mycotoxins under favorable conditions (Ikon & Atadoga, 2020, Olopade *et al*., 2014). Post process contamination of garri could be by divers microbial population is specifically associated with sieving of products after heat treatment and the spreading of products in the open to airdry, coupled with the practice of leaving garri open for sales could accounted for the divers of microbial population contaminating the product. Their presence in Garri must therefore be treated with caution because it could be of potential risk to public health or customers. Bacteria and fungi can also adhere to particles of grain dust and be transported through air. Grain dust is generated during the process of farming and secondary processing of grains (sacking, milling, handling of powdered grains, sorting, etc.) in markets and can play a role as an effective infectious aerosol because its organic materials provide essential nutrients for airborne microorganisms adhered to their surfaces (Kim *et al*., 2009).

Biochemical Characteristic of Bacterial Isolates of Garri

Most of the isolates were glucose positive, indole negative, catalase positive and a reasonable number of both Gram positives and Gram negatives (Table 3). The isolation of diverse microbial species from this ready-to-eat fermented foods did not completely agree with the earlier findings (Agah *et al*., 2016) as each author had dissimilarities in bacterial presence in their study samples. Most of these studies reported the presence of *Escherichia coli*, *Staphylococcuus epidermids*, *Bacillus* spp and *Klebsiella* sp. The observation of

diverse bacteria isolates could be attributed to the fact that these samples was carried out at different retailers in the study areas could affect the distribution of organisms. Buyer's attitude towards the exposed food products in the market could also contribute to the microbial load and diversity as they touch the products with bare hands and taste it before they buy. The presence of *Escherichia coli*, in this study calls for concern as this organism is the common cause of human food poisoning, and *Escherichia coli* can affect all species of domestic animals and man. It is important to draw to our attention that the young, aged, stressed, debilitated and pregnant individuals are more susceptible while the immunosuppressed and those suffering from malnutrition are at risk for *Escherichia coli* infection (Ikon & Atadoga, 2020). The presence of *Bacillus* and *Staphylococcuus epidermids* also calls for concern because some strains of these organisms are known to be toxigenic and often implicated in food borne intoxication (Olopade *et al*. 2014). *Bacillus* a common environmental contaminant and a spore former can withstand environmental stress and this may account for its presence in the samples. Meanwhile, *Staphylococcuus epidermids* is of human origin and their presence could therefore be from the food handlers, utensils and the environment. Moreover, garri is a common food widely consumed by all in Nigeria and increasing intake of it, especially drinking garri as snacks or with cold water is an added practice that exposes the populace to serious health risk due to the microbial status of the product.

V. CONCLUSION

In conclusion, results obtained from this study have shown that air bone contaminants in market areas may contribute considerably to the microbial burden of Garri sold in main market of Langtang North L.G.A, Plateau State. This is worsened by the unhealthy but accepted mode of selling and distributing Garri in open basins, trays and mats in Nigerian markets which may pose potential risk for public health.

VI. RECOMMENDATIONS

From the findings of this research, the researcher made the following recommendations

1. Sellers of Garri and other food products should stop exposing their products but cover with a transparent poly-ethane bag to protect against contamination.
2. Effective Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Points (HACCP) will help reduce or eliminate product contamination and thus makes the products safe for consumption.
3. Adequate inspections should also be carried out by public health sectors or services to ensure clean environment and hygienic practices during the sales of these food products.
4. Governments should provide and incorporate food supply managements system during processing of Garri in order to reduce the prevalence of food borne pathogens.
5. Governments should established standard Garri processing industries to managed by trained personnel in food handling to reduce contamination due to poor handling.

CONTRIBUTION TO KNOWLEDGE

The researcher was able to provide data base information about the bacteriological quality and public health implications of Garri sold which other researchers and non-researchers can use in Plateau State.

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