MICROBIAL EVALUATION OF GARRI SOLD IN OPEN MARKETS

BENIN CITY

BY

NWOSA IJEOMA VICTORIA
LSCI608978

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY
FACULTY OF LIFE SCIENCES
UNIVERSITY OF BENIN
BENIN CITY

NOVEMBER, 2022.

MICROBIAL EVALUATION OF GARRI SOLD IN OPEN MARKETS

BENIN CITY

BY

NWOSA IJEOMA VICTORIA
LSCI608978

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY
FACULTY OF LIFE SCIENCES
UNIVERSITY OF BENIN
BENIN CITY

NOVEMBER, 2022.

MICROBIAL EVALUATION OF GARRI SOLD IN OPEN MARKETS

BENIN CITY

BY

NWOSA IJEOMA VICTORIA
LSCI608978

AN UNDERGRADUATE PROJECT SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FUFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF B.Sc. (HONS) IN DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

NOVEMBER, 2022.

CERTIFICATION

This is to certify that this project was written by NWOSA IJEOMA VICTORIA (Miss) with matriculation number LSCI608978 of the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City This work has been read and approved to meet the requirements for the award of Bachelor of Science (B.Sc) degree in Microbiology.

________________________ ______________

DR. (Mrs.) I. H. Igbinosa Date
(Project Supervisor)

____________________ _______________

Dr C.F. Amaechi Date

(Project Coordinator)

______________________ ______________

Prof A. Enuleku Date
(Head of Department)

DECLARATION

I “NWOSA Ijeoma Victoria” declare that “Microbial evaluation of garri sold in Benin City” is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other University.

NWOSA Ijeoma Victoria

…………………………

Date

DEDICATION

This project is heartily dedicated to the Almighty God, Creator of Heaven and Earth for His immeasurable grace and His faithfulness during the project work and academic pursuit.

ACKNOWLEDGEMENT

My heartfelt appreciation goes to my Supervisor DR. (Mrs.) I. H. Igbinosa for her patience, contribution and guidance which made this research work a great success even amidst tight schedules, thank you and God bless you ma.

A special thanks also goes to the Head of Department of Microbiology, Prof. Prof A. Enuleku, my lecturer, Dr C. F. Amaechi and my course adviser Mrs. Edeme for their support in the course of my project work.

My immeasurable gratitude goes to my loving parents Mr. and Mrs. Nwosa who thoroughly laid the foundation for my education, they are ever supportive of my goals and aspirations and are always willing to sacrifice theirs so I can achieve mine. Their love and guidance are always with me and I owe my success to them.

Finally, I wish to thank my sisters who provide me with unending inspiration: Josephine, Joy, Jennifer, Nkechi and Winner and my brothers Victor and Jeffery for their love and being a constant support system.

ABSTRACT

Garri is a commonly consumed cassava product in Nigeria. Poorly processed/stored garri could pose serious health risk to consumers. This study seek to investigate the microbial evaluation of garri sold in open markets Benin City. Five garri samples were purchased from eight open markets which are; Egor market, Oba market, Ekiosa market, Oluku market and Adolor market, Ikpoba-Hill market, and Aduwawa market, all in Edo State making a total of 40 samples. 500 mg each for the sample and appropriately labeled. The samples were transported to the Environmental Management and Toxicology Department laboratory, for microbial, pH and moisture content analysis. Different media such as Potato Dextrose agar (PDA), Nutrient Agar (NA) were prepared separately. 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 total number of bacteria, yeast and moulds in the garri samples was determined. The total number of colony forming unit (CFU/g) was calculated, the moisture content and pH of the garri samples were also calculated. Data obtained were analyzed in percentage and mean. Total Heterotrophic bacteria count in garri samples (cfu/g x10^3) indicated that Egor and Adolor markets had the highest heterotrophic bacteria count of (9.25 x10^3) respectively while Ikpoba Hill market had the lowest count of (1.00 x10^3). The highest fungal count was recorded in Ekiosa market (1.75) and the lowest was in New Benin market (0.50). The bacteria identified are; *Micrococcus* sp., *Escherichia coli*,: *Klebsiella* sp.,*Lactobacillus* sp.,: *Enterobacter* sp., *Staphylococcus aureus*, *Enterococcus* sp., *Pseudomonas* sp,, *Streptococcus* sp., *Shigella* sp., *Bacillus* sp. the fungi identified are *Rhizomucor* sp., *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* sp., *Mudurella* sp and *Candida* sp. The highest moisture content was noticed in Aduwawa market 16.80% sample C and last was in Oluku market 8.70% sample B. The highest pH was noticed in Oluku sample C (6.76) and the lowest pH was in Egor market sample A (4.11). There is therefore a need to maintain proper sanitary conditions so as to avoid health risks. The moisture content of garri samples analyzed is low and within standard specification, this could have accounted for keeping the microbial load of garri low.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Food security both in developed and developing countries has been a growing concern that has led to an unprecedented global interest in Agriculture 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).

The Federal Government of Nigeria launched an agricultural transformation agenda to promote agriculture as a business integrate, the agricultural value chains and as a possible key way of driving Nigeria's economy (Agah *et al*., 2016). Cassava supplies about 70% of the daily calorie to over 50 million of people worldwide (Oluwole *et al*., 2014). It can be processed into bread, garri, flour etc. Among the proceeds of cassava, garri is an important by product that is commonly consumed in Nigeria because of its ready to eat nature (Orji *et al*., 2016) it is the major source of energy and fiber. Garri can be produced locally by fermentation of peeled cassava tuber in Nigeria and other parts of the world (Ogiehor *et al*., 2017).

The unhygienic handling and poor sanitary measure that obviously are been observed between the last stages of production could constitute serious health implication as many chances have been given to contaminate the food products. The dust being raised by the breeze, storm, passing by vehicles and every other form of air movement bring solid particles and heavy metals into the fermented cassava products (Garri). Heavy metal contents in food has a limit, if these limit are exceeded, it could cause harm to the human body (Adejumo and Adebayo 2015).

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 (Hussain, 2013).Open bowl display of this fermented cassava products (garri) is perceived to be a major public health risk due to lack of basic infrastructure (Rane, 2011; Hussain, 2013).

Ghosh *et al*. (2017) have identified the source of food safety issues involved in market sales of garri to be microorganisms. The processing of cassava tuber and maize grain to garri and its handling involves different stages, at each stage there is a level of contamination (Adejumo and Adebayo, 2015). The quality of the product depends on the management of each stage of the processing and handling. The processing of cassava grain into garri usually takes three to five days both at household and factory level. The unhygienic practices carried out in local markets in Nigeria is associated with practices that lead to microbial contamination due to deposition of bio aerosols on exposed products, which may cause food poisoning and may lead to disease outbreak as a result of these contaminated food products .The practices associated with the production process and handling includes drying on the floor, mat, rock, road side etc. After frying and displaying in open bowls or basins, bags, and mats during packaging at a point of sales increases solid and microbial contamination (Ogiehor and Ikenebomeh 2018).

1.2 Statement of the Problem

Garri is mainly sold by the road sides in open basin, and wheelbarrows and are exposed to dust, automobile smokes, airborne microorganisms, saliva and sneezing from nearby people and different person who want to patronize the garri vendor touches the garri with their hands without putting it in mind that their hands have been contaminated from where they are coming from. All this stated above have compromised the hygiene quality of garri sold in different markets in Benin City, therefore, this research seek to investigate the microbial quality of garri sold in different markets in Benin City.

1.3 Aim and Objects

The aim of this study was to carry out the microbial evaluation of Garri sold in some open markets in Benin City.

Objectives of the Study

The specific objectives are;

- **i.** To isolate and identify bacteria from garri sold in some open markets in Benin City.
- **ii.** To determine the percentage occurrence of the isolates.
- iii. Determination of pH content of the garri samples,
- iv. and Moisture Content of Garri Samples

1.4 Significance of the Study

This research is significant to local consumers of garri, the health care management and providers, the government and the general public

i. This research will enable the local garri consumer to consider the hygiene condition of environment where the garri vendor is located if it is toxic or in good condition before patronizing such person.

ii. The findings will enable health care management and providers identify the microbial organisms that are present in garri sold in different markets in care of any food borne disease outbreak, the sources and accurate treatment will be given since the organisms responsible have been identified.

iii. The findings will also help government and other regulatory agencies to put in place proper laws and regulations, and educating the vendors of garri how to package their products in other to prevent this contaminations.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Cassava crop

Cassava (*Manihot esculenta*) is a tuber crop serving as a cheap source of carbohydrates and other nutrients in the diet of the teeming population in Africa and Asia, which provides energy for about 500 million people (Achi & Akomas, 2006). Bamidele *et al*. (2015) posited cassava as a supplementary staple food to more than 200 million Africans aside from its uses as livestock feeds. Nigeria is ranked first and largest producer of cassava but with less export compared to Thailand (Otekunrin & Sawicka, 2019). Cassava production and processing are usually concentrated in the hands of numerous smallholder farmers located primarily in the South and Central regions of Nigeria. Cassava tuber consists of 64 - 87% starch depending on the growth stage or at maturity, but with low protein, fats, vitamins, and minerals (Aloys & Hui Ming, 2006). Cassava tubers are composed of starch depending on the growth stage or at maturity and the starch content compared to other starchy carriers (Lindeboom *et al*., 2014).

Adequate processing of cassava tubers by traditional means has yielded to a variety of edible products, such as *fufu*, '*Akpu'*, *Lafun*, *Garri*, *Abacha,* and *Tapioca*. Fermentation is one of the oldest and most important traditional food processing and preservation techniques. Employing this technique enhances the nutrient content and reduces the antinutrient contents in cassava (Oyetayo, 2006).

2.2 Cassava Fermentation

Food is one of the basic necessities of life for which traditionally fermented food is an indispensible part of these necessities (Braide *et al*., 2018). Different parts of Nigeria have a locally fermented food peculiar to them because of their ethno-cultural and religious background. This has made it difficult to have one traditional food (Adebayo *et al.,* 2010). Locally fermented food is a form of food processing where microorganisms (e.g. lactic acid bacteria) are utilized for food production through the process of fermentation (Chelule *et al.,* 2010). The fermentation processes of these foods constitute a vital body of indigenous knowledge used for food preservation. They are acquired by observation and experience, and passed from one generation to another (Aworh, 2008). The fermentation process is on a small scale and is within the household which is generally characterized by the use of non-sterile equipment, natural inoculums, sensory fluctuations, and unattractive packaging which results in unpredictable quality of the end products (Olarenwaju *et al*., 2009).

2.3 Foods products from cassava

In Nigeria, cassava has been processed into many fermented and unfermented products in many ways. Some of the fermented products include cassava flour (*lafun),* which is produced by drying and milling fermented cassava tubers, cassava flakes (*garri),* which is produced by grating, soaking, fermenting, and roasting cassava mash. Other products include fermented cassava slurry used to produce "*fufu"* (Adegbehingbe *et al*., 2019) and is most commonly consumed in the Eastern and Southern regions of Nigeria. Fermentation of cassava involves the steeping of cassava roots in water for 3 to 4 days, which softened the root to disintegrate the tissue structures in contact with linamarin which is located in the cell walls by the action of linamarase (Adeleke & Olaniyi, 2018). This enzyme hydrolyses linamarin to glucose and cyanohydrins and subsequently breaks down to ketone and HCN (Aloys & Hui-Ming, 2006). Traditionally, African fermented foods and products, for instance, *garri* and *fufu* can be obtained from a series of operational procedures, which include grating, dewatering, fermenting, and roasting and these processes generate waste among which is steeping water, wastewater, and solid waste. However, the focus of this study is on steeping water.

2.3.1 Fufu

Fufu is prepared by peeling fresh cassava tubers, washing and soaking it in water (Aworh, 2008). Thereafter, they are cut into chunks of different sizes and soaked in earthen pots and drums for 3-5days to undergo fermentation. The pH value is reduced during this period of lactic acid fermentation while the tubers are softened. This facilitates the reduction of cyanogenic compounds in the tubers (Uyoh *et al*., 2009).

When the cassava tubers are steeped into water, the retting processes sets in. *Bacillus* sp plays a major role by breaking down the pectin in the cell walls of the cassava root. This was as a result of the production of pectinase. After the pectinase activity, the lactic acid bacterium (LAB) acts by the production of flavour. The soft tubers are then sieved and allowed to sediment and dewatered with press (Adesulu and Awojobi, 2014).

2.3.2 Garri

A fresh cassava tuber is peeled to remove the brownish thin outer covering. The inner whitish portion is then grated in a machine and placed in cloth bags for 18 – 48 hours to allow it to undergo fermentation (Obire, O. and Amadi*,* 2015). The mash is dewatered by placing heavy objects on the cloth bags. The mash is sieved through a coarse sieve and heated in iron pot while stirring. During the first stage (48hours), the bacterium *Corynebacterium manihot* played a significant role in the fermentation (Braide *et al*., 2018). It breaks down the starch to organic acids including lactic acid. This brings about a drop in the pH value which encouraged the rapid breakdown of linamarin and this ushers in the second stage where there is subsequent proliferation of the fungus *Geotrichum candidum* which produces the favouring ketones, aldehydes and other compounds (Obire, O. and Amadi*,* 2015). *Lactobacillus* sp, *Leuconostoc* sp and the yeast *Candida* sp are also present in the fermenting mash and they produce linamarse which breaks down the linamarin and remove the cyanide in the *garri* (Oyewole and Isah, 2012).

2.4 Significance of food fermentation

1. Enhancement of organoleptic properties

A food that is fermented becomes palatable as there will be improvement on the organoleptic properties, texture, aroma and flavour (Chelule *et al.,* 2010). The organoleptic properties of the fermented food make them more important since it has wider acceptance than the unfermented foods (Osungbaro, 2009).

2. Provision of nutritional quality

It is known that staple foods for the low income populations like the cereals have poor nutritional value (Chelule *et al.,* 2010). Improvement in the nutritional value and digestibility of foods has been associated with lactic acid bacteria fermentation (Nout, 2009). The enzymes like amylase, proteases, lipases and phytates modify the primary food products through hydrolysis of polysaccharides, phytates, proteins and lipids (Adeyemi, 2008). The quantity of proteins, quality of proteins and the content of the water soluble vitamins increases, while the antinutrient factors (ANFs) in the foods decline during fermentation. This leads to increased bioavailability of minerals such as zinc, calcium, phosphorous iron and amino acids (Murwan and Ali, 2011).

3. Preservative Properties

Research has shown that there is a preservative activity that local fermentation has on fermented products like cereals and fruits (Adeyemi, 2012). This is lowering of the pH value through the production of acid. The acid produced inhibits the growth of pathogenic microbes which are implicated on food spoilage and food poisoning thereby prolonging the shelf life of fermented foods (Olukoya *et al.,* 2011). This in turn makes the foods safe for consumers in terms of transportation, stability and storage (Chelule *et al.,* 2010).

4. Antibiotics production

Lactic acid bacteria produce antimicrobial agents such as bacteriocin and peptides that induce antimicrobial activities against food spoilage microorganisms and food borne pathogens, but do not affect the microbes producing them. LAB fermentation is used to prevent diarrheal disease since they modify the composition of intestinal microorganism thereby acting as deterrents to pathogenic enteric bacteria (Olukoya *et al.,* 2011). They are also applied as a barrier against non-acid tolerant bacteria, which are ecologically eliminated from the medium due to their sensitivity to acidic environment (Ikon and Atadoga*,* 2020).

5. Detoxification during Fermentation

Through infestation of foods by microbes such as bacteria, yeast, moulds and viruses, a number of toxins such as fumonisin and aflatoxin are eliminated in foods (Ari *et al*., 2012). Making use of lactic acid bacteria in fermentation detoxifies toxins and is a milder method since it preserves the flavour and nutritional value of foods (Chelule *et al.,* 2010). Furthermore, fermentation degrades mycotoxins without having adverse effects on the nutritional values of foods (Ari *et al.,* 2012).

6. Decreased cooking time

Research has shown that processing foods to destroy any anti-nutrient will eventually facilitate processing and cooking and improve the nutritional quality of fermented foods like cereals and legumes. This is mostly associated with fermented soybean products and ogi from maize (Braide *et al*., 2018).

7. Improvement of health

Fermented food products consumed like fermented milks (e.g. yoghurt) have therapeutic values as they contain high concentrations of pro-biotic bacteria which lowers the cholesterol level in blood (Jyoti, 2010). It also improves digestion and nutrient absorption, balances the bacteria in the gut to hinder constipation, lactose and gluten intolerance (Abdel *et al.,* 2009). Raw fermented foods are rich in enzymes and the human body needs these enzymes to properly

digest and make efficient use of the food (Egbere, 2008). Research has shown that the slurries of Nigerian fermented carbohydrate foods like fufu and ogi have shown great health promoting properties which makes it relevant in the control of gastroenteritis in humans and animals (Aderiye *et al.,* 2007).

2.5 Description of Garri

Garri is dry, crispy, creamy-white and granular. It is a dehydrated, cassava product. It is classified or grouped based on texture, length of fermentation, region or place where it is produced and color imparted by the addition/non addition of palm oil (Abu *et al*., 2006). It has a high swelling capability and can absorb up to four times its volume in water (Osungbaro *et al.,* 2010). Obtainable in the market is the dry form of post processed garri which can be consumed soaked in cold water. Sugar can also be added to the soaked garri and it can be eaten with meat, roasted groundnuts, smoked fish, boiled beans, coconut, palm kernel, groundnut cake (kwuli kwuli), and fermented maize snacks kokoro. Beverages and milk may also be added as complements. Eba is another food prepared from garri. The granules are added into hot water and stirred to form a stiff paste which can be eaten with indigenous soups or stew (Ogiehor *et al.,* 2017).

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 (Olapade *et al.,* 2014). Garri is an important by-product of cassava being an important item in the menu of most Nigerians. It is particularly popular because of its ready-to-eat nature (Abu *et al*., 2006). Garri is a good source of energy and fiber. Other nutrients are also present in marginally nutritional significance (Ikegwu *et al*., 2009). Cassava for garri production is harvested manually in the farm with the aid of cutlasses, hoe and flat iron sheet (digger), which occasionally inflicts various degrees of injury on the root tubers. After harvesting, the root tubers are hauled to the market where they are heaped in 20s, 40s, 50s, and 100s for sales under humid and warm topical conditions. These practices predispose the root tubers to contamination and infestation by various microorganisms (Ikon sand Atadoga, 2020).

The production of garri is a burdensome and a tasking procedure and its method of production differs from one locality to another, garri is typically produced by peeling the cassava tubers, washing and grating them, which is packed into closely woven bags (Ray and Sivakumas 2009). After fermentation, frying at high temperature dries the fermented pulp to about 10% moisture content and this may result in partial dextrinization of starch. Also, high temperature destroys both enzymes and microbe's present. The garri market is competitive, sellers or buyers cannot unilaterally impose prices on the market. present. The garri market is competitive, sellers or buyers cannot unilaterally impose prices on the market (Ikon sand Atadoga, 2020).

In major garri producing areas, garri is produced by numerous smallholder units which sell garri essentially in village markets. Big markets, which are often fewer, act as an assembly center for garri from the numerous surrounding smallholder units. Such assembly markets are generally well attended by traders from far and wide, especially those markets that are well known for the supply of top quality garri. Garri quality can be defined on the basis of its safety and fitness for use by the target consumer (Osho, 2003). Thus in order to satisfy the taste of the consumers a processor needs to integrate quality into the processing operations in order to build quality into the product. In so doing the processor is able to attract more customers and remain competitive in the market place. Both processors and consumers alike have various indices by which they judge the quality of garri. These include taste (acidity or sourness), swelling capacity, color, texture, crispiness, and absence of foreign matter (cleanliness) (Adebayo *et al*., 2012).

2.6 Procedure of Garri Production

Traditional methods of processing cassava roots can result in poor quality products that contain unacceptable levels of cyanide, as well as being contaminated by foreign matter and disease-causing agents (Tsegai and Kormawa 2002). Following processing garri is spread on bare floor or on mats to allow cooling before final sieving and packaging for marketing. In the open market garri is displayed in open basins, bowls, bags and mats. These practices potentiate contamination by various groups of microorganisms and may predispose public health hazards (Ogiehor *et al*., 2002). If people eat these kinds of products, they can suffer from acute cyanide poisoning, goiter, and a nerve-damaging disorder that makes them unsteady and unable to walk properly.

2.7 Sources of Microbial Contaminations in food

Most of our foods are excellent source for rapid microbial growth. Food materials contain organic substances in plenty and sufficient amount of water, and they may be either neutral or slightly acidic in nature (Singh *et al*., 2013). They are subjected to natural contamination by many different kinds of microorganisms, including pathogens. Metabolic activities of microbes alter the condition of food, resulting in its spoilage. The airborne microbes fall on fruits and vegetables and enter through the ruptured skin. The microorganisms present in the soil reach the processing plant through the crops (Neeraj and Sharma, 2020). Several insects are also responsible for the transference of microbes to the food. In general, the keeping quality of food depends on the success of preventing the entry of micro-organisms and restricting their growth (Sing *et al*., 2013).

Foods and microorganism have long and interesting association which developed long before the beginning of recorded history (Sing *et al*., 2013). Foods are not only nutritious to consumers, but are also excellent source of nutrients for microbial growth. Depending upon the microorganism present, foods may spoil or be preserved by fermentation (Neeraj and Sharma, 2007).

2.8 Factors Improving Contamination of Garri During Production

Garri processors are involved in practices which contribute negatively to the microbial quality of the processed garri. Some of the practices include; burying of basin inside the ground to serve as a discharged point for the grinded cassava paste from the machine. This practice enhances soil particles and debris to fall directly into grinded paste thereby enhancing microbial contamination. The grinding machine is also characterized by visibly unwashed left over paste. This serve as a source of contamination to fresh cassava paste (Lawani *et al*., 2015).

Keeping of dried cassava paste sack on bare ground. There is the possibility of soil microbes finding its way through the sack into the dried cassava paste. The floor of the manual presser also having direct contact with the ground enhances microbial contamination. Unskilled nature of the garri producers introduces contaminants to their products. Sitting of the cassava effluent site close to the processing site (Baine, 2000). Poor source of water and dirty processing environment (Ogiehor and Ikenebomeh 2005). Dirty environments attributed to markets and indiscriminate dumping of refuse around the markets where garri is sold is another major source of contamination (Trickett, 1992).

2.9 Factors contributing to the emergence of food borne illnesses

Outbreaks occur wherever pathogenic agents in sufficient number or quantity encounter a susceptible population without effective measures (Holt *et al*., 2017).

1. **Genetic Variability**

The large genetic variability of microorganisms is the principal reason why so often some microorganisms survive after any unfavorable environmental change. Some strains are hyper mutable, which reinforces the potential for survival and have very short generation times (Holt *et al*., 2017).

2. **Environment**

Environmental factors also contribute to emergence of food borne illnesses; hot humid climates favor the growth of fungi and the production of mycotoxins. Human actions and behavior directly affects food safety. People are vectors for disease, traveling from place to another more rapidly than ever before. According to WHO, it is estimated that about 900.10 of all cases of Salmonella in Sweden are imported (WHO, 2002).

3. **Urbanization**

Urbanization is a major factor in emergence. Crowding increase human contact and chances for transmission particularly in developing countries where the health services are far away from the villages and farms, so there will be gab in reporting the cases of outbreaks and investigations or disease surveillance will be very low (Holt *et al*., 2017).

4. **Economics**

War and economic collapse provide opportunities for disease outbreaks. The infrastructure that provides clean water, community medicine, disease surveillance, and food control of these are easily affected by economic disruption (WHO, 2004).

2.10 Nutritional value of Garri

Garri is highly rich in starch and fiber content. It is also noticed to contain some amount of proteins, calories, sodium, fat, potassium, copper, iron magnesium, manganese, little calcium selenium, zinc and some essential vitamins like vitamins B6, C and E. The fiber content of Garri makes one to feel full when it is been consumed, and it is very helpful in preventing ailments such as constipation and bowel diseases. It provides us with energy because of its high starchy content. Red or yellow Garri contains fats and oils, which are great sources of additional nutrients and health benefits. The major health benefits of garri are that it serves as a complementary food to balance our diet For example, garri (eba) is being eaten with soups such as vegetables, meats, fish, fats and oil, minerals etc., and they provide various nutrients that make the meal to be a balanced diet. (Health and nutrition 2017).

2.11 Food borne illness

Food borne illness is defined as diseases usually either infectious or toxic in nature, Caused by agents that enter the body through the ingestion of food (WHO, 2002).Governments all over the world are intensifying their efforts to improve food safety in response to an increasing number of food safety problems and rising consumer concerns (WHO, 2004). According to one report from the United States Department of Agriculture Economic Research Service, "food borne illnesses account for about 1 of every 100 U.S. hospitalizations and 1 of every 500 deaths" (Buzby *et al*., 2001). They also estimated that food borne illness triggered by just five food borne Pathogens - *Campylobacter, Salmonella, E. coli* 0157:H7, *Listeria monocytogenes* and *Toxoplasma gondii* - cause $6.9 billion in medical costs, lost productivity and premature deaths each year in the United States. The presence of bacteria is diverse and may be introduced in majority of post heating procedures. Water used in production of locally made foods has been identified as the major source of contamination (Okeke *et al*., 2000). The World Health Organization (WHO, 2002) describes important population factors which could result in a high susceptibility to food borne infections. According to the WHO, age is an important factor because those at the extremes of age have either not developed or have partially lost protection from infection. People with a weakened immune system also become infected with food borne pathogens at lower doses which may not produce an adverse reaction in healthier persons.

Seriously ill persons, suffering, for example from cancer or AIDS, are more susceptible to infections with Salmonella, Campylobacter, Listeria, Toxoplasma, Cryptosporidium, and other food borne pathogens. In developing countries reduced immunity due to poor nutritional status render people, particularly infants and children, more susceptible to food borne infections (WHO, 2002). Food borne illnesses can occur as isolated cases or constitute an outbreak, which can involve two to thousands of people and reach different states. Food borne outbreaks in recent years in the United States have been linked to the consumption of such food items as ground beef, cookie dough, peanut butter and jalapeno peppers (WHO, 2004). According to Altekruse *et al*. (1999), some of the factors altering food borne disease patterns are the types of food that people eat, the sources of those foods, and the possible declining public awareness of safe food preparation practices.

2.13 Previous studies

Ogiehor *et al*. (2007) investigated the microbial contamination level, presence, prevalence and distribution of Aflations B1, B2, G1 and G2 in market garri with the aim of developing useful indices for safe handling and acceptable public health standards. A total of 300 samples comprising of 30 samples each from various market in both urban and rural settings were randomly collected using sterile polyethylene bags. These were analysed for microbiological quality and aflatoxins content using standard procedures. Eight bacteria genera *(Bacillus, Staphylococcus, Streptococcus, Pseudomonas, Clostridium, Salmonella Klebsiella* and *Coliforms* groups) genera and six fungi genera (*Aspergillus, Penicillium, Rhizopus, Botrytls, Fusarium and Cladosporium)* were detected and isolated. Aflatoxins B1, B2, G1 and G2 were detected in varying concentrations amongst the samples analysed within and amongst the states investigated with an average occurrence rate of 17.5%**.** Market garri was found to contain high bioload with vast array of micro-organisms and Aflatoxins in all the states investigated. Results are useful in developing and establishing public health standards for the production and safe handling of garri.

Olopade *et al*. (2014) studied microbiological quality of fermented Cassava (Garri) sold in Ota Ogun State, thirty six garri samples (eighteen each of white and yellow types) were subjected to microbial analysis. Samples were serially diluted to 10^4 and appropriate dilutions inoculated by spread plate method onto Nutrient agar, MacConkey agar and Potato Dextrose agar plates for Total aerobic plate count (TAPC), Coliform count (CC) and Fungal count respectively. TAPC for white garri ranged from $2.0x10^2$ to $1.1x10^4$, coliform count ranged from no growth (NG) to $7.1x10^3$ while fungal count ranged from no growth to $6.0x10^2$. The microbial load of yellow garri ranged from $1.0x10^2$ to $5.0x10^3$ for TAPC, NG to $6.0x10^3$ for coliform count and NG to $3.0x10^3$ for fungal count. The bacteria isolates from the various samples include *Bacillus spp Enterobacter spp, Pseudomonas, Staphylococcus* and *Klebsiella spp.* Fungi isolated includes *Aspergillus niger, Aspergillus fumigatus, Fusarium, Rhizopus and Penicillium spp*. The pH of the samples ranged from 4.76 to 4.94 in the yellow type and 4.78 to 4.91 in the white type. The moisture content was 6 to 8 percent in yellow type and 4 to 7 percent in the white type. Application of good manufacturing practices (GMP) and HACCP in garri production is imperative.

Orji *et al*. (2016) examined the bacteriological quality of fermented cassava (garri) sold in Okwor and Nkalagu markets in Ebonyi State, Nigeria. A total of sixteen (16) samples (8 white and 8 yellow) were purchased from the two markets and processed using standard procedures. The results revealed a high microbial burden in the garri samples examined ranging from 6.6×10^6 to 1.07×10^7 Aerobic Plate Counts (APC). The pH values of the garri samples purchased from both markets ranged from 5.47 to 6.61. Out of the sixteen samples, a total of 32 bacterial isolates were obtained, out of which 14(43.8%) were *Staphylococcus aureus*, 6(18.8%) *Escherichia coli*, 5(15.6%) *Bacillus cereus*, 4(12.5%) *Pseudomonas aeruginosa*, 2(6.2%) *Streptococcus* species, while the least occurring isolate was *Yersinia* species with recovery rate of 3.1%. *Staphylococcus aureus*, *Escherichia coli* and

Streptococcus species were isolated from Okwor market while *Yersinia* species, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Escherichia coli* and *Staphylococcus aureus* were isolated from Nkalagu market. The study reveals unacceptable bioload in garri from both markets. The heavy bacterial contamination and vast array of bacteria isolated from the garri sold in both markets portend alarming danger posed by consumption of garri sold in these markets. Therefore renewed vigilance on the efficacies of food processing conditions, handling techniques and handlers technical knowhow, personal hygiene practices and safety of finished products are hereby recommended.

Sherifat and Wunmi (2018) evaluated the microbial quality of garri soldin Ijebu community. Six garri samples were randomly collected from six retail sellers in three towns of Ijebu-igbo, Ago-Iwoye and Oru Ijebu in Ijebu-North Local Government Area of Ogun State. Samples were serially diluted to 10^{-2} andinoculated by pour plate method onto Nutrient agar, MacConkey agar and Potato-Dextrose agar plates for Total aerobic plate count (TAPC), Coliform count (CC) and Fungal count (FC) respectively. The Coliform counts of garri ranged from 3.0×10^2 to 3.0×10^3CFU/ml and Fungal counts ranged from 3.0×10^3 to 4.0×10^3 CFU/ml. The pH ranged content ranged from 4.78 to 4.90. A total number of fourteen (14) bacterial isolates belonging to five genera were isolated. The occurrences were *Escherichia coli* (4),*Staphylococcus aureus* (3), *Klebsiella pneumoniae* (3), *Bacillus* spp.(2)and *Pseudomonas aeruginosa* (2).A total of nine (9) fungal isolates were *Aspergillus flavus* 1(11.11%), *Aspergillus niger* 2(22.22%), *Penicillium* sp. 2(22.22%), *Fusarium* sp. 1(11.11), *Candida albican* 2(22.22) and molds 1(11.11%).

Faparusi (2021) investigated the microbial quality of yellow and white garri sold in Ilaro town Twenty garri samples were obtained from various marketing sites in the town. The microbial load of the samples was determined using pour plate technique and the isolates were identified using conventional method. The total aerobic plate count of the white garri ranged from 1.0 x 10^5 to 4.0 x 10^7cfu/g and *Staphylococcus aureus* count ranged from 7.0 x 10^2 to 1.5 x 10^3 cfu/g, while coliform count and fungal count ranged from 1.1 x 10^2 to 1.5 x10^2 cfu/g and 6.0 x 10^2 to 3.5 x 10^3 cfu/g respectively. The microbial load of the yellow garri ranged from 6.1 x 105 to 7.3 x 10^7cfu/g for total aerobic plate count while the *Staphylococcus aureus* count ranged from 3.0 x 10^2 to 6.0 x 10^3cfu/g. More so the coliform count ranged from 1.0 x 10^2 to 2.0 x 10^2cfu/g and the fungal count was from 4.0 x 10^2 to 3.0 x 10^3cfu/g. The bacteria isolated from the samples include *Bacillus cereus*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Escherichia coli*, although presence of *Pseudomonas aeruginosa* was not recorded in white garri. Fungi isolated from the garri include *Aspergillus niger*, *Aspergillus flavus*, *Mucor* sp., *Rhizopus* sp. and *Penicillium* sp. High microbial load and array of microorganisms associated with garri sold in Ilaro are of great concern.

Okolo and Makanjuola (2021) 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 × 103 CFU/g – 6.7 × 104 CFU/g) and total fungal counts (1.0 × 103 CFU/g – 2.0 × 103 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.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study area is in New Benin market, Egor market, Oba market, Ekiosa market, Oluku market and Adolor market, Ikpoba-Hill market, and Aduwawa market, in Oredo Local Government Area, Ikpoba-okha Local Government Areas, Ovia North East Local Government Areas and Egor Local Government Areas all in Edo State.

3.2 Sample Collection

Garri regularly sold in these markets mention above were purchased at different locations. Five (5) samples of garri were purchased from each markets giving a total of forty samples. On purchases, each sample was collected into sterile nylon (polythene) bags 500 mg each for the sample and appropriately labeled. The samples were transported to the Environmental Management and Toxicology Department laboratory, Faculty of Life Sciences, University of Benin, Benin City for microbial, pH and moisture content analysis.

3.3 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 ^{o}C for 2 hours

3.4 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^{o}C for 40 minutes. Different media such as Potato Dextrose agar (PDA), Nutrient Agar (NA) were prepared separately.

3.4.1 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 ^{o}C for 40minute. The medium was cooled to 40-50^{o}c and poured into sterile petri-dishes.

3.4.2 Potato Dextrose Agar

Thirty-nine grammes (39 g) of potato dextrose agar were dissolved in 1 litre of distilled water in a conical flask covered with cotton wool and aluminium foil paper. It was mixed thoroughly and sterilized by autoclaving at 121 ^{o}C for 15 min. The medium was cooled to 45 ^{o} - 50 ^{o}C and then dispensed aseptically into steril Petri dishes.

3.5 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 370c. 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 ^{o}C for 24 hours. The plates were observed and the single colonies werepicked for sub-culture in order to obtain pure culture.

3.6 MICROSCOPIC EXAMINATION

3.6.1 Microbial count

After the pour plates were incubated in an inverted manner at 37 ^{o}C for 24 hours. The plates were observed and the single colonies werepicked for sub-culture in order to obtain pure culture. The total number of bacteria, yeast and moulds in the garri samples was determined. The total number of colony forming unit (CFU/g) was calculated. Then it is converted to organisms per cubic meter air using the standard equation given below (Gouse *et al.*, 2015).

$$cfu/g = \frac{(\text{no. of colonies on the petriplate}) \cdot 10000/(\text{ petriplate surface})}{(\text{petriplate surface}).\ (\text{petriplate exposure time}).\ 0.2}$$

3.6.2 Bacterial Identification

Identification of bacterial isolates was done using the standard procedures according to Cheesbrough (2009). Bacterial colonies were initially characterized by morphology and using staining techniques (Gram staining) and identified further by biochemical tests.

3.6.3 Gram Staining

Gram's staining was done to find the reactions of the bacterial isolates to Gram reagents. A smear was prepared and heat fixed. The crystal violet (primary stain) stain was flooded over the fixed culture for 60 seconds, the stain was washed with water. The iodine solution was added onto the smear for 60 seconds, pour off and rinsed with water. A few drops of decolorizer (ethyl alcohol) was added and washed with water immediately after 5 seconds and finally safaranin (Secondary stain) will be added for 60 seconds and washed, the smear was allowed to air dry. After drying the slide was mounted under microscope and observed.

The stain differentiates bacterial species into two groups; Gram positive bacteria, which take up crystal violet dye (primary stain) and are stained violet and Gram-negative, which pick up safranin (Secondary stain) are thus stained red after decolourization with alcohol.

3.6.4 Biochemical Test

Biochemical tests such as Catalase, Oxidase, Indole, Methyl Red test (MR), Coagulase, Voges Proskauer (VP), Citrate utilization, were carried out on the isolated bacteria according to cheesbrough (2009).

3.6.5 Sugar fermentation test (Triple Sugar Iron test)

A well isolated colony was picked with sterile wire loop and inoculated in TSI by first stabbing through the centre of the medium to the bottom of the tube and then streaking the surface of the slant. The cap was left loose and incubated the tube at 35 in ambient air for 18 to 24 hours. After which the reaction was observed

3.6.6 Indole Test

A sterilized test tubes containing 4 ml of tryptophan broth was taken. This was inoculated aseptically by taking the growth from 18 to 24 hours culture. This was then incubated at 37°C for 24-28 hours. After growth was observed, 0.5 ml of Kovac's reagent to the broth culture. Formation of a pink to red color ("cherry-red ring") in the reagent layer on top of the medium within seconds of adding the reagent indicated a positive reaction. No color change even after the addition of appropriate reagent indicated a negative reaction (Maria, 2009).

3.6.7 Oxidase Test

A strip of Whatman's No. 1 filter paper was soaked in a freshly prepared 1% solution of tertramethyl-p-phenylene-diamine dihydrochloride. After which the strip was laid in a petri dish and moistened with distilled water. The colony tested was picked up with a platinum loop and smeared over the moist area. A positive reaction was indicated by an intense deep-purple hue, appearing within 5-10 seconds, a "delayed positive" reaction by colouration in 10-60 seconds, and a negative reaction by absence of colouration or by colouration later than 60 seconds.

3.6.8 Catalase Test

A loop or sterile wooden stick will be used to transfer a small amount of colony growth on the surface of a clean, dry glass slide. A drop of 3% H_2O_2 was placed in the glass slide. A positive result yielded copious bubbles production or active bubbling, while a negative result yielded no or very few bubbles production.

3.6.9 Urease Test

A sterilized test tubes containing 4 ml of diluted urease agar was taken. 1ml of preheated urea solution was added to it. This was inoculated aseptically by taking the growth from a 18 to 24 hours culture. This was incubated at 37°C for 24-28 hours. Colour change from the initial solution indicated a positive reaction and no color change indicated a negative reaction.

3.6.10 Citrate Utilization Test

The slant was streak back and forth with a light inoculum picked from the center of a well-isolated colony. It will be incubated aerobically at 35 to 37C for up to 4-7 days. A positive reaction gave growth with color change from green to intense blue along the slant while a negative reaction gave no growth and no color change; Slant remains green.

3.7 Cultural morphological characterization of fungal isolates

The fungal isolates was characterized using their colonial morphology on the plates. Parameters such as colour of the colonies, nature of the hyphae and appearance of the colonies was also considered for proper characterization of the isolate. Microscopic examination of the isolates was be carried out. Reproductive and vegetative structures were observed. Nature of spores and nature of hyphae were also considered during microscope (Barnett and Hunter, 1998).

3.7.1 Identification of fungal

The fungal colonies was be sub-cultured on Sabaraud Dextrose Agar (SDA). The isolates was identified based on their morphological and microscopic features. Two drops of cotton-blue-in-lactophenol was placed on clean glass slide and small piece of mycelium free of medium was removed with sterile inoculating needle and transferred on to the stain. The mycelium was teased (picked) out with the needles and covered with clean cover slip carefully avoiding air bubbles and observed under the microscope for vegetative and reproductive structures (Barnett and Hunter, 1998).

3.8 Determination of pH, and Moisture Content of Garri Samples

3.8.1 pH Determination

The pH of each garri samples were determined using a reference electrode pH meter by homogenizing 10 g of each garri sample in 10 ml of sterile distilled water and the pH of the sample determined (Ogiehor and Ikenebomeh, 2005).

3.8.2 Moisture content Determination

Petri dishes were washed and placed in hot air oven at 100oC 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)

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

3.9 Data analysis

Data obtained in the study were subjected to descriptive and inferential statistical for all the treatments measurable variables were presented as a mean of 3 replicates, while observable and categorical data were presented as a modal representation of 3 observations. Means had been disjointed by the use of Duncan Multiple Range Test at p<0.05. Using Statistical Package for Social Science (SPSS) software version 20 was used for statistical analyses.

CHAPTER FOUR

RESULTS

The microbial quality of Garri sample were analyzed from New Benin market, Egor market, Oba market, Ekiosa market, Oluku market and Adolor market, Ikpoba-Hill market, and Aduwawa market, in Oredo Local Government Area, Ikpoba-okha Local Government Areas, Ovia North East Local Government Areas and Egor Local Government Areas all in Edo State which are total heterotrophic bacteria count, total coliform count of fungal, physiochemical properties such a pH and moisture content was also analyzed and the results are presented below.

Table 4.1: Total Heterotrophic bacteria count in garri samples (cfu/g x10^3)

	MARKETS (x10^3)							
Samples	**Oluku**	**Egor**	**Adolor**	**Aduwawa**	**Oba**	**Ekiosa**	**New Benin**	**Ikpoba-Hill**
A	6.70	1.22	9.950	1.45	5.50	**1.45**	5.00	1.00
B	7.70	9.25	7.75	3.00	8.65	2.50	6.00	4.50
C	8.10	1.15	9.25	3.10	3.15	3.10	3.00	1.20
D	7.75	1.25	7.70	2.20	5.60	2.20	7.00	5.00
E	5.05	1.95	7.35	2.55	7.45	2.60	9.00	3.50

The Total heterotrophic bacteria count in garri samples gotten from different market indicated that Oluku market ranged from (8.10 – 5.050 x10^3), Egor market (9.250 – 1.25 x10^3), Adolor (9.95 – 7.35 x10^3), Aduwawa (3.10 – 1.45 x10^3), Oba market (8.65 – 3.15 x10^3), Ekiosa (3.10 – 1.45 x10^3), New Benin (9.00 – 3.00 x10^3) and Ikpoba Hill (5.00 – 1.2 x10^3). From the sampled markets, it was revealed that Egor and Adolor markets had the highest heterotrophic bacteria count of (9.25 x10^3) respectively while Ikpoba Hill market had the lowest count of (1.00 x10^3).

Table 4.2: Total fungal count in garri samples (cfu/mlg x10^3)

				MARKETS (x10^3)				
Samples	**Oluku**	**Egor**	**Adolor**	**Aduwawa**	**Oba**	**Ekiosa**	**New Benin**	**Ikpoba-Hill**
A	1.40	1.30	1.30	1.40	1.90	1.10	0.31	0.44
B	1.25	1.75	1.35	1.25	1.50	1.75	0.50	0.50
C	1.50	1.50	1.40	1.50	0.12	0.72	0.71	0.53
D	0.95	1.70	1.30	1.25	0.65	0.80	0.14	0.58
E	0.73	1.00	1.25	0.80	0.51	0.81	0.46	0.61

The total fungal count in garri sample purchased from different markets indicate that Oluku fungal count ranged from (0.73 – 1.40), Egor market (1.00 – 1.75), Adolor (1.25 – 1.40), Aduwawa (0.80 – 1.50) Oba (0.51 – 1.90), Ekiosa (0.80 – 1.75), New Benin (0.31 – 0.71) and Ikpoba Hill (0.44 – 0.58). The highest fungal count was recorded in Ekiosa market (1.75) and the lowest was in New Benin market (0.50)

Table 4.3: Morphological characteristics and biochemical reaction of the bacterial isolates

	Isolate code										
Parameter	**A**	**B**	**c**	**D**	**E**	**F**	**G**	**H**	**1**	**J**	**K**
Shape	Cocci	Rods	Rods	Rods	Rods	Cocci	Cocci	Rods	Coca	Rods	Rods
Cell	Cluster	Singly				Cluster			Chain		Singly
Gram stain	+	-	+	+	+	+	+	-	+	-	-
Catalase	+	+	+	-	+	+	+	+	-	+	+
Coagulase	-	-	-	-	+	+	-	-	+	+	+
Methyl red	+	+	-	-	+	+	-	-	-	+	-
Voges Proskauer	+	-	+	-	+	+	+	-	-	-	-
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

Isolated bacteria

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.

The morphological characteristics and biochemical reaction of the bacterial isolates from the markets indicated that the following bacteria were identified which are *Micrococcus* sp., *Escherichia coli*,: *Klebsiella* sp.,*Lactobacillus* sp.,: *Enterobacter* sp., *Staphylococcus aureus*, *Enterococcus* sp., *Pseudomonas* sp,, *Streptococcus* sp., *Shigella* sp., *Bacillus* sp.

Table 4.4: Cultural Characteristics of Fungi Isolates

	1	2	3	4	5	6
Colour of spore	Cotton-like colonies, white at first turns grey to yellowish brown	Very common colours of colony (black and white)	Waxy-colony with white to bright yellowish top colour and a pale to yellowish bottom	Colonies were fast growing, flat, white to cream, dry and finely suede-like with no reverse pigment	Flat, leather/ white to yellow-brownish, folded colonies	White to creamy colonies
Shape, name and type spore	Aseptate, irregular, sporangiophores. with spherical to pyriform-shaped columellae,	Hyphae divided and transparent with columnar head	Conidiophores with pyriform in shape, solitary or arranged in clustered mirocomdia.	Hyphae were hyaline, septate, branched and broke up into chains of smooth subglobose to cylindrical arthroconidia.	Flask-shaped-phialides, spherical, pyriform conidia one conidiophores	Pseudo-hyphae smooth oval globose bastoconidia
Possible isolate	*Rhizomucor* sp.	*Aspergillus* sp.	*Trichophyton* sp.	*Geotrichum* sp.	*Mudurella* sp	*Candida* sp.

The cultural characteristics of fungi isolates indicated that the following fungi were isolated from the garri samples purchased from the open markets which are; *Rhizomucor* sp., *Aspergillus* sp., *Trichophyton* sp., *Geotrichum* sp., *Mudurella* sp and *Candida* sp.

Table 4.5: Percentage of bacteria in garri samples (%)

Samples	MARKETS (%) Oluku	Egor	Adolor	Aduwawa	Oba	Ekiosa	New Benin	Ikpoba-Hill
Micrococcus sp.	4(8%)	1 (4.16%)	3 (7.89%)	1(3.70%)	3 (9.09%)	1 (4.17%)	4 (7.69%)	2 (4.88%)
Escherichia coli,	5 (10.4%)	2 (8.33%)	4(10.53%)	3 (11.11%)	3(9.09%)	2(8.33%)	5(9.62%)	4 (9.76%)
Klebsiella sp.	3 (6.25%)	2 (8.33%)	4(10.53%)	2(7.41%)	5 (15.15%)	2 (8.33%)	8(15.38%)	3 (7.32%)
Enterobacter sp.	4(8%)	3(12.5%)	4(10.53%)	2(7.41%)	3(9.09%)	5(20.83%)	3 (5.77%)	3(7.32%)
Staphylococcus aureus	3 (6.25%)	3 (12.5%)	5(13.16%)	4 (14.81%)	1 (3.03%)	1(4.17%)	3(5.77%)	2 (4.88%)
Enterococcus sp.	4 (8%)	2 (8.33%)	3 (7.89%)	3(11.11%)	3 (9.09%)	2 (8.33%)	5 (9.62%)	3 (7.32%)
Pseudomonas sp,	5 (10.4%)	1 (4.16%)	3 (7.89%)	2(7.41%)	3(9.09%)	4 (16.67%)	3(5.77%)	6 (14.63%)
Streptococcus sp.	4 (8%)	1(4.16%)	2 (5.26%)	1(3.70%)	3(9.09%)	3 (12.50%)	6 (11.53%)	5 (12.20%)
Shigella sp.	4 (8%)	2 (8.33%)	1 (2.63%)	3(11.11%)	2(2.06%)	1(4.17%)	5 (9.62%)	2 (4.88%)
Bacillus sp.	3 (6.25%)	2 (8.33%)	1(2.63%)	1(3.70%)	2(2.06%)	1(4.17%)	2 (3.85%)	4(9.76%)
TOTAL	**48(100%)**	**24(100%)**	**38(100%)**	**27(100%)**	**33(100%)**	**24(100%)**	**52(100%)**	**41(100%)**

The percentage of occurrence of bacteria from the garri samples purchased from the open markets indicated that in Oluku market *Lad tctobacillus* sp. (18.75%) had the highest and *Bacillus* sp. (6.25%) had the last, in Egor market, *Lactobacillus* sp. (20.83%) had the highest and *Pseudomonas* sp, and *Streptococcus* sp. had (4.16%), Adolor market *Staphylococcus aureus* (13.16%) had the highest and *Shigella* sp. (2.06%) had the lowest. In Ikpoba Hill market *Pseudomonas* sp, (14.63%) had the highest and *Micrococcus* sp., *Staphylococcus aureus* and *Shigella* sp. had (4.88%) each as the lowest. However, *Klebsiella* sp. had the highest number of bacteria count in New Benin Market and *Micrococcus* sp in Egor and Ekiosa, *Staphylococcus aureus* in Oba market had the lowest bacteria count.

Table 4.6: Percentage of fungi in garri samples (%)

Samples	MARKETS (%)							
	Oluku	Egor	Adolor	Aduwawa	Oba	Ekiosa	New Benin	Ikpoba-Hill
Rhizomucor sp.	1 (7.69%)	2(22.22%)	1(7.69%)	1(14.29%)	2 (15.38%)	2 (16.67%)	1(10%)	1(11.11%)
Aspergillus sp.	2 (15.38%)	1(11.11%)	2(18.18%)	1(14.29%)	1 (7.69%)	3(25%)	2(20%)	2(22.22%)
Trichophyton sp.	2 (15.38%)	1(11.11%)_	3(27.27%)	2(28.51%)	1 (7.69%)	1(8.33%)	1(10%)	1(11.11%)
Geotrichum sp.	2 (15.38%)	3(33.33%)	1(7.69%)	1(14.29%)	4 (30.77%)	2(16.67%)	3(30%)	1(11.11%)
Mudurella sp	3 (23.08%)	1(11.11%)	2(18.18%)	1(14.29%)	3 (23.08%)	2(16.67%)	1(10%)	2(22.22%)
Candida sp.	3(23.08%)	1(11.11%)	2(18.18%)	1(14.29%)	2 (15.38%)	2(16.67%)	2(20%)	2(22.22%)
TOTAL	**13 (100%)**	**9 (100%)**	**11(100%)**	**7 (100%)**	**13 (100%)**	**12 (100%)**	**10 (100%)**	**9 (100%)**

The percentage of occurrence of fungi from the garri samples purchased from the open markets indicated that Oluku market *Candida* sp. and *Mudurella* sp had the highest fungi count of (23.08%) in Egor *Geotrichum* sp had the highest fungi count of(33.3%) in Ikpoba Hill market *Aspergillus* sp., *Mudurella* sp and *Candida* sp. and the highest count of 22.22%) and *Rhizomucor* sp, *Trichophyton* sp., *Geotrichum* sp. and the lowest count of (11.11%). The highest fungi count was recorded in Oba market *Geotrichum* sp (30.77%) and the lowest *Candida* sp.(11.11%)

Table 4.7: Percentage of moisture content of garri samples (%)

	MARKETS (%)							
Samples	**Oluku**	**Egor**	**Adolor**	**Aduwawa**	**Oba**	**Ekiosa**	**New Benin**	**Ikpoba-Hill**
A	10.95	12.40	11.50	10.60	11.80	13.20	10.70	8.85
B	8.70	13.25	19.65	11.40	11.15	10.00	13.75	10.80
C	11.45	11.30	11.65	16.80	12.30	15.60	12.25	13.45
D	10.4	12.65	9.75	13.15	12.40	11.50	15.00	13.45
E	9.75	14.6	11.15	13.95	9.00	12.30	12.20	10.05

The percentage of moisture content of garri samples collected at five different locations in the different markets in Benin City indicated that in Oluku market the percentage moisture ranged from 8.70% (B) - 11.45 (C), Egor market 11.30 (C) – 14.60 (E), Adolor market 9.75% (D) – 19.65% (B), Aduwawa market 10.60% (A) – 13.95% (D), Oba market 9.00% (E) – 12.40 (D), Ekiosa market 10.00% (B) – 15.60% (C), New Benin market 10.70% (A) – 13.75% (B) and Ikpoba Hill market 8.85% (A) – 13.45% (C and D). The highest moisture content was noticed in Aduwawa market 16.80% sample C and last was in Oluku market 8.70% sample B.

Table 4.8: pH content of garri samples

	MARKETS							
Samples	**Oluku**	**Egor**	**Adolor**	**Aduwawa**	**Oba**	**Ekiosa**	**New Benin**	**Ikpoba-Hill**
A	4.64	4.11	4.72	4.82	4.21	4.64	4.80	4.56
B	4.93	4.83	4.91	4.73	4.56	4.75	4.83	4.46
C	6.76	4.84	4.60	4.66	4.83	4.56	4.77	4.60
D	4.54	4.93	4.57	4.54	4.63	4.51	4.53	4.45
E	4.65	4.33	4.53	4.61	4.43	4.45	4.51	4.83

The pH of garri sample collected from five different collected from each markets in Benin City indicated that Oluku ranged from (4.65 - 6.76), Egor (4.93 – 4.11), Adolor (4.91 – 4.53), Oba market (4.83 – 4.51) New Benin (4.83 – 4.51) and Ikpoba – Hill (4.83 – 4.45). The highest pH was noticed in Oluku sample C (6.76) and the lowest pH was in Egor market sample A (4.11).

CHAPTER FIVE

DISCUSSION OF RESULTS

The Total heterotrophic bacteria count in garri samples gotten from different market revealed that Egor and Adolor markets had the highest heterotrophic bacteria count of (9.25×10^3) respectively while Ikpoba Hill market had the lowest count of (1.00×10^3). This finding is in line with Faparusi (2021) investigated the microbial quality of yellow and white garri sold in Ilaro town Twenty garri samples, the total aerobic plate count of the white garri ranged from 1.0×10^5 to 4.0×10^7cfu/g and *Staphylococcus aureus* count ranged from 7.0×10^2 to 1.5×10^3 cfu/g. Okolo and Makanjuola (2021) evaluated the microbial loads of garri sold, the total aerobic plate counts (9.5×10^3 CFU/g – 6.7×10^4 CFU/g)

The finding is higher the that of Sherifat and Wunmi (2018) evaluated the microbial quality of garri sold in Ijebu community, the Coliform counts of bacteria in garri ranged from 3.0×10^2 to 3.0×10^3CFU/ml. Orji *et al*. (2016) examined the bacteriological quality of fermented cassava (garri) sold in Okwor and Nkalagu markets in Ebonyi State, Nigeria, the results revealed a high microbial burden in the garri samples examined ranging from 6.6×10^6 to 1.07×10^7 Aerobic Plate Counts (APC).

The total fungal count in garri sample purchased from different markets indicate that the highest fungal count was recorded in Ekiosa market (1.75) and the lowest was in New Benin market (0.50)

Faparusi (2021) investigated the microbial quality of yellow and white garri sold in Ilaro town, twenty garri samples stated that the coliform count ranged from 1.0×10^2 to 2.0×10^2cfu/g and the fungal count was from 4.0×10^2 to 3.0×10^3cfu/g.

Sherifat and Wunmi (2018) evaluated the microbial quality of garri sold in Ijebu community and the fungal counts ranged from 3.0×10^3 to 4.0×10^3 CFU/ml.

Faparusi (2021) stated that the microbial quality of yellow and white garri the coliform count and fungal count ranged from 1.1 x 10^2 to 1.5 x10^2 cfu/g and 6.0 x 10^2 to 3.5 x 10^3 cfu/g respectively.

Okolo and Makanjuola (2021) evaluated the microbial loads of garri sold, the total fungal counts (1.0 × 10^3 CFU/g – 2.0 × 10^3 CFU/g).

The percentage of moisture content of garri samples collected at five different locations in the different markets in Benin City indicated that the highest moisture content was noticed in Aduwawa market 16.80% sample C and last was in Oluku market 8.70% sample B. This finding is in line with Okolo and Makanjuola (2021) evaluated the microbial loads of garri sold within Ahmadu Bello University main campus, Samaru, Zaria, Kaduna State. The percentage moisture content the garri samples ranges from 9.98 – 13.10 % and 8.66 – 15.03 % respectively. The finding was contrary to Olopade *et al*. (2014) in his findings indicated that the moisture content was 6 to 8 percent in yellow type and 4 to 7 percent in the white type.

The pH of garri sample collected from five different collected from each markets in Benin City indicated that the highest pH was noticed in Oluku sample C (6.76) and the lowest pH was in Egor market sample A (4.11). It was observed that the result was comparable to the findings of Adebayo, *et al*. (2013) and Orji, *et al*. (2016). Meanwhile, the increase in pH observed in some selling points may be due to short period of fermentation by some of the processors thereby limiting the activities of lactic acid bacteria. This is because the product is always in high demand which allows some of these processors to compromise the quality of these products. And this may be hazardous to the consumers as observed by Capozzi, *et al*. (2017).

Sherifat and Wunmi (2018) evaluated the microbial quality of garri sold in Ijebu community, the pH ranged content ranged from 4.78 to 4.90.

Orji *et al*. (2016) examined the pH values of the garri samples purchased from local markets ranged from 5.47 to 6.61.

Okolo and Makanjuola (2021) evaluated the microbial loads of garri sold within Ahmadu Bello University main campus, Samaru, Zaria, Kaduna State, a range of 4.60 – 5.00 was observed for pH. Olopade *et al*. (2014) in his findings indicated that the pH of the garri samples ranged from 4.76 to 4.94 in the yellow type and 4.78 to 4.91 in the white type.

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 dryfrying/roasting and storage condition of the finished product.

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.

5.2 Conclusion

Garri is a basic staple food in Nigeria and some African countries, it accounts for 70% of the entire cassava production in Nigeria (IITA, 1990). There is therefore a need to maintain proper sanitary conditions so as to avoid health risks. The moisture content of garri samples analyzed is low and within standard specification, this could have accounted for keeping the microbial load of garri low. It is therefore recommended that garri should be sold well packaged in bags and not as exposed in basins/ bowls. Optimization of the process to using a starter culture with reduced post process handling is imperative. Effective HACCP and GMP will help reduce or eliminate product contamination and thus make the product safe for consumption.

REFERENCES

Achi, O. and Akomas, N. (2006). Comparative assessment of fermentation techniques in theprocessing of fufu, a traditional fermented cassava product. *Pakistan Journal of Nutrition* **5**: 224-229.

Adebayo, G. B., Otunola, G. A. and Ajao, T. A. (2010). Physicochemical, microbiological and sensory characteristics of kunu Prepared from millet, maize and guinea corn and stored at selected temperatures. *Advance Journal of Food Science and Technology* **2**: 41-46.

Adebayo-Oyetoro, A.O., Oyewole, O. B., Obadina, A. O. and Omemu, M. A. (2013). Microbiological safety assessment of fermented cassava flour lafun' ' available in Ogun and Oyo States of Nigeria. *International Journal of Food Science* **10**:11- 15.

Adejumo, A. O. D. and Adebayo, A. O. (2015). A Solid microbiological quality assessment of garri. *Journal of scientific research and report* **4**(2): 162-167.

Aderiye, J. B., Laleye, S. A. and Odeyemi, A. T. (2007). Hypolipidemic potential of *Lactobacillus* and *Streptococcus* species from some Nigerian fermented foods. *Research Journal of Microbiology* **2**(6):538-544.

Adesulu, A. T. and Awojobi, K. O. (2014). Enhancing sustainable development through indigenous fermented food product in Nigeria. *African Journal of Microbial Research* **8**(12): 1338 – 1343.

Adeyemi, O. T. and Muhammad, N. O. (2008). Biochemical assessment of the chemical constituents of *Aspergillus niger* fermented *Chrysophyllum albidum* seed meal. M.Sc Thesis. Department of Biochemistry, University of Ilorin, Nigeria.

Agah, M. V., Orji, J. O., Nnachi, A. U., Chukwu, S. O., Udu-Ibiam, O. E.. Nwachi A. C., & Olaosebikan, O. O. (2016). Isolation and Identification of *Rhizobium* species from Root Nodules of *Arachishy pogaeab* and *Telfairiaoc cidentalis* in South East, Nigeria. *International Journal of Science and Research* **5**(6): 227-230.

Aloys, N. and Hui Ming, Z. (2006). Traditional cassava foods in Burundi - A review. *Food Reviews International* **22**: 1-27.

Ari, M. M., Ayanwale, B. A., Adama, T. Z. and Olatunji, E. A. (2012). Effects of different fermentation methods on the proximate composition, amino acid profile and some antinutritional factors (ANFs) in soybeans (*Glycine Max*). *Fermentation Technology and Bioengineering* **2**: 6-13.

Aworh, O. C. (2008). The role of traditional food processing technologies in National development: The West African experience. *International Union of Food Science Technology* 1-18.

Bamidele, O. P., Fasogbon, M. B., Oladiran, D. A. and Akande, E. O. (2015). Nutritional composition of fufu analog flour produced from cassava root (*Manihot esculenta*) and Cocoyam (*Colocasia esculenta*) tuber. *Food Science and Nutrition* **3**: 597-603.

Braide, W., Azuwike, C. O. and Adeleye, S. A. (2018). The role of microorganisms in the production of some indigenous fermented foods in Nigeria. *International Journal of Advanced Research in Biological Sciences* **5**(5): 86 – 94.

Capozzi, V., Fragasso, M., Romaniello, R., Berbegal, C., Russo, P. and Spano, G. (2017). Spontaneous Food Fermentations and Potential Risks for Human Health. *Fermentation* 3(49):1- 19.

Chelule, P. K., Mbongwa, H. P., Carries, S. and Gqaleni, N. (2010). Lactic acid fermentation improves the quality of amahewu, a traditional South African maize-based porridge. *Food Chem*istry **122**(3): 656-661.

Faparusi, F. (2021). *Microbial quality of garri sold in Ilaro town.* 10th National Conference of The Faculty of Science, The Polytechnic Ibadan, Oyo State, 28th – 29th June, 2021

Ghosh, M., Wahi, S., Kumar, M. and Ganguli, A. (2017). Prevalence of enterotoxigenic *Staphylococcus aureus* and *Shigella* spp in some raw street vended *Indian foods. International Journal of Environmental Health* **17**(2): 151-15.

Holt, J. G., Krieg, N. R., Sneath, P. H., Staley, J. T. and Williams, S.T. (2017). Bergeys Manual of Determinative Bacteriology. *Wiliams and Wilkins, Baltimore,* 786-788.

Hussain, M. A. (2013). Economic implications of microbiological food safety scares. *Food Technology* 48: 33.

Ikegwu, O. J., Nwobasi, V. N., Odoh M. O. and Lledinma, N. U. (2009). "Evaluation of pasting and some functional properties of staqarch isolated from some improved cassava varieties in Nigeria. *African Journal of Biotechnology* **8**(10): 2310-2315.

Ikon, G. M. and Atadoga, F. O. (2020). Bacteriological Quality of Garri and Ogi Sold in Markets in Keffi Metropolis Nasarawa State Nigeria. *Global Journal of Science Frontier Research: C Biological Science* **20**(2):26 – 48.

Lawani, E. U., Alade, T. and Pelssia, G. (2015). The mycological content of ready to eat garri in amassoma, bayelsa state. *African journal of food science* **9** (2) 51-58.

Lindeboom, N., Chang, P. R. and Tyler, R. T. (2014). Analytical, biochemical and physicochemical aspects of starch granule size, with emphasis on small granule starches: a review. *Starch‐Stärke* **56**: 89-99.

Murwan, K. S. and Ali, A. A. (2011). Effect of fermentation period on the chemical composition, *in-vitro* protein digestibility and tannin content in two sorghum cultivars (*Dabar* and *Tabat*) in Sudan. *Journal of Applied Biosciences* **39**: 2602 –2606.

Neeraj, D. and Sharma, S. (2007). Food spoilage food infection and intoxication caused by microorganism and method of their detection.

Nout, M.J.R (2009). Rich nutrition from the poorestcereal fermentations in Africa and Asia. *Food Microbiology* **26**(7):685-692.

Obire, O. and Amadi, P. O. (2015).Microorganisms and antibiotic resistance of *Lactobacillus* species from fermented and dewatered maize slurry (*Akamu*) sold in Port Harcourt Metropolis, Nigeria. *Journal of Science and Technology* **1**(10):43-51.

Ogiehor, I. S. and Ikenebomeh, M. J. (2018). Extension of shelf life of garri by hygienic handling and sodium benzoate treatment. *African Journal of Biotechnology* **4**: 744 - 748.

Ogiehor, I. S., Ikenebomeh, M. J. and Ekundayo, A. O. (2017). The bioload and aflatoxin content of market Garri from some selected states in southern Nigeria: Public health significance. *Journal of African Health Science* **7**(4): 223-227.

Okolo, E. and Makanjuola, A.T. (2021). Microbial evaluation of garri sold within Ahmadu Bello University main campus, Samaru - Zaria, Kaduna State. *Science World Journal* **16**(3): 259 – 265.

Olalekan, B. B., Bartholomew, S. A. and Ibukun, I. O. (2021). Characterization of bacteria isolates from fermented cassava steeping water *International Journal of Applied Biology* **5**(2):190 – 199.

Olanrewaju, O. O., Victor, O. O. and Titilayo, T. A. (2009). Safety of small-scale food fermentations in developing countries. *Internet Journal of Food Safety* **11**: 29-34.

Olapade, B. K., Oranusi, S., Ajala, R. and Olorunsola, S. J. (2014). Microbiological quality of fermented cassava (garri) sold in Ota Ogun State, Nigeria. *International Journal on Current Microbiology and Applied Science* **3**(3): 888-895.

Oluwole, O. B., Olatunji, O. O., & Odunfa, S. F. (2014). A process technology for conversion of dried cassava chips into Garri. *Nigeria Food Journal*, 22: 65-73.

Orji, J. O., Nnachi, A. U., Ojiochie, C. O., Egwuata, C. C., Efunshile, A. M., Ezejiofor, O. I., Ezeama, C. O., Nwaneli, C. U. and Mbachu, I. (2016). Bacteriological quality and public health implications of fermented cassava (Garri) sold in Okwor and Nkalagu markets in Ebonyi state, Nigeria. *International Journal of Scientific and Technology Research Volume* 5.

Orji, J. O., Nnachi, A. U., Ojiochie, C. O., Egwuatu, C. C., Efunshile, A. M., Ezejiofor, O. I., Ezeama, C. O., Nwaneli, C. U. and Mbachu, I. (2016). Bacteriological quality and public health implications of fermented cassava (Garri) sold in Okwor and Nkalagu markets in Ebonyi State, Nigeria. *International Journal of Scientific & Technology Research* **5** (11): 85 – 91.

Orji, J. O., Nnachi, A. U., Ojiochie, C. O., Egwuatu, C. C., Efunshile, A. M., Ezejiofor, O. I., Ezeama, C. O., Nwaneli, C. U., Mbachu, I. (2016). Bacteriological quality and public health implications of fermented cassava (Garri) Sold in Okwor and Nkalagu markets in Ebonyi State, Nigeria. *International Journal of Scientific & Technology Research Volume* **5**(11): 85 – 91.

Orji, J. O., Nnachi, A. U., Ojohi, C. O. (2016). Bacteriological quality & public health implication of fermeted cassava (Garri). *International Journal of Science Technology Research* **2**(5). 89-108.

Osho, S. M. (2003).The Processing and acceptability of a fortified cassava based product (Garri) with Soybean. *Nutrition & Food Science* **33**(6): 278-283.

Osungbaro, T. O. (2009). Physical and nutritive properties of fermented cereal foods. *African Journal of Food Science* **3**(2): 23-27.

Osungbaro, T. O., Jimoh, D. and Osundeyi, E. (2010). Functional and pasting properties of composite cassava-sorgum flour meals. *Agricultural and Biology Journal of North America* **1** (4): 715-20.

Otekunrin, O. A. and Sawicka, B. (2019). Cassava, a 21st century staple crop: How can Nigeria harness its enormous trade potentials. *Acta Scientific Agriculture* **3**: 194-202.

Oyewole, O. A. and Isah, P. (2012). Locally fermented foods in Nigeria and their significance to National Economy: A review. *Journal of Record and Advance Agriculture* **1**(4):92-102.

Rane, S. (2011). Street vended food in developing world: hazard analyses. *Indian Journal of Microbiology* **51**(1): 100-6.

Ray, R. C. and Sivakumas. P. S. (2009). Traditional and novel fermented foods and beverages from tropical root and tuber crops: Review. *International Journal of Food Science and Technology* **44***:* 1073-1087.

Sherifat, T. A. and Wunmi, A. A. (2018). Microbial evaluation of garri sold in Ijebu community. *Journal of Environmental Science, Toxicology and Food Technology* **12**(7): 35 – 38.

Singh, V., Pande, P.C. and Jain D. K. (2013). *A text book of botany.* Fourth Edition. Rastogi publication.

Uyoh, E. A., Ntui, V. O. and Udoma, N. N. (2009). Effect of local cassava fermentation methods on some physiochemical and sensory properties of *fufu*. *Pakistan Journal of Nutrition* **8**: 1123-1125.

World Health Organization (WHO) (2004). Global *Salmonella* Surveillance (GSS). Recovered From http://www.who.int/salmsurvIFAQ/eni.

World Health Organization (WHO), (2002). Food safety and food borne illness. 2:2