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Bacteriological Quality of Garri and Ogi Sold in Markets in Keffi Metropolis Nasarawa State Nigeria

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I. Introduction

a) Background of 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 (Orji *et al.*, 2016) 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 and ogi handlers who lack adequate understanding of the basic food safety issues (Ghosh *et al.,* 2007; Hussain, 2013; Almeida, 1994).Open bowl display of this fermented cassava and maize grain products (garri and ogi) is perceived to be a major public health risk due to lack of basic infrastructure (Rane, 2011; Hussain, 2013). Various studies have identified the source of food safety issues involved in market sales of garri and ogi to be microorganisms (Ghosh *et al.,* 2007). The processing of cassava tuber and maize grain to garri and ogi 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 and maize grain into garri and ogi 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 2005).Today Cassava remains one of the most common source of dietary food energy of people especially in Africa. Ogi is a popular traditional infant food and a major staple food in West Africa. (Tsegai and Kormawa 2002).

Recently in Nigeria, the Federal Government 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. (Orji *et al.*, 2016) (Adejumo and Adebayo 2015). Most preparation of pap meal is from cereals, namely, maize, guinea corn or millet readily available in all parts of the country. 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) (Adejumo and Adebayo 2015), it is the major source of energy and fiber (Ogiehor *et al.*, 2007). Garri can be produced locally by fermentation of peeled cassava tuber in

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Nigeria and other parts of the world (Ray and Sivakumas 2009).

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 (Arasi and Adebayo 2000).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 and maize grain products (Garri and Ogi). The traditional fermentation method employed in ogi production is an untamed process and microorganisms are not controlled (Cheesebrough, 2000). Heavy metal contents in food has a limit, if these limit are exceeded, it could cause harm to the human body.

It has also been reported that garri sold in markets contain high load of microorganism (Ogiehor *et al.*, 2007) 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* (Arasi and Adebayo 2000).

Garri and it ready to eat nature has made it a common practice in Nigeria especially among students to eat garri as snacks without considering the bacteriological implication (Egbuobi *et al.,* 2005). Pap meal is served in Nigeria as a weaning food for infants (1-3 year old) and a morning breakfast for children and adults. In Nigeria, the production process of the wet flour paste, a staple food mostly consumed by children in rural communities and also by adults even in the metropolis, requires the use of water which is often not pure because of the high risk of environmental pollution (Amadi and Adebola 2008). People who patronize open roadside sale of these fermented products have been reported to suffer food borne diseases like diarrhea, cholera, typhoid fever and food poisoning. The environment in which cassava root and maize grain products stay when it has been processed (or not processed) goes a long way in contributing to the contamination of the fermented products (garri and ogi).Contamination of this can be traced to the hands and garments of handlers and utensil in processing, sales and bagging. The method of drying on the bare floor or road exposes the product to air borne microorganisms and this type of contamination is deadly (Adams and Moss 1995).

b) Statement of the Problem

The sale of garri and ogi in the local markets in Nigeria is associated with practices such as open display in bowls and trays, open buckets and mats at points of sale and the use of bare hands in handling and selling of cassava and maize grain products (garri and ogi).These unhygienic practices, may lead to microbial contamination and can cause deterioration in food quality and spoilage, food borne illness and may pose a threat to public health.

Food security has been a major challenge to the world populace over the last few centuries because of the alarming concern of disease outbreak caused by consumption of contaminated food and food products.

c) Justification of the Study

There is limited information to the assessment of some bacteria associated with garri and ogi sold in Nigeria (Olapade *et al.*, 2014) and even the study area, studies have not been reported, and hence this study provides information on bacteriological quality of garri and ogi sold in Keffi metropolis, Nigeria.

d) Objectives of the Study

The specific objectives are;

- To isolate and identify bacteria from garri and ogi sold in Keffi metropolis, Nigeria.
- To determine the percentage occurrence of the isolates.
- To determine antibiotic susceptibility of the isolates.

II. Literature Review

a) Description of cassava

Plate 1: Cassava

Cassava (*Manihot esculenta Crantz*) is a woody shrub native to South America of the spurge family, *Euphorbiaceae*. Although it is a perennial plant, cassava is widely cultivated as an annual crop in tropical areas. The cassava root is long and tapered; it has a firm homogenous flesh enclosed in a detachable rind and about 1mm thick, rough and brown on the outside. The fleshy part may be chalk-white or yellow in color on the outer part with woody vascular bundle extended along the root axis. It is the chief source of dietary food energy for the majority of the people living in the low land tropics, and much of the sub-humid tropics of West and

Central Africa (Tsegai and Kormawa 2002). It supplies about 70% of the daily calories of over 50 million people (Oluwole *et al*., 2014) in Nigeria and about 500 million people in the world (Abu *et al*., 2006). The competing needs for cassava cut across both humans and animals. It is fast becoming a popular raw material in industrial production and is now a preferred material for making biofuels. Cassava is God's gift to the tropics because it can grow in poor soil with inadequate rainfall. The starchy roots of cassava are major source of food for more than 700 million people all over the world. It ranks third in order of staple food crops in developing countries after rice and maize. It has universal applications. Nigeria is the world largest producer of Cassava (Adeniji *et al.,* 2005). We produce over 41 million metric tons per annum and we are followed by Brazil, Thailand, Zaire (now Democratic Republic of Gongo), and Indonesia. Nigeria has tried to expand the local cassava business through the Composite Flour Initiative and the Cassava Empowerment Fund but so far, they have attained little or no success (Knipscheer *et al*., 2007).

i. *Description of garri*

Plate 2: 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 a*l., 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.,* 2007).

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 (Agboola, 1968).

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 (Akindahunsi *et al*., 1999). 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.

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).

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.

ii. *Mechanization of Garri Production*

Fig. 3: Flow chart for Garri production

Mechanization of garri production is the use of machines, either wholly or in part, to replace human or animal labor in the production of garri, unlike automation, which may not depend at all on a human operator, mechanization requires human participation to provide information or instruction. It implies the use of machinery more complex than hand tools and would not include simple devices such as an un-geared horse or donkey mill. Devices that cause speed changes or changes to or from reciprocating to rotary motion, using means such as gears, pulleys or sheaves and belts, shafts, cams and cranks, usually are considered machines.

Equipment for rapid processing of cassava has been used in Nigeria for over 20 years (Amadi and Adebola 2008). The stages in the processing of cassava include: peeling, washing, grating, dewatering, granulating or sieving, roasting, cooling and packaging (Adeniji, 2000, Oyewole *et al*., 1986; Sanni, 1990). Peeling is sometimes done manually because cassava is bulky and irregular in shape with various peel thickness. Mechanical peeling results in heavy losses. Washing are also manual for convenience and to reduce cost. There are many models of grater. Using electricity, diesel or petrol motor, the grating surfaces are made from iron sheet, galvanized iron or stainless steel; the

first two being rust-prone. Low cost and low energy graters are available in the market; women processors use them. Sieving or granulating is manual and is done on raffia or metal sieves. There are metal sieves which can be used while standing or shaken mechanically (James *et al.,* 2012). Rapid removal of water from fermented pulp lasts from 30mins to 2hr and is achieved by using hydraulic jack or screw press. Rotating over heat 22-60^{0}c (Aseidu and Wieneke 1989) is preferably carried out in a cast-iron pan or an assortment of trays (Ayehu *et al.,* 2014). Rotating-drum roasters do not produce garri of good quality because such devices do not mix and roast well (Amadi and Adebola 2008).The cooling of garri after roasting takes place on suitable trays and the product may be packaged in thick polythene bags.

iii. *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).

iv. *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).

b) Description of maize

Plate 4: Corn (maize)

Maize also known as corn is a cereal grain first domesticated by indigenous peoples in southern Mexico about 10,000 years ago. Maize has become a staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice (Singh *et al.,* 2001). However, little of this maize is consumed directly by humans: most is used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. The six major types of maize are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn.

Maize is the most widely grown grain crop throughout the Americas, with 361 million metric tons grown in the United States in 2014. Sugar-rich varieties called sweet corn are usually grown for human consumption as kernels, while field corn varieties are used for animal feed, various corn-based human food uses (including grinding into cornmeal or masa, pressing into corn oil, and fermentation and distillation into alcoholic beverages like bourbon whiskey), and as chemical feed stocks. Maize is also used in making ethanol and other biofuels. Raw, yellow, sweet maize kernels are composed of 76% water, 19% carbohydrates, (Adeniji and Potter 1978). In a 100g serving, maize kernels provide 86 calories and are a good source (10-19% of the Daily Value) of the B vitamins, thiamin, niacin, pantothenic acid (B5) and folate. In moderate amounts, they also supply dietary fiber and the essential minerals, magnesium and phosphorus whereas other nutrients are in low amounts. Maize has suboptimal amounts of the essential amino acids tryptophan and lysine, which accounts for its lower status as a protein source (Aguirre *et al.,* 1953).

i. *Mechanization of Ogi production*

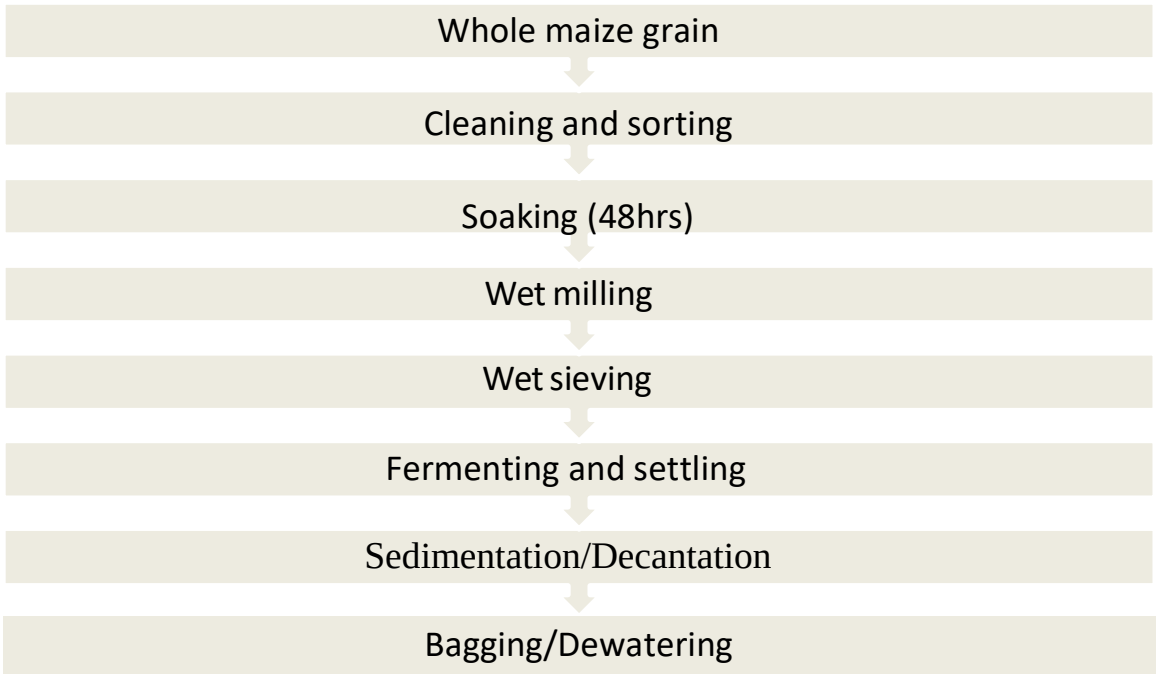

Fig. 5: Flow chart for Ogi production

Akamu (Igbo, ibibio), ogi (Yoruba) or Pap is Nigerian corn meal made from wet corn starch. It has a distinctive sour taste that makes people crave it. It is processed from dry white or yellow corn, millet, guinea corn. After processing it we get the raw akamu, pap or ogi which is then prepared with hot water before serving as a meal. (Akingbala *et al.,*1981)

The dry corn is washed thoroughly and soaked in a generous quantity of cold water for 3 to 4 days. The water in the corn is changed daily, on the 3rd or 4th day; it is washed and blended till smooth. In Nigeria, heavy duty grinders are used for this purpose.

A chiffon cloth is draped over a big bowl and tied up. The bowl should be big enough to accommodate the ogi and the water that will be used to rinse. The blend is sieved rinsing as necessary till only the chaff is left.

When done, take off the chiffon cloth and set the mixture of water and ogi aside to settle for at least 3 hours, after about 3 hours or when you notice that the water is clear, decant the clear water and pour the rest of the mixture into the muslin bag. Tie the bag and keep it in such a way as to let the water drain from the ogi.

After 24 hours, bring out the ogi from the bag, cut it up into single-use chunks, place in containers (bowls or plastic bags) and put in your freezer till you are ready to use it. (Akingbala *et al.,* 1981).

ii. *Nutritional value of Ogi*

Traditional weaning foods in West Africa are known to be of low nutritive value and are characterized by low protein, low energy density, and high bulk. Maize pap or *koko* has been implicated in the etiology of protein-energy malnutrition in children during the weaning period. Cereal-based diets have lower nutritional value than animal-based ones. Cereals form the primary basis for most of the traditional weaning foods in West Africa. The protein content of maize and guinea corn is of poor quality, low in lysine and tryptophan. These two amino acids are indispensable to the growth of the young child. (Ankinrele and Basir 1967).

iii. *Factors improving microbial contamination of Ogi*

Akamu is a nutritive food mostly consumed by infants as weaning food, adults also enjoy this delicacy. ogi is often produced locally by local producers and there is risk of high microbial contamination which often makes the food product unfit due to the presence of organisms that cause spoilage, food poisoning or food intoxication in the food product. (Awada *et al.,* 2005).

Food poisoning and infection results to fatal consequences in infected individuals and the main risk factors are channeled towards contaminated raw materials, poor fermentation conditions, poor personal and environmental hygiene and post processing handling (Ezendianefo and Dimejesi 2016). It could also be due to the contaminants from the grinding engine which was only washed before use (Nout, 1994).

Typically, microbial load starts multiplying from the first day (0hr) and attain optimum at 24-48 hrs of fermentation before it starts declining from 72-96hrs. The number of microbes of the family *Enterobacteriaceae* is usually the least during fermentation of maize used in preparing ogi, this growth that can proliferate in MacConkey agar which includes *Escherichia coli, Klebsiella*, *Citrobacter*, *Proteus*, *Salmonella*, *Shigella* e.t.c does not participate in fermentation processes (Sylvester *et al.,* 2016). In a study by Oyelana and Coker (2012), the growth of *E.coli* and *Klebsiella* reduces significantly at the end of fermentation; hence their occurrence could result from the water used in fermentation or as normal flora of the maize before fermentation. Microbes found in food products get in through diverse means which include exposure, handling, and use of contaminated utensils for processing. The processing of maize fermentable food is mostly done by small holders who process it for little and to a larger extent for commercial purposes or sales. The processing of this food product is carried out using rudimentary or undeveloped equipment and seldom in an unhygienic environment majorly during processing and handling. Microbe is known to be wide spread and prevalent, this makes the product prone however to unintentional contamination by microbes found in the environment. Oyelana and Coker (2012), listed *P.aurogenosa, Lactobacillus plantanum*, *Staphiloccocus aureus, E.coli, Klebsiella* e.t.c as microbes found in air, the authors have reported that the organisms can be found in water used for fermentation. A study reported by Izah and Ineyougha (2015) proved *S.aureus, E.coli, Alcallegenes fecalis, Proteus, Micrococcus, Citrobacter, Streptococcus, Vibrio, Shigella, Enterococcus, Flavobacterium, and Chromobacterium* species are commonly found in different portable water source in Nigeria such as lakes, hand dug wells, borehole, rain water e.t.c (Izah *et al.,* 2016) which are also used in domestic activities. Several microorganisms found in fermentation medium are pathogenic and infectious, whereas a few are non hazardous, virulent strains of this microbes lead to the condition such as gastroenteritis, this happens generally but most time unreported especially in rural areas. The storage procedures of fermented maize product are mostly carried out in environment devoid of quality control. Food gets contaminated through the storage material. This may include bagging of milled fermented maize for Ogi production, the bagging of milled maize is however fermented in water prior to use, during this process it could get contaminated by microbes in the water and putting prospective consumers of this food at risk of food borne illnesses (Sylvester *et al.,* 2016). Ogi processed by small holders lack control measures, no laid down step by step procedure for processing such as stating the quantity of water that could be added to certain weight or quantity of maize during fermentation. The fermentation period lies solely on individual and quality. The only quality control often carried out by producers is the organoleptic characteristics and to a great extent depends on the individual (Sylvester *et al.,* 2016).

Fermented foods are affected by temperature, water activity, hydrogen ion concentration (pH), oxygen availability and substrate used for the fermentation process of the food (Oyewale and Isah 2012) and to a large extent are influenced by their environmental factors, this could be controlled by manipulating the environmental factors where possible. Fermentation process for ogi involves the use of naturally occurring microorganisms to produce new products therefore; fermentation could be a functional and effective approach for curbing microbial contamination of this food product (Kohajdova and Karovicova 2007).

c) *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.

In cases of suspected food borne illnesses drug resistance is now of serious concern in hospitals. Drug resistance is one of the natures ending process whereby organisms develop tolerance for new environmental condition. They may be due to pre-existing factor in the organisms or it may result from the acquired factors. Some naturally susceptible strains of bacteria may acquire resistance (Onifade *et al*., 2005).

d) Mechanism of pathogenesis of food pathogens

Bacterial Infections

The Majority of all cases of Food Poisoning are due to bacterial infections. These include:

i. *Salmonellosis*

Salmonella is a type of bacteria that cause typhoid fever and many other infections of intestinal origin (Clark, *2002). Salmonella* species are Gram-negative bacilli, most are motile with peritricious flagella, ferment glucose with the production of acid and gas or acid only. Some *Salmonella* produce H_2S (Jawetz and Adelberg 2004). Compared with other gram-negative rods, *Salmonella* is relatively resistant to various environmental factors; grow at temperatures between 8^{O}C and 45^{O}C and in a pH range of 4 to 8 (Adams and Moss 1995). *Salmonella* is often pathogenic to humans and animals. Humans, animals such as rodents and even insects such as flies may play an important role in spread of *Salmonella* bacteria especially from contaminated fecal matters to food. Large scale handling tends to increase spread of trouble and food prone to this bacterial infection are food held unrefrigerated for a long period of time (Center for Disease Control 1978). Infection results from the ingestion of food or water containing sufficient number of these bacteria to reach and invade the small intestine (Adams and Moss 1995). *Salmonella* produce three main types of disease in humans: Enteric fever (Typhoid fever), *Bacteremia* and *Enterocolitis*, but mixed forms are frequent (Jawetz and Adelberg 2004). Nontyphoidal strains of the genus *Salmonella* are estimated to be responsible for over 1.4 million illnesses and, subsequently, to account for 9.7% of total food borne illnesses, 25.6% of total hospitalizations, and 30.6% of deaths caused by known food borne pathogens (Mead et al., 1999) . *Salmonella* are associated with the intestinal tracts of animals and humans, and, although human illness has been associated with exposure to other vehicles of transmission (e.g., pets, and contaminated water), it is estimated that 95% of Salmonellosis cases involve food borne transmission (Tauxe, 1991). Most cases of Salmonellosis are considered to be endemic or sporadic because they are not clustered. The usual explanation for endemic cases is the inappropriate handling in kitchens and restaurants of contaminated food (including improper storage, undercooking, or cross contamination (Blaser, 2004). Salmonellosis is the most frequently occurring bacterial food infection and in some years the most frequently occurring bacterial food borne illnesses. This is from a report from Center for Disease Control within 1984-1986, *Salmonella* infection had highest number of cases and outbreaks from 1978-1982 and over time has not changed in comparism to other bacterial infection such as *Escherichia coli, Staphylococcus aureus*, *Shigella*, *Klebsiella*, *Proteus* e.t.c (CDC 1983b). Symptoms of Salmonellosis include fever, abdominal pain, diarrhea and vomiting caused by contaminated foods, contaminated beef meats, raw poultry; unwashed fruits; Vegetables grown in contaminated soils; Eggs; Rice.

The emergence of antimicrobial-resistant *Salmonella* has been a problem (Dabney *et al*., 1997). Multidrug-resistant (MDR) strains of *Salmonella* are now frequently occurring worldwide and the rates of multidrug-resistance have increased considerably in recent years. The incidence of multidrug resistance (MDR - resistance to three or more antibiotics) in *Salmonella* strains increased from 1.6% in 2005 to 2.1% in 2010 (Gordana *et al*., 2012). Even worse, some species of *Salmonella* have developed multidrug-resistance as an integral part of the genetic material of the organism, and are likely to retain their drug-resistant genes even when antimicrobial drugs are no longer used, a situation where other resistant strains would typically lose their resistance (WHO, 2005).

ii. *Typhoid Fever*

Typhoid fever is a life threatening illness caused by *Salmonella typhi*. *Salmonella Typhi* lives only in humans; persons with typhoid fever carry the bacterium in their blood stream and intestinal tract .Typhoid fever is common in most parts of the world except in industrialized regions such as United States, Canada, Western Europe, Australia and Japan. According to WHO "Typhoid fever is still common in the developing world, where it affects about 12.5 million persons each year, (WHO, 2004).Patients with typhoid fever usually have a sustained fever as high as (39-40°C).They may also feel weak or have stomach pain, headache or loss of appetite. In some cases, patients have a rash of flat and rose- colored spots. The only way to know for sure if an illness is typhoid fever is to have samples of stool or blood tested for the presence of *Salmonella typhi*. The disease is prevented by: Avoiding foods and beverages from street vendors; avoiding unpasteurized milk and milk products; cook poultry and egg thoroughly; avoiding unwashed fruits.

iii. *Listeriosis*

Listeriosis is a bacterial infection. Two species of *Listeria* are pathogenic; *L. monocytogenes* infects humans and animals, (Ryan and Ray 2003) and *L. ivanovii* has been considered to infect ruminants only.

Listeria is one of the causes of food poisoning. It's triggered by *Listeria* bacteria that can live in soil, water, dust, animal poop, and other substances. One can get sick if they eat food that carries it. For most healthy people, the infection doesn't pose much of a threat, even if it makes you sick for a day or two. But for some people, the infection can be serious or even life-threatening, particularly pregnant women and their babies. Although a *Listeria* infection may cause only a mild illness in the mother, consequences for the baby may include: Miscarriage, Stillbirth, Premature birth, a potentially fatal infection after birth, people whose immune systems aren't working right, and seniors.

People pick up the infection most often from deli meats that aren't processed properly or from dairy products made from milk that isn't pasteurized in other words; the milk hasn't been heated to kill germs. Other common sources of outbreaks are: Cantaloupes, Hot dogs, Soft cheeses.

When infected with *Listeria*, the signs typically include: Diarrhea, Nausea, Achy muscles, Fever (Mahon *et al*., 2014).

They could appear a few days after one eats the bad food, or they might take a couple of months to show up. If the infection spreads to your nervous system, it's more serious. This severe form is called Listeriosis, it is fatal for 20% of people who have it. This happens most often with the very young, the very old, and people with weakened immune systems. The signs could be: Headache, Stiff neck, Confusion, Loss of balance, Convulsions. *Listeria* is ubiquitous and is primarily transmitted via the oral route after ingestion of contaminated food products, after which the organism penetrates the intestinal tract to cause systemic infections. The diagnosis of Listeriosis requires the isolation of the organism from the blood and/or the cerebrospinal fluid. Treatment includes prolonged administration of antibiotics, primarily ampicillin and gentamicin, to which the organism is usually susceptible (Swaminathan and Gerner 2007).

iv. *Campylobacteriosis*

Campylobacteriosis is an infection by the *Campylobacter* bacterium, most commonly *C. jejuni*. It is among the most common bacterial infections of humans, often a food borne illness. Occasional deaths occur in young, previously healthy individuals because of blood volume depletion (due to dehydration), and in persons who are elderly or immune compromised. The illness can also be caused by *C. coli* (also found in cattle, swine, and birds), *C. upsaliensis* (found in cats and dogs) and *C. lari* (present in sea birds in particular). It produces an inflammatory, sometimes bloody, diarrhea or dysentery syndrome, mostly including cramps, fever and pain.

The prodromal symptoms are fever, headache, and myalgia, which can be severe, lasting as long as 24 hours. After 1–5 days, typically, these are followed by diarrhea (as many as 10 watery, frequently bloody, bowel movements per day) or dysentery, cramps, abdominal pain, and fever as high as 40 °C (104 °F). In most people, the illness lasts for 2–10 days. Complications include toxic mega colon, dehydration and sepsis. Such complications generally occur in young children (< 1 year of age) and immune compromised people. A chronic course of the disease is possible; this disease process is likely to develop without a distinct acute phase. Chronic Campylobacteriosis features a long period of sub-febrile temperature and asthenia; eye damage, arthritis, endocarditis may develop if infection is untreated (Wilson *et al.,* 2008).

e) 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.,* 1994).

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.,* 1994).

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.,* 1994).

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).

f) Impact of food safety in homes and public

Food safety is important for the people's general health and daily life, economic development, and social stability, and the government's and country's image (Rohr *et al.,* 2005). The potential impact of food safety outbreaks can be devastating. A single event of a food borne disease outbreak can bring unimaginable economic losses (Hussain, 2013).

g) Improving food safety in 21st century

Food is essential to life; hence food safety is a basic human right. Billons of people in the world are at risk of unsafe food. Many millions become sick while hundreds of thousand die yearly. The food chain starts from farm to fork/plate while challenges include microbial, chemical, personal and environmental hygiene (Rajul *et al.,* 2016). To ensure food safety and to prevent unnecessary food borne illnesses, rapid and accurate detection of pathogenic agents is essential. Innovative technology such as Nuclear Magnetic Resonance (NMR) coupled with nano particles can detect multiple target microbial pathogens' DNA or proteins using nucleic acids, antibodies and other biomarkers assays analysis. The food producers, distributors, handlers and vendors bear primary responsibility while consumers must remain vigilant and literate. Government agencies must enforce food safety laws to safeguard public and individual health. Medical providers must remain passionate to prevent food borne illnesses and may consider treating diseases with safe diet therapy under proper medical supervision. The intimate collaboration between all the stakeholders will ultimately ensure food safety in the 21st century (Fung *et al.,* 2018).

III. Materials and Methods

a) Materials

i. *Glass wares/Equipment*

The glass wares used include: Petri dishes, test tubes, conical flask, glass slides and cover slips, pasture pipette, sterile bottles, beakers, measuring cylinder, Bijou bottle.

The equipment used include: autoclave, Incubator, hot air oven, microscope and other laboratory tools such as Bunsen burner, weighing balance, colony counting chamber, spatula, test tube rack, wire loop, foil paper, wire gauze, forceps, and cotton wool.

ii. *Antibiotics*

The antibiotics used in this study include; Gram negative antibiotics - ampicillin, cefurorrixime, ceftazidime, chloramphenicol, sulphamethoxazole (trimethoprim), streptomycin, ciprofloxacin, gentamicin, amoxicillin/clavulanic acid, and ceftriaxone.

Most of this antibiotics act on both gram positive and gram negative bacteria (broad spectrum antibiotics), but are majorly gram negative antibiotics.

iii. *Media and reagents*

The media that were used include:

Nutrient agar: a general purpose nutrient medium used for the cultivation of microbes supporting growth of a wide range of non-fastidious organisms.

Salmonella shigella agar: is a selective and differential medium. It is used for the isolation, cultivation and differentiation of gram-negative enteric microorganisms

Deoxycholate citrate agar: It is particularly useful for the isolation of organisms that cause bacillary dysentery, *Salmonella* strains that cause food poisoning and *Salmonella Paratyphi*.

Manitol salt agar (MSA): commonly used, a selective and differential growth medium in microbiology, it inhibits the growth of some microorganisms while encouraging growth of others.

MacConkey agar: is an indicator, a selective and differential medium for bacterial. Designed to selectively isolate gram negative and enteric bacilli and differentiate them based on lactose fermentation.

Nutrient broth: is a general purpose medium used for general maintenance of cultures and routine work.

Eosine Methylene Blue Agar (EMB): a selective media for the isolation of *Escherichia coli*

Mueller Hinton broth: is recommended for dilution of antimicrobial susceptibility testing of all species of most commonly encountered aerobic and facultative anaerobic bacteria.

Mueller Hinton agar: agar is a microbiological growth medium that is commonly used for antibiotic susceptibility testing.

Peptone water: is a microbial growth medium composed of peptic digest of animal tissue and sodium chloride, is rich in tryptophan, used as a primary enrichment medium for the growth of bacteria.

Simon citrate agar: It is a defined, selective and differential medium that tests for an organism's ability to use citrate as a sole carbon source and ammonium ions as the sole nitrogen source.

MR.VP agar: used for The Methyl Red and Voges proskauer test.

Urease agar: is used to differentiate between rapidly positive Proteus species and other slower urea positive members of the *Enterobacteriaceae* and urease activity in other gram-negative organisms.

Crystal violet: it is the active ingredient in Gram's Stain, used to classify bacteria. The primary stain.

Lugos iodine: it is the active ingredient in Gram's Stain, used as the mordant.

Safranin: is used as a counter stain in some staining protocols, coloring all cell nuclei red.

Ethyl alcohol: is an important industrial chemical; it is used as a solvent, in the synthesis of other organic chemicals, and as an additive to automotive gasoline. Also used as a decolorizer in gram staining

Hydrogen peroxide: used as a reagent in catalase test.

b) Study Area

This work was carried out within Keffi metropolis of Nasarawa State. The microbiological analysis was carried out in the microbiological laboratory of Nasarawa State University Keffi. Keffi is located in the middle belt of Nigeria. It is geographically situated on the latitude 8°50°N longitude 7°52°E. Keffi town is on latitude 85° above sea level and it is in North West of Lafia, the state capital of Nasarawa State. It is 53km away from Abuja (Capital of Nigeria) in the guinea savannah of Nigeria (Akwa *et al*., 2007).

c) Collection of Samples

A total number of forty (40) samples were collected from Keffi and Angwan lambo markets in Nasarawa State. Ten (10) each of yellow and white garri types was randomly collected from the market and twenty (20) of fresh ogi was collected using sterile sampling bottles. The samples were appropriately labeled to indicate the name of the market, garri type (yellow and white), sample number, date and time of collection. Samples were transported in sterile laboratory box to the microbiology laboratory for analysis within one hour of collection.

d) Media preparation and Sterilization

The laboratory media used were prepared according to the manufacturer's instruction and were sterilized using autoclave at 121°C for 15 minutes when required.

e) Microbiological Analysis

One gram (1.0g) of each sample of Garri was homogenized in 9.0ml of sterile distilled water (10^{-1} dilution), further serial dilution of sample homogenate to 10^{-7} was carried out also in sterile distilled water, transferring 1ml of initial suspension into subsequent tubes used for the serial dilution. Approximately 0.2ml aliquot of appropriate dilution was spread on plates of *Salmonella-Shigella* agar, Eosin Methylene Blue agar (EMB), Mannitol salt agar (MSA) and MacConkey agar. All culture plates were incubated at 37°C aerobically for 24-48 hours. Culture plates were examined for enumeration and identification of colonies after incubation period.

i. *Coliform Test*

Aliquot 1g samples in test tubes with inverted Durham tubes in Lactose broth were incubated at 37°C for 24-48h. Tubes showing gas production and or color change of dye were reported as presumptive coliform test positive. These positive tubes were streaked out. Duplicate plates were made for confirmatory test. Plates were incubated for 24h at 37°C and 44°C respectively. Growth of characteristic colonies constituted a confirmatory test positive. Colonies from confirmatory test were Gram stained and inoculated into lactose broth for completed coliform test. Gas production and or color change of dye plus Gram negative non-spore bearing rod represent presence of coliform (Speck, 1976; Oranusi and Braide 2004). Absence of growth at 44°C indicated absence of fecal coliforms.

f) Identification of bacterial isolates

Bacterial isolates were characterized on the basis of the colonial morphology and biochemical characteristic. The colonial morphology that was observed for each isolate includes color, shape, elevation, colony surface and optical characteristics. The cellular morphology of isolates that were noted included Gram reaction and behavior, shape of cell, arrangement and spore staining where necessary. The biochemical tests that were carried out include citrate test, methyl red, indole test, catalase test, oxidase test, urease test and voges-poskauer test. Representative bacteria were characterized and identified as described by Holt *et al* (1994).

i. *Gram staining*

The gram staining for presumptive identification of the bacteria isolates was carried out as prescribed by Cheesbrough (2006). Briefly, a pure colony of each of the bacterial isolate was smeared on a slide containing a drop of normal saline on a clean grease free slide, and allowed to air dry and fixed by passing it over a Bunsen burner flame. The smear was stained with crystal violet (primary stain) for 1min and rinsed with water, further

staining with iodine (mordant) for 1 minute and rinsed with water. The slide was then briefly decolorized with 95% ethanol and rinsed with water and counterstained with safaranin for another 1 minute after which the slide was rinsed with water and allowed to air dry. The air dried slide was then examined using oil immersion objective lens. Red or pink reaction after gram staining indicated the presence of gram negative bacteria while purple color indicated the presence of gram positive bacteria.

ii. *Indole Test*

The indole test for the bacterial isolates was carried out as described by Cheesbrough (2006). Briefly a colony of each bacterium isolate was inoculated in 5ml of sterile peptone water in Bijou bottle and incubated at 37°C for 24 hours: after which four (4-15) drops of Kovac's indole reagent was added through the bottles side. Formation of red ring indicated indole positive test.

iii. *Citrate Utilization*

The citrate test for the bacterial isolates was carried out as earlier described by Cheesbrough (2006). A colony of bacteria isolate was inoculated by aseptically stabbing into Simon Citrate Agar slant and incubated at 37°C for 72hours. Formation of blue color indicated citrate positive and forest green color indicated citrate negative.

iv. *Catalase Test*

The catalase test for the bacterial isolates was carried out as earlier described by Cheesbrogh (2006). A colony of the bacteria isolates was emulsified in a drop of hydrogen peroxide on a clean grease free slide. Effervescence, indicating free oxygen as bubble signified the presence of catalase whereas no effervescence signified the absence of catalase.

v. *Oxidase Test*

The oxidase test for the bacterial isolate was carried out as earlier described by Cheesbrogh (2006). A piece of filter paper was placed in a Petri dish and 3 drops of freshly prepared oxidase reagent was added. Using a sterile glass rod, a colony of test organisms from a culture plate was removed and smeared on the filter paper. Oxidase positive organisms gave purple color within 5-10 seconds, and in oxidase negative organisms, color did not change.

vi. *Methyl Red/ Voges-Proskauer Test*

The Methyl Red/Voges Proskauer test for suspected organisms was carried out as follows; a pure colony of suspected organism was aseptically inoculated into 10ml of Methyl red/Voges Proskauer medium in Bijou bottles and incubated at 37°C for 48hr.The 48hr culture was divided into two portions. To the 1st portion some drops of Methyl Red indicator was added and formation of red color indicated Methyl Red positive. To the 2nd portion, a drop of 40% (w/v) KOH was added followed by some drops of β-napthol and formation of pink-red color indicated Voges-Proskauer positive.

vii. *Urease Test*

The urease test for the bacteria isolates was carried out as earlier described by Cheesbrogh (2006). The surface of a urea agar slant was streaked with a portion of a well- isolated colony or inoculate slant with 1 to 2 drops from an overnight brain-heart infusion broth culture. The cap was left on loosely and the tube was incubated at 35°-37°C in ambient air for 48 hours to 7 days. It was examined for the development of a pink color for as long as 7 days.

g) Disc diffusion antibiotics susceptibility test

In this test, wafers containing antibiotics are placed on an agar plate where bacteria had been inoculated, and the plate left to incubate at 37°c for 24hrs. If an antibiotic stops the bacteria from growing or kills the bacteria, there will be an area around the wafer where the bacteria have not grown enough to be visible. This is called a zone of inhibition. Once the zone diameter is measured it must be compared to a database of zone standards according to the CLSI standards to determine if the bacterium being studied is susceptible, moderately susceptible or resistant to the antibiotic in question.

IV. Results

In this study a total of 40 samples were collected from the markets (Main market and Angwan lambo market), 20 of Garri and 20 of Ogi. The microorganisms isolated were *Salmonella* species, *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella* species (Table 1). The percentage occurrence of isolates in garri from the markets was *E.coli* 15%, *S.aureus* 5%, *Salmonella* species 25% and *Klebsiella* species 0% (Table 2). The percentage occurrence of garri isolates based on garri type were *E.coli* 30% from white and 0% from yellow, *S.aureus* 10% from white and 0% from yellow, *Klebsiella* specie 0% in both yellow and white, *Salmonella* specie 10% in white and 40% in yellow (Table 3). In ogi, percentage occurrences of isolates were *E.coli* 45%, *Staphylococcus aureus* 30%, *Salmonella* species 65% and *Klebsiella* species 10% (Table 4). This study manifested bacterial contamination of samples of garri and ogi with *Salmonella* species being the predominant organism. A total of eighteen (18) isolates were gotten from both samples, thirteen (13) of ogi and five (5) of garri. The isolates were resistant to ciprofloxacin at 100%, ceftriaxone at 100%, ampicillin at 100%, amoxicillin at 100%, ceftazidime at 100%, cefurixime at 100%, streptomycin at 27.8%/ chloramphenicol at 27.8%, sulphamethoxazole at 61.1%, and gentamicin at 33.3% (Table 5).

Table 1: Cultural, morphological and biochemical characteristic of bacterial isolates of garri and ogi

Cultural characteristics		Morphological characteristics		Biochemical characteristics							
Shape	Pigment	Morphology	Gram Staining	IN	CAT	OX	MR	VP	COG	CIT	Presumptive Organisms
Circular	Greenish metallic sheen on EMB	Rod	-	-	+	-	+	-	-	-	*E.coli*
Circular	Yellow on MSA	Cocci	+	-	+	-	+	+	+	+	*S. aureus*
Smooth	Pink on MacConkey	Smooth	-	-	+	-	-	+		+	*Klebsiella* species
Circular	Blackish on SSA	Rod	-	-	+	-	+	+	+	+	*Salmonella* species

Where: IN-Indole, CAT-Catalase, OX-Oxidases, MR-Methylene red, VP-Voges proskauer, COG- coagulase, CIT- citrate, - = Negative, + = Positive, SSA- *Salmonella shigella* agar, EMB- Eosin Methylene Blue, MSA – Mannitol Salt Agar

Table 2: Percentage occurrence of bacterial isolates of garri sold in markets in keffi

Markets	Samples collected	Number of samples	*E.coli (%)*	*S,aureus (%)*	*Salmonella specie (%)*	*Klebsiella Specie (%)*
Main market (1)	A	5	0 (0.00)	0(0.00)	2(40.00)	0(0.00)
Main market (2)	B	5	2(40.00)	1(20.00)	1(20.00)	0(0.00)
Angwan lambu market (1)	A	5	0(0.00)	0(0.00)	2(40.00)	0(0.00)
Angwan lambu market (2)	B	5	1(0.00)	0(0.00)	0(0.00)	0(0.00)
Total		20	3(15.00)	1(5.00)	5(25.00)	0(0.00)

Key = A- yellow Garri, B- white Garri.

Table 3: Percentage occurrence of bacterial isolates based on the type of Garri from markets

Isolates	Garri types	
Bacteria isolates	White (%)	Yellow (%)
Escherichia coli	3 (30.00)	0(0.00)
Staphylococcus aureus	1(10.00)	0(0.00)
Salmonella specie	1(10.00)	4(0.00)
Klebsiella specie	0(0.00)	0(0.00)
Total	5 (25.00)	4(20.00)

Table 4: Percentage occurrence of bacterial isolates of Ogi sold in markets in Keffi

Markets	Number of samples	*E.coli (%)*	*S.aureus(%)*	*Salmonella* species*(%)*	*Klebsiella* species*(%)*
Main market (1)	5	4(80.00)	3(60.00)	5(100.00)	2(40.00)
Main market(2)	5	4(80.00)	2(40.00)	5(100.00)	0(0.00)
Angwan lambu(1)	5	1(20.00)	0(0.00)	1(20.00)	0(0.00)
Angwan lambu(1)	5	0(0.00)	1(20.00)	2(40.00)	0(0.00)
Total	20	9(45.00)	6(30.00)	13(65.00)	2(10.00)

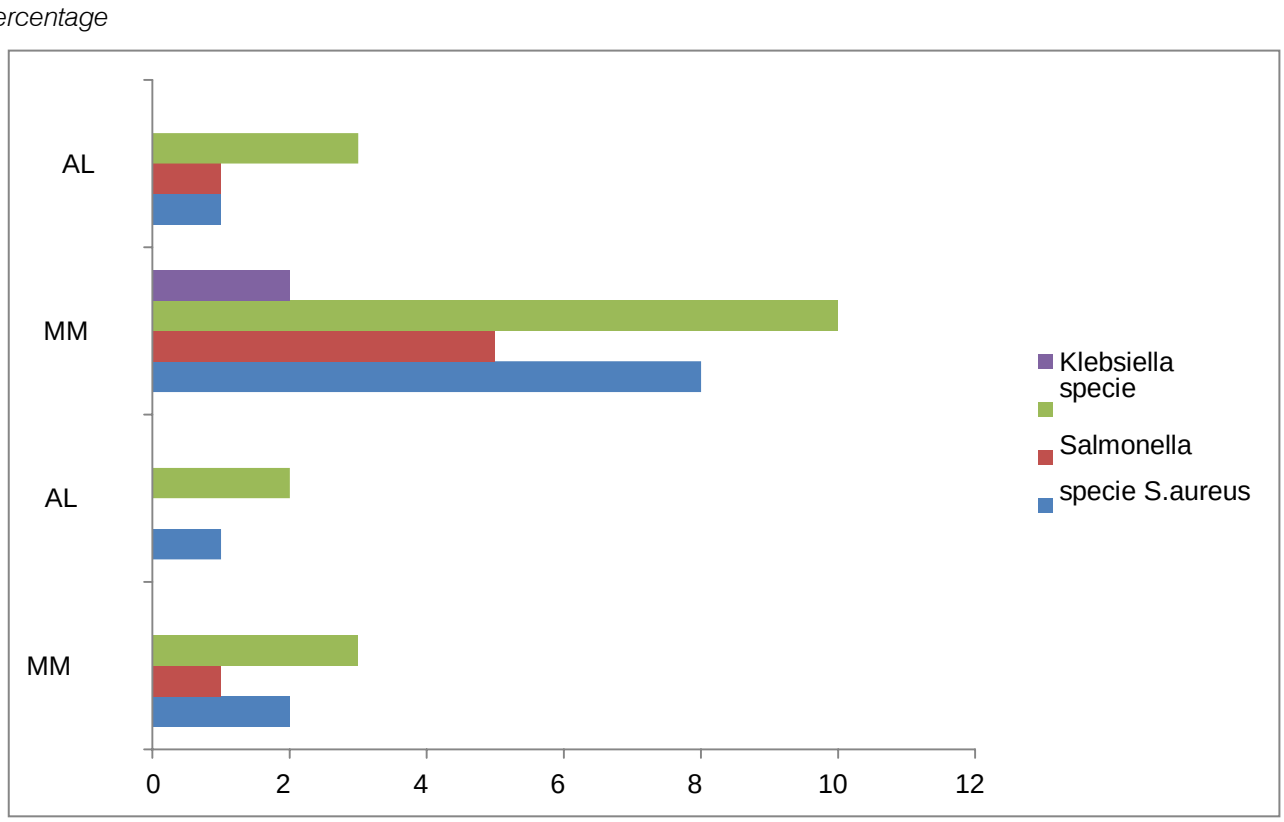

Fig. 6: Percentage occurrence of total bacterial isolates of garri and ogi from markets in Keffi. KEY= AL- Angwan lambo, MM- Main market

Table 5: Antibiotics susceptibility of *Salmonella* species isolated from Garri and Ogi

S/N	Antibiotics	Susceptibility (%)
1	CIP	0 (0.00)
2	S	13 (72.2)
3	C	13 (72.2)
4	CRO	0 (0.00)
5	AMP	0 (0.00)
6	CXM	0 (0.00)
7	CAZ	0 (0.00)
8	AUG	0 (0.00)
9	SXT	7 (38.9)
10	CN	6 (33.3)

Where: CIP- ciprofloxacin, S- streptomycin, C- chloramphenicol, CRO- ceftriaxone, AMP- ampicillin, CXM- cefurixime sodium, CAZ- ceftazidime, AUG- amoxicilin/ clavulanic acid, SXT-sulphamethoxazole, CN- gentamicin.

V. Discussion, Recommendation and Conclusion

a) Discussion

The study has made it evident that ogi had the highest bacterial contamination with *Salmonella* as the highest contaminant, followed by *E.coli, S.aureus* and *Klebsiella* specise, this microbial contamination can be attributed to the fact that Ogi is produced mainly by natives of the area and does not undergo any heat process like garri before final consumption. The presence of these organisms causes food spoilage, food poisoning or food intoxication in the food product this is in agreement with an earlier study by Awada *et al* (2005).

The differences in the level of contamination of garri and ogi can be as a result of the differences in their method of preparation, storage, handling during sales, fermentation. Garri during preparation or processing goes through heat at a temperature capable of distorting the activities of these bacteria, but ogi production does not undergo any of these processes (Ayehu *et al.,* 2014). Use of bare hands, unhygienic practices, use of contaminated utensils for processing and sales, poor personal and environmental hygiene, use of unsanitised or unsterilized packaging bags for sale of Ogi, use of contaminated water, contamination of raw material, and post processing handling are the major sources of contaminations. This tally with a study reported by Ezendianefo and Dimejesi (2014), who listed their risk factors as poor fermentation condition, poor personal and environmental hygiene post processing handling as well as contamination of raw materials.

Processing of the food is carried out by small holders who produce a large quantity for commercial purposes, most times rudimentary or un-standardized equipment are used for its production, Microbes are said to be wide spread and prevalent, this makes the

product prone however to unintentional contamination by microbes found in the environment.

Salmonella and *E.coli* were the predominant organisms at 65% and 45% in this product, this indicate recent fecal contaminations, they get into food through contaminated water, human, animal (rodents), and poor hygienic practices (Adams and Moss 1995). Hence, it can be deduced that the presence of this organisms has resulted from any of the above mentioned sources of contamination. This is in agreement with a study reported by Izah and Ineyougha (2015), they listed a group of microorganism including *Salmonella* and *E.coli* as species commonly found in different portable water sources in Nigeria such as lakes, boreholes, and hand dug wells e.t.c.

Oyelana and Coker (2012) studied the growth of *Klebsiella* specie and other organisms to significantly reduce at the end of fermentation hence, its occurrence according to them could have resulted from the water used for fermentation, it could also be a normal flora of the maize before fermentation.

Staphylococcus aureus was one of the bacteria isolated in this study, they may have found their way into this food product through carriers during sales; this organisms are found around the nose, throats, hands, and clothing's of the carriers (Cheesebrough, 2000). The storage procedures of this food product are mostly carried out in environment devoid quality control. Food gets contaminated by means of storage materials too and this include bagging, fermentation in water after bagging prior to use during which it could get contaminated by this microorganisms. This corroborates with a study reported by Sylvester *et al* (2016), the authors reported this in their study as a source of contamination which put prospective consumers of the product at risk of food borne illnesses.

Control measures are lacking in terms of ogi production by small holders; no laid down step by step procedure for processing such as stating the quantity of water that could be used for a certain weight and quantity of maize during fermentation. Fermentation period also lies on individuals and locality, the only quality control often carried out by producers is the organoleptic characteristics and to a great extent depends on individuals (Sylvester *et al*., 2016). Garri samples were also contaminated and *Salmonella* species was the predominant organism as well. This does not corroborate with a study reported by Almeida (1994) who showed that *Staphylococcus* spp had the highest rate of occurrence in garri. This also agrees with a report by Center for Disease Control, U.S who showed Salmonellosis as the most frequently occurring bacterial food borne infection. It was observed that there was more microbial contamination in white Garri than in yellow Garri, which may be due to the antimicrobial property of the oil added to the yellow Garri. This is in consonance with the work of Orji *et al.* (2014), but on a contrary in this study *Salmonella* contamination was higher in yellow Garri than in white Garri. The variation in these results can be explained by point of sale contamination that could have raised the *Salmonella* burden of the Yellow Garri in this study (Thoha *et al.,* 1890). This food borne pathogen have been marked as one of the organisms which has developed high resistance to antimicrobials. The emergence of antimicrobial-resistant *Salmonella* has been a problem (Dabney, 1997).

Garri contamination maybe associated with inadequate post processing, some post processing handling practices such as spreading on the mat, spreading on the floor after frying, open display in bowls and basins in the market, measurement with bare hands, coughing, sneezing while selling, and use of non-microbiological packaging material. Agboonlahor (1997) listed these factors as a source of contamination in a similar study. Typically it was observed that cassava for gari production is harvested manually in the farm with equipment such as cutlass, hoe and flat iron sheets, which occasionally inflicts injury on the root tuber which are later hauled in their numbers and heaped in the market for sales under humid and warm conditions, this practices predispose the tuber to contamination by organisms prior processing.

Garri may be contaminated during processing and production and contaminants may be killed when frying locally with a temperature ranging from 22-60^{0}c (Aseidu and Wieneke 1989) and using a modernized oven for 8hrs at 110^{0}c, Garri still gets contaminated after cooling during packaging and unhygienic practices during sales.

Bacteria load was high in samples collected in main market than in Angwan lambo market, this can be attributed to the fact that the main market is more populated and activities that will make these food products prone to contamination are high. The distribution of the organisms varied from both markets. The main market also harbors many waste dumps, muddy environment with stagnant water hence recorded more contamination than Angwan Lambo market which is a mini market with lesser population and activities. This is in line with findings made by Almeida (1994) who attributed variation in distribution of organisms to environmental condition and practice of the food handlers. Insects such as flies may play an important role in spread of these bacteria especially from contaminated fecal matters to food. (Center for Disease Control 1978).

The isolates showed resistance to cephalosporin's, quinolones and penicillin class of antibiotics, and susceptible to aminoglycoside class of antibiotics. This is not in agreement with a similar study reported by Bacon *et al* (2002) who reported that the *Salmonella* isolates were susceptible to the cephalosporin and quinolones class of antibiotics. This

could be as a result of the fact that this test organism developed resistant pattern over the years.

All isolates studied were found to be multi-drug resistant (MDR) as all of them were resistant to 60% of the antibiotics tested; this tally's with a report by Gordana *et al* (2012) who reported that multidrug-resistant (MDR) strains of *Salmonella* are now frequently occurring worldwide and the rates of multidrug-resistance have increased considerably in recent years.

Drug resistance is one of the nature ending processes, organisms develop tolerance for new environment which may be due to pre-existing factors in the organism or acquired factors. This bacterium is capable of inflicting economic losses such as cost of treatment, cost of disease investigation and control. Mead *et al.,* (1999) estimated *Salmonella* strains to be responsible for over 1.4million illnesses and subsequently accounted for 9.7% of total food borne illnesses and many cases of death.

b) Conclusion

This work on Garri and Ogi sold in Keffi markets showed that these food products are mostly unfit for consumption and present significant risk of food poisoning to consumers. This work should serve as a pointer for relevant agencies of government to carry out frequent checks and ensure compliance with best hygiene practices for the safety of food sold in the markets of Keffi. The enforcement of these measures could help reduce diseases related to contaminated food sold in the market. A strict application and implementation of quality control (QC), good manufacturing practices (GMP), quality assurance (QA) and hazard analysis critical control point principles (HACCP) will ensure the safety of Garri and Ogi consumed by the people in Nigeria. The emergence of antibiotics resistance suggests excessive use of antibiotics in human which has resulted to an increased risk to human health. Controlling the use of antibiotics wisely is needed to reduce spread of antibiotic resistant strains of microorganisms.

c) Recommendations

The following recommendations should be taken into consideration:

1. To protect against bacterial infection, heating food for at least 10mins to an internal temperature of 75^0c is recommended.
2. Sellers of Garri and Ogi and other food products should stop exposing their products but cover with a transparent poly-ethane bag to protect against contamination.
3. Sanitized containers should be used during production and sales.
4. 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.
5. The state and federal government should establish standard Garri and especially Ogi processing industries as Ogi is a common weaning food for children and as such should be prevented from contamination.
6. Sellers should also use gloves instead of their bare hands in sales of these products.
7. Good water sources should be made priority during production.
8. Sensitivity test for food infection should be conducted often in order to hinder administration of wrong drugs to affected persons.
9. The government through the ministries of water resources, health and education should collaborate with various public health organization and lunch a campaign in order to create awareness to smallholders, market women and even the public on the need for hygienic practices during production and sales of food products.
10. A hand wash station or site should be made set up and made compulsory in markets especially large markets in the country, with the availability of disinfectants and clean water for use often.

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Appendix I

1. Nutrient agar (oxoid CM3)

	gms/ltr
Agar	15.00
Peptone	5.00
Sodium chloride	5.00
Yeast extracts	2.00

Dissolve 28g in 1000ml of water completely and sterilize by autoclaving at 121^{0}c for 15 minutes

2. Nutrient broth (oxoid CM1)

	gms/ltr
Yeast extract	2.00
Lab-lemco powder	1.09
Peptone	5.00
Sodium chloride	5.0

Dissolve completely 13g in 1000ml 0f water and sterilize by autoclaving at 121^{0}c for 15 minutes.

3. MaCConkey agar (TM MEDIA)

	gms/lrt
Peptic digest animal tissue	20.00
Agar	12.00
Lactose	10.00
Bile salts	5.00
Neutral red	0.075
pH	7.4 at 25^{0}c

dissolve 47g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes.

4. EMB (L:S BIOTECH)

	gms/ltr
Peptic digest animal tissue	10.00
Dipotassium phosphate	2.00
Lactose	5.00
Sucrose	5.00
Eosin-Y	6.40
Methylene-blue	0.065
Agar	13.50
pH	7.2 at 25^{0}c

Dissolve 36g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes.

5. Simon citrate agar

	gms/ltr
Agar	15.00
Sodium chloride	5.00
Sodium sitrate	2.00
Dipotassium phosphate	1.00
Ammonium dyhydrogen	1.00
Magnesium sulphate	0.20
Bromothymol-blue	0.80
pH	6.8 at 25^{0}c

Dissolve 24g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes.

6. Indole test medium (HI-MEDIA)

	gms/ltr
peptone	25.00
sodium chloride	5.00

Dissolve 15g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes.

7. SSA (HI-MEDIA)

	gms/ltr
Proteose peptone	5.00
Lactose	10.00
Bile salts mixture	8.50
sodiumcitrate	8.50
sodium thiosulphate	8.50
ferric citrate	1.00
brilliant green	0.003
neutral red	0.25
agar	13.50
pH	7.0 at 25^{0}c

Dissolve 60g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes

8. Mueller Hinton Agar

	gms/ltr
Beef extract	2.00
Acid hydrolysate	17.00
Starch	1.50
Agar	17.00
pH	7.3 at 25^{0}c

Dissolve 38g in 1000ml of water and sterilize by autoclaving at 121^{0}c for 15 minutes.

Urea agar	gms/ltr
Peptone	1.00
Glucose	1.00
Sodium chloride	5.00
Disodium phosphate	1.20
Potassium dihydrogen phosphate	0.80
Phenol red	0.012
Agar	15.00

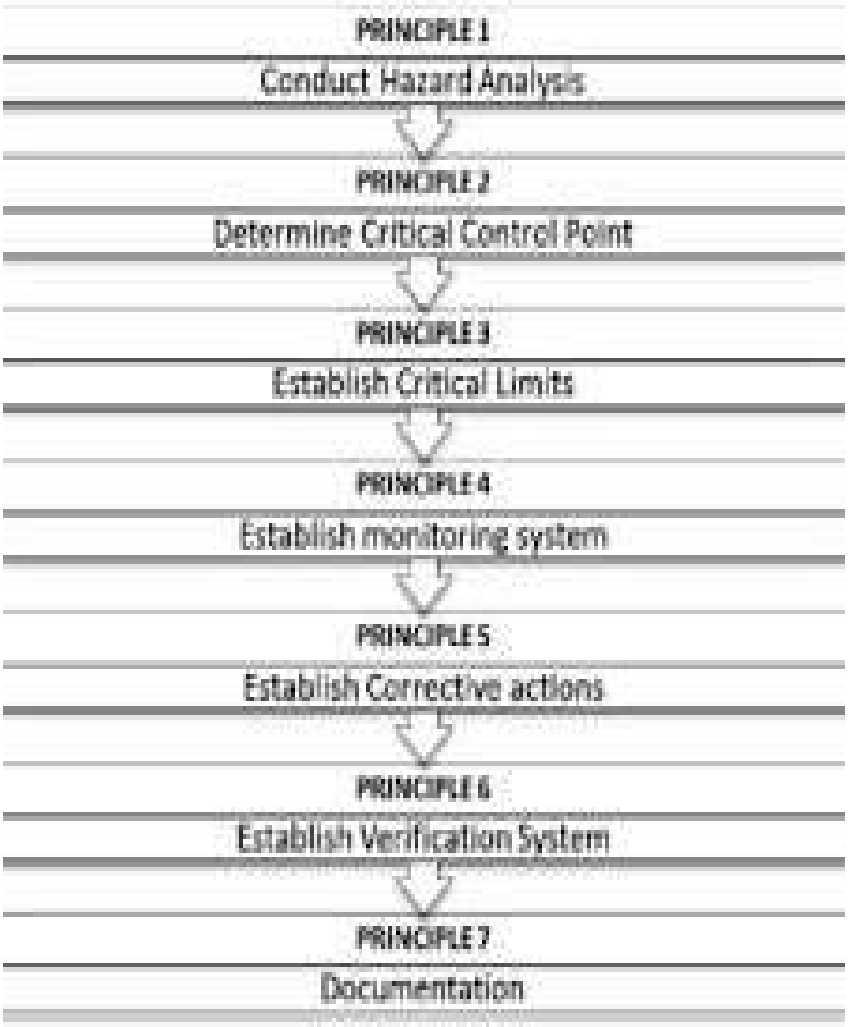
Appendix II

Table 6: Total bacteria isolate of Ogi and Garri from markets in Keffi (figure 6)

Markets	No. of samples	E.coli (%)	S.aureus (%)	Salmonella specie(%)	Klebsiella specie(%)
MM garri	10	2(20.00)	1(10.00)	3(30.00	0(0.00)
AL garri	10	1(10.00)	0(0.00)	2(20.00)	0(0.00)
MM ogi	10	8(80.00)	5(50.00)	10(100.00)	2(20.00)
AL ogi	10	1(10.00)	1(10.00)	3(30.00)	0(0.00)
Total	40	12(30.00)	7(17.50)	18(45.00)	2(5.00)

Keys: MM= main market, AL= angwan lambo market

Hazard Analysis Critical Control Point Principle



Appemdix III

Antibiotics Used

Antibiotics used	Abbreviation	Concentration(μg)	Company name
Chloramphenicol	C	30	Oxoid Ltd
Sulphamethoxazole	SXT	25	Oxoid Ltd
Gentamicin	CN	30	Oxoid Ltd
Ciprofloxacin	CIP	5	Oxoid Ltd
Ceftazidime	CAZ	30	Oxoid Ltd
Amoxicillin	AUG	30	Liofilchem roseto italy
Ampicillin	AMP	10	Oxoid Ltd
Cefurixime	CXM	30	Oxoid Ltd
Ceftriaxone	CRO	30	Oxoid Ltd
Streptomycin	S	30	Liofilchem roseto italy
Antibiotics Break Points			
Antibiotics	Break points (mm)		
Ciprofloxacin	≥ 31		
Streptomycin	≥15		
Chloramphenicol	≥18		
Ceftriaxone	≥23		
Ampicilin	≥22		
Cefurixime	≥18		
Ceftazidime	≥21		
Amoxicillin	≥18		
Sulphamethoxazole	≥16		
Gentamicin	≥15		

Antibiotic Susceptibillity Test

Isolates	CIP	S	C	CRO	AMP	CXM	CAZ	AUG	SXT	CN
1	R	S	R	R	R	R	R	R	R	R
2	R	S	S	R	R	R	R	R	R	R
3	R	S	R	R	R	R	R	R	S	S
4	R	S	S	R	R	R	R	R	R	R
5	R	R	S	R	R	R	R	R	R	R
6	R	S	S	R	R	R	R	R	R	R
7	R	S	S	R	R	R	R	R	S	R
8	R	S	S	R	R	R	R	R	R	S
9	R	R	R	R	R	R	R	R	R	R
10	R	R	S	R	R	R	R	R	R	S
11	R	S	R	R	R	R	R	R	R	R
12	R	R	S	R	R	R	R	R	R	R
13	R	S	S	R	R	R	R	R	S	S
14	R	S	S	R	R	R	R	R	S	S
15	R	R	S	R	R	R	R	R	S	R
16	R	S	S	R	R	R	R	R	S	R
17	R	S	S	R	R	R	R	R	S	S
18	R	S	R	R	R	R	R	R	R	R