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Most Prominent Factors of Food Poisoning in Africa: Nigeria Based Perspective

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Abstract

Food poisoning, is an acute disease caused by the consumption of contaminated, spoiled or toxic foods as a result of poor hygiene, poor packaging and ignorance of the consumer. The major sources of food poisoning are viruses, bacteria and parasites. Reports show that Asia and the sub-Saharan have the highest case of illness which can be traced back to food poisoning and in Nigeria, about 200,000 cases of Nigerians death was as a result of food poisoning. Other factors that contribute to food poisoning are food allergies, about 4-8% of human beings have food allergies especially in developed countries although the sensitivity levels vary. Microbial contamination which is caused by infectious organisms is also another major factor that contributes to food poisoning. Infectious organisms like rodents deposits pathogens that are toxic to human health into the soil, fruits and water supplies. Pathogens like; *Staphylococcus aureus*, *Toxoplasma spp.*, *Streptobacillus moniliformis*, *Trichinella spp.*, *Yersinia pestis*, *Francisella tularensis*, and *Hantaviruses* can be deposited by rodents. This article helps to elucidate the dangers of consuming poisonous foods, factors to look out for in food processing and packaging and the important causes of food poisoning.

Keywords: *Food, pathogens, causes, food allergies, food poisoning, infectious pathogens, Nigeria*

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Introduction

Food is one of the most essential needs of human beings just as water is to the body because the human body utilizes food as energy for work and its metabolic activities. There is an intersection between food quality and public health since the quality of food people eat within a territory determines the health quality of the people. Across the world, food poisoning has been a significant risk to public health (WHO, 2006). Food poisoning occurs when contaminated food and water is ingested, the contamination is mostly a result of foreign substances which could be bacteria and bacteria toxins, viruses, insecticides, parasites present in food substances.

It was reported that Asia and the sub-Saharan have the highest cases of illness which can be traced back to foodborne infections (World Bank, 2018). Although, the Nigerian government is putting in its best to improve food safety in the food system and eradicate foodborne diseases from the food supply chain, the Ministry of Science and Technology has estimated that a minimum of 200,000 Nigerians die annually from food poisoning (Onyeaka *et al*., 2021). Food poisoning which can be an acute intestinal disease can be linked to a number of factors which are not limited to the ingestion of contaminated food and drinks (Ntambwe, 2016). In Nigeria, some factors include microbial contaminations, this can occur as a result of inadequate and poor storage conditions which exposes the agricultural produce to microbial contamination, and environmental pollution. This can also occur when industrial wastes which contains lead and other toxic substances are passed into the river and are ingested by fishes in the river, the consumption of those fishes can cause foodborne diseases such as high blood pressure, kidney and liver damage. Another factor of food poisoning is poor hygiene and poor processing. Viruses, bacteria and parasites thrive in an un-hygienic environment, as such when foods are poorly cooked or processed in such unhealthy condition, it can lead to contamination. Undercooked poultry meat such as chicken, duck and turkey can cause food poisoning due to the presence of bacteria in them when they are consumed. Furthermore, poverty is a predisposing and major factor that makes people opt-in for any food available at a given time regardless of the quality (Samuel *et al*., 2020). This article focuses its aim to evaluate the most prominent factors of food poisoning in Nigeria.

Poor Hygiene (Food Handlers)

Food hygiene is a deliberate and intentional effort to keep food safe from contamination. Thus, protecting the health of consumers (FAO and WHO, 2009). Food handlers being one of the main determinants of ready to eat food plays a major role in the health status of the populace. Careless food handling and poor hygiene in Nigerian eateries, cafeterias and restaurants can facilitate disease transmission in meat, pork and other foods when not properly cooked. Poor hygiene can also occur during storage which includes foods stored in;

non-ventilated areas, areas prone to pest invasion, poor sanitation, moisture build-up resulting in spoilage and bacterial infection which can lead to adverse effects on consumers.

Food handlers play a vital and critical role during the phases of food production which include processing, milling, preparation and packaging. Unhealthy food handling can lead to foodborne diseases as the handlers may be asymptomatic carriers of disease (Emmanuel *et al*., 2015).

The level of education, consciousness and awareness is also an important factor in determining the level of hygiene practice the food handlers can put into play as the technical ''know-how'' is pivotal in their roles for food safety. The problems posed to mankind as a result of poor hygiene underpins the importance of healthy practices. According to World Health Organization (WHO) (2015), in an estimated 600 million world population, almost one in ten people fall sick after eating contaminated food and 420,000 die every year from food poisoning. WHO also reported that children under 5 years of age are susceptible to food poisoning and have 40 per cent of the food-borne disease burden, with 125,000 deaths every year.

Other studies on poor hygiene carried out in Nigeria's Federal Capital Territory reported that up to 54% of food handlers reuse water repeatedly for washing and rinsing before changing (Ifeadike *et al*., 2014). Other studies reveal that in a low-income earning country like Nigeria, some food vendors and processors do not stay away from work during illness, as they work as much as the illness allows them (Ofuebe, 2015). These are unethical food practices that when neglected, cause food poisoning.

Food Allergy

A food allergy is an aberrant immune response to food with symptoms of the allergic reaction ranging from mild to severe (Anaphylaxis) and may include itchiness, swelling of the tongue, vomiting, diarrhea, hives, trouble breathing, or low blood pressure, which can typically occur instantaneously, in minutes or several hours after exposure (Boyce, 2010). Food intolerance and food poisoning are separate conditions, and is usually not due to an immune response (Boyce *et al*., 2010). Food allergy, defined as an adverse immune response to food proteins, affects as many as 6% of young children and 3% to 4% of adults. Food-induced allergic reactions are responsible for a variety of symptoms involving the skin, gastrointestinal tract, and respiratory tract and might be caused by Immunoglobulin E (IgE)-mediated and non–Immunoglobulin E-mediated (cellular) mechanisms (Sicherer, 2006).

In the developed world, about 4% to 8% of people have at least one food allergy (Sicherer and Sampson, 2018). Studies have shown that they are predominant in children than adults and appear to be increasing in frequency, male children appear to be more susceptible than females (Sicherer and Sampson, 2018). Some allergies develop at early stages in life, and others develop at later stages in life (Boyce, 2010). In developed countries, a large proportion of people believe they have food allergies when they actually do not have them.

Causes of Food Allergy

Although sensitivity levels vary by country, ''the big eight'' which are the most predominant food allergies, are allergies to milk, eggs, peanuts, tree nuts, fish, shellfish, soy, and wheat. Allergies to seeds — especially sesame — seem to be increasing in many countries. An example of an allergy more common to a particular region is that to rice in East Asia and shellfish where it forms a large part of the diet as a result of its abundance (Lee *et al*., 2013).

One of the most common food allergies in Nigeria is sensitivity to peanuts, a member of the bean family. Peanut allergies may be severe, but children with peanut allergies sometimes outgrow them. Tree nuts including almonds, brazilnuts, cashews, coconuts, hazelnuts, macadamia nuts, pecans, pistachios, pine nuts, and walnuts are also common allergens (Sicherer, 2006). Sufferers may be sensitive to one particular tree nut or to many different ones (Sicherer, 2006). Peanuts and seeds, including sesame seeds and poppy seeds, can be processed to extract oils, but trace amounts of protein may be present, and elicit an allergic reaction (Sicherer, 2006).

Egg allergies affect about one in 50 children but are frequently outgrown by children when they reach age five (Savage, 2007). Typically, the sensitivity is to proteins in the white, rather than the yolk (Sicherer, 2006).

Classification of Food Allergies

Food allergies can be grouped by the nature of the hypersensitivity reaction, by the nature of the allergen or by the immune context in which they are presented.

Classification by the nature of the hypersensitivity

In a time when the primary structure of the proteins was unknown, experiments with anaphylactic guinea pigs and their respective antibodies (reagins and precipitins) were considered to be elements for understanding the biochemical nature of the protein itself more than for understanding the allergic phenomenon. The specificity of antigen-antibody interactions and the biological consequences of these interactions generated a branch of study called the "chemistry of anaphylaxis", which in the early twentieth century generated the first reviews. The IgE-mediated reactions are the Type 1 hypersensitivity reactions and directly de-granulate the effector cells (mast cells and basophils) with the release of autacoids and chemotactic agents for eosinophils. The Type 2 reactions are characterized by antigen-antibody interactions that activate complement and stimulate the local production of anaphylatoxins (C3a and C5a) that de-granulate mast cells and basophils and recruit polymorphonuclear leukocytes. Type 3 reactions are triggered by circulating immune complexes but also depend on cytotoxic effector cells and the complement system. Type 4 reactions are T cell-mediated and are independent of specific serum antibodies. It has been proposed to include in this classification the type 5 or granulomatous reactions (Rajan, 2003).

Classification by the nature of the allergen.

According to the nature of the allergen, food allergies can be divided into two groups or classes. In class one food allergy, the allergens are resistant to gastric digestion, and the sensitization process occurs in the gastrointestinal tract (Astwood *et al*., 1996). A class one food allergy is rare in adults but affects children as one of the first manifestations of atopic syndrome. The most prevalent allergens in this class are cow's milk, hen eggs and some vegetables. Generally, these manifestations disappear during the course of childhood and are replaced by other manifestations (allergic march) (Linnerberg, 2008; Høst *et al.*, 2002).

Classification by the immune context.

Classification of allergic phenotypes according to the immune context presented by the individual has also been proposed, which separates the allergies into three classes (atopy, mono-allergy and non–IgE-mediated allergy). These classes are not mutually exclusive because they can overlap (Akdis *et al*., 2004).

Atopy: Atopic diseases include atopic dermatitis, allergic rhinitis and asthma and develop within a complex genetic background. The concept of atopy, initially described by (Niggemann, 2008) refers to a personal or familial predisposition to produce IgE antibodies in response to specifc allergens. Atopy is characterized by increased levels of total serum IgE. The atopic allergic disease often begins in children when an allergic inflammation affects a single organ, such as the skin, the lung, the nose, or a combination of all of these. Cutaneous manifestations of an allergy usually represent the beginning of the atopic march. Approximately two-thirds of the affected individuals with atopic dermatitis develop allergic rhinitis and half develop asthma. The onset of an atopic march is characterized by the IgE-mediated sensitization to food allergens, which subsequently evolves to inhaled allergies (Akdis *et al*., 2004).

Mono-allergy: Mono-allergy (allergic breakthrough) is characterized by the development of a specifc IgE-mediated hypersensitivity in the absence of an increase in the level of total IgE in non-atopic individuals. The mono-allergy can develop at any time of life without any predisposing factors. It manifests itself as an anaphylactic event with insect venom, some foods or medicines or with the involvement of a particular organ, such as rhinitis, asthma or dermatitis. Usually, mono-allergies respond well to allergen-specific immunotherapy (Akdis *et al*., 2004).

Non–IgE-mediated allergy: Some individuals with atopic dermatitis, asthma and/or rhinitis have normal levels of total and specific-IgE and non-reactive allergy skin tests.

Classification by clinical presentation

As a systemic disease, an allergy may theoretically manifest itself in any organ system. When classifying food allergies, it is useful to differentiate the digestive manifestations from the non-digestive manifestations. This separation leads us to a local and/or systemic pathophysiology (Sampson, 1999).

Inadequate and Poor Storage Conditions

Poor storage conditions or structures of food serves as an invitation to animal pests (insects, rodents). These animals thrive better when foods are improperly stored and they cause damage to foods. Although these animals do not directly

cause food poisoning, they help to spread the organisms that does (Gil *et al*., 2004).

Insects

Foodborne pathogenic bacteria such as *Salmonella spp*., *E. coli*, *Shigella spp*., and many others belong to the Gamma proteo-bacteria, which comprises most bacteria linked with insects (Gil *et al*., 2004). The prevalence of foodborne pathogenic bacteria in insects, like *E. coli* and *Salmonella spp*., could play a role in the global public health crisis currently underway.

Insects normally carry microorganisms, however foodborne pathogenic bacteria, like *Salmonella spp*., are less commonly found in insects (Priest and Goodfellow, 2000). When *Salmonella spp.* and *E. coli* are linked to insects, it is possible that the involvement of insects in the relationship is unclear. Insects can act as transmission vehicles, carriers, hosts, mechanical and biological vectors for *E. coli* and *Salmonella spp.* which are the etiological agents of foodborne illness.

Even though foodborne pathogens can endure out of their ecological reservoir for some period, insects can become physiologically infected after coming into contact with feces or other inadequately inspected biohazards brimming with pathogens, and then physiologically hold these pathogens, which is a representation of a mechanical vector. A biological vector, on the other hand, includes a pathogen that is reproducing or growing inside the vector's body (Goddard, 2009). Insects are considered to be biological vectors if foodborne diseases survive within them for any length of time. Vectors of foodborne illness outbreaks are usually referred to as vehicles of transmission according to the Centers for Disease Control and Prevention, while a foodborne pathogen reservoir is defined as a pathogen's environmental source. It is also worth noting that not every member of a given involved species contains pathogens that cause food poisoning. In fact, most insects do not have *Salmonella spp.* or *E. coli* on their bodies.

Insect species associated with *Salmonella spp.* and *E. coli*

The histerid beetle, *Carcinops pumilio* (Erichson); lesser mealworm, *Alphitobius diaperinus* (Panzer); hairy fungus beetle, *Typhaea stercorea (L.)*; rice weevil, *Sitophilus oryzae* (L.) and dump fly, *Hydrotaea aenescens* (Wiedemann) are among the insects associated with *E. coli* and/or *Salmonella spp.* (Casas *et al*., 1972; Gray *et al*., 1999; Olsen and Hammack, 2000). All synanthropic flies, which include houseflies, *Musca domestica* (L.); flesh flies, *Sarcophaga carnaria* (L.); stable flies, *Stomoxys calcitrans* (L.); and fruit flies, *Drosophila melanogaster* (Meigen) among tens of others, that live around and coexist in human habitation; and the secondary screwworm (blow fly), *Cochliomyia maceli* also carry *E. coli* and/or *Salmonella spp.* (Greenberg, 1973; Ahmad *et al*., 2006; Forster *et al*., 2007; Forster *et al*., 2009). At least four cockroach species have been implicated in the possible mechanical transmission, including the American cockroach, *Periplaneta americana* (L.), Oriental cockroach, *Blatta orientalis* (L.), German cockroach, *Blatella germanica* (L.), Speckled feeder cockroach, *Nauphoeta cinerea* (Olivier), and Pacific beetle cockroach, *Diploptera punctata* (Eschscholtz) (Singh *et al*., 1980). When infected for research projects, the face fly *Musca autumnalis* (De Geer) is a possible vehicle of *E. coli* spread; the bacteria's survivability during the inoculation tests suggests the potential spread of foodborne diseases (Hollis *et al.*, 1985; Janisiewicz *et al*., 1999).

Salmonella spp., especially *S. enterica subsp. enterica serovar Typhimurium*, are carried by the secondary screwworm (blow fly) *C. maellaria*. It only appears when there are decomposing dead animals because it feeds on decaying organic waste (Byrd, 1998). Carrion-associated insects are a source of worry. Despite the lack of a direct link to food safety, Urban and Broce (1998) discovered that *M. domestica* and *C. macellaria* are the most important pathogen transmission vectors in Kansas dog kennels. The evidence suggests that the housefly and secondary screwworm are capable vectors of foodborne pathogens.

Salmonella spp. contamination has also been linked to cockroaches (Singh *et al*., 1980; Jones *et al*., 1991). Cockroaches, long thought to have vector potential, live on both hygienic waste and human food, and their lifestyle has a significant impact on food safety programs (Klowden and Greenberg, 1976). Cockroaches are especially well-known pests in metropolitan areas, where population densities are higher and more people are susceptible to poorly handled foodborne disease outbreaks.

Cockroaches are also possible *Salmonella spp.* vectors when a supply of *Salmonella spp.* is present (Kopanic *et al*., 1994). Given the large number of cockroaches seen in poultry processing factories, hospitals, residences, supermarkets, and eateries, among other sites with inadequate sanitation, this is a major problem (Devi and Murray, 1991; Fathpour *et al*., 2003).

Rodents

Rodents, which account for more than 40% of the class Mammalia's species variety, have a global range and can be seen in any region. House mice (*Mus musculus*), brown rats (*Apodemus spp*.) black rats (*Rattus rattus*), and field mice (*Apodemus spp*.) of the Muridae family, and woodrats (*Neotoma spp.*), and cotton rats (*Sigmodon hispidus*) of the Cricetidae family are small rodents that live in close proximity to people. Squirrels in the Sciuridae family have a widespread distribution and coexist with people (Grzimek, 2004). These rodents are well-known for transmitting foodborne illnesses. Food attracts them, but they don't wander far from their breeding locations or shelters. Harborage (areas to shelter and breed), nutrition, and water are the three essential needs of a mouse. If one or more of these elements are lacking, a reduction in rodent numbers in a given location is normally predicted. These rodents live near food sources, devour chicken feed, pollute food with their feces, pee, and filth, and destroy crops, food packaging, and containers far more than they eat due to their ecology. They also have a high rate of reproduction and offer a special concern because they live in close proximity to humans and cattle. Rodents can also transfer pathogenic agents into soils, vegetables, water supplies, and fruits (Weil's disease and hepatitis). Furthermore, they are deemed significant pests round the farms and homes because they cause physical damage to the structure and equipment (Loven, 2010; Tabler *et al*., 2014).

List of Rodent's Infections of Significant Public Health Importance

Many human infections can be transmitted by rodents. They carry different pathogens on their skins and in their digestive system such as *Borrelia spp*., *Cryptosporidium parvum, Escherichia coli. (E. coli.), Campylobacter spp*., *Clostridium spp*., *Leptospira spp*., *Salmonella spp*., *Listeria spp*., *Mycoplasma spp*., *Staphylococcus aureus, Toxoplasma spp*., *Streptobacillus moniliformis, Trichinella spp*., *Yersinia pestis, Francisella tularensis*, and *Hantaviruses* (Moravvej *et al*., 2015; Hamidi, 2015).

The following are some of the most prevalent foodborne diseases caused by rodents in Nigeria, along with some background information:

Two pathogenic bacteria are *Clostridium perfringens* and *E. coli*. The first produces one of the most common types of food poisoning. This gram-positive bacterium can be found in the air, water, soil, sewage, and on a variety of food products. *E. coli*, the other pathogen, lives in the intestines of men, rats, and other mammals and aids in the degradation of waste products. They can, nevertheless, cause sickness when they reach the stomach and small intestines. *E. coli* can be transferred through the feces and out of the body. Listeriosis is yet another foodborne disease triggered by *Listeria monocytogenes* bacteria. This gram-positive rod-shaped bacterium can be found in water, soil, and several animal species, and it can produce flu-like symptoms. This infection can cause miscarriages or stillbirth in expectant mothers. Almost a quarter of all serious cases result in death. Salmonella is a gram-negative bacteria genus that causes salmonellosis, a disease caused by rod-shaped bacteria. The most common isolates from mice are *S. enteriditis* and *S. typhymurium*. Food handlers frequently carry dangerous bacteria from one food to another because they can survive on people's hands for hours before being introduced to foods. This pathogen can be found in animal and human excreta, insects, soil, dust, and raw meat (Szyfres and Acha, 2003; Ryan and Ray, 2004; Meerburg and Kiljstra, 2007).

The pathogenic roundworm *Trichinella spiralis* is arguably the most well-known endoparasite that causes foodborne disease. Trichinosis is an infection caused by this small worm. It affects both wild animals and humans, including bears, boars, rats, and rabbits. Via infected food, this parasite can infiltrate a host as larvae or adult worms. Sin Nombre, or the "No Name Virus," causes hantavirus pulmonary syndrome (HPS), a fatal viral disease. Cotton rats (*Sigmodon hispidus*), deer mouse (*Peromyscus maniculatus*), rice rats (*Oryzomys palustris*), and leucopus (*Peromyscus leucopus*) are among the virus's reservoirs (Krauss *et al*., 2003; Peters, 2006; Ryan and Ray, 2004).

Microbial Contamination

Food is the principal source of nutrients to man and other living organisms. Microorganisms are ubiquitous, requiring nutrients to survive (Balali *et al*., 2020). They are readily present in foods conferring health benefits when inactivated before consumption. Also, make food better or deteriorate. The presence of fermenting microbes increases the shelf life of foods and eliminate harmful substances from raw food state (Tamang *et al*., 2016). For example, the poisonous cyanide content of cassava is reduced via fermentation activity of Bacteria (Lactic Acid) in the process of making garri (cassava flakes)

(Sharma *et al*., 2020). In the same manner, bacteria produce microbial enzymes that can lead to food spoilage.

Microbial contamination leading to foodborne diseases is one of the primary concerns of food safety and public health worldwide (Ameme *et al*., 2016; Efunshile *et al*., 2020). Nigeria encounters problems with the high occurrence of foodborne diseases due to microbial infection. Food contamination is not unusual. The process of moving food produce from farm to the ultimate consumer is enough exposure to contaminants when not handled properly. Thus, poor management of foods can lead to the growth of biological contaminants (Abdolshahi and Yancheshmeh, 2020). In 2016, an outbreak of *Listeria monocytogenes* was due to contaminated prepacked salad products (Hussain, 2016). The act of ensuring that food is edible and regarded fit for consumption under hygienic standards is known as a food safety measure (Kamboj *et al*., 2020). Unhygienic food handling, poor sanitation practices and cooking environment and unhealthy lifestyles of increased patronage of "street food" are pathways of increased vulnerability to food contamination by microorganisms (Oladoyinbo *et al*., 2015; Odeyemi and Bamidele, 2016; Onyeneho and Hedberg, 2013). These claims are bolstered by the fact that most street food sold in Nigeria engage in unhealthy food practices.

The dearth in knowledge of food safety measures contributes to an increase in microbial growth and spread. As a result, the absence of proper waste and toilet facilities, poor access to potable water and food ingredients contributes to widespread of food disease-causing microbes via the faecal-oral route (Pepple, 2017). Poor storage infrastructures, inadequate cooking and exposure of cooked meals with raw foods (such as poultry, pork, beef and fish) are other known transmission means of foodborne illnesses in Nigeria (Odeyemi and Bamidele, 2016; Odeyemi and Sani, 2016). Previous studies have linked most incidences of microbial foodborne diseases to human contact with animals (directly, indirect) and the environment (Abebe *et al*., 2020; Odeyemi, 2016). Bacteria, viruses, fungi and parasites are infectious agents of foodborne diseases (Odeyemi, 2016). Bacteria are the main causative agents of foodborne illnesses. Microbial spoilage of food varies from region to region (Abebe *et al*., 2020; Gbolabo *et al*., 2020). The point of contamination differs. Although, the highest chances of contamination occur during meal preparation or serving (Ameme *et al*., 2016). When foods are contaminated by microorganisms, it could lead to fatal conditions. Children, the elderly and individuals with an underlying health condition are the front markers threatened by the effects of eating foods infested with unhealthy microbes (Mensah *et al*., 2012; Nyenje and Ndip, 2013).
Bacillus species (Such as *B. cereus*), *Campylobacter jejuni*, *Clostridium botulinum*, *C. perfrigens*, Pathogenic *Escherichia coli*, *Listeria monocytogenes*, *Salmonella sp*., *Shigella sp*., Pathogenic *Staphylococcus aureus*, *Vibrio cholera*, *V. parahaemolyticus*, *V. vulnificus* and *Yersinia enterocolitica*, viruses such as *hepatitis A* and *E*; Norovirus are common microbial agents of foodborne diseases (Hussain, 2016; Oladoyinbo *et al*., 2015; World Health Organization - WHO, 2006).

In West Africa, Nigeria, a lot of agricultural produce is processed traditionally to add value to the food and create varieties of foods for consumption. Many of these food processing techniques and facilities are still home-based with very little consideration for Good Manufacturing Practice (GMP), unhygienic processing environment leads to frequent microbial contamination (Folarin, 2014). Epidemiological surveillance of foodborne illness cases in West Africa has revealed a high prevalence of infantile and traveler diarrhea, as well as mortality, caused by different etiological agents derived from contaminated food and water (Barrel and Rowland., 1979, Guerrant *et al*., 1990, Okeke *et al*., 2000). In West Africa, both fermented and non-fermented foods confront a variety of microbiological safety concerns. Fermented foods are created by microbial fermentation, which produces biochemical changes in the solid substrate or liquid substrate, resulting in flavor and aroma development. As a result, the presence of pathogenic and spoilage bacteria during manufacturing cannot be completely ruled out, particularly during fermentation under extremely low hygiene circumstances, which is typical in West Africa (Folarin, 2014). In a study by Oguntoyinbo and Oni, 2004, *Bacillus cereus* was isolated from all tested traditional alkaline fermented protein meals in Nigeria. This bacterium generates diarrhea toxin and is responsible for many cases of self-limiting diarrhea in West Africa (Oguntoyinbo and Oni, 2004). Foodborne pathogens have been shown to thrive in lactic fermented cereal meals with acidic pH, which are eaten as supplementary baby feeding in West Africa. *Shigella* survival and the presence of pathogenic *Escherichia coli* bacteria in traditional fermented ogi, akasa, and kenkey have been documented (Nyatoti *et al*., 1997, Tetteh *et al*., 2004).

Also, non-fermented foods produced in Nigeria are processed through techniques like dehulling, grating, drying, etc. Poor and unhygienic processing and handling conditions may contribute to microbial contamination of food. *Cronobacter sakazaki*, a ubiquitous bacterium, was identified from traditional non-fermented Nigerian Akara in research on the microbiological safety quality of traditional non-fermented food in West Africa (Bulgarelli *et al*., 1988).
Food poisoning is a serious threat to consumers and the Nigerian population. Some of the pathogenic organisms associated with food poisoning and subsequent foodborne diseases are shown in Table 1 below.

Table 1: Food Borne Diseases and their pathogenic Micro-organism associated with W. African Foods (Source: Bulgarelli *et al*., 1988; Bankole and Adebanjo, 2003; Bankole and Mabekoje, 2004; WHO, 2001).

Etiology	**Microorganisms**	**Virulence Factor**	**Susceptible Foods**	**Incidence Countries**
Fungal Toxins	*Aspergillus niger*	Aflatoxins	Cereals, roots and tubers chips, legumes	Nigeria, Senegal W. Africa countries
Bacterial Toxins	*Fusarium*	Fumonisins	Cereals	All W. Africa Countries Nigeria, Ghana
	B. cereus	Emetic and diarrhea toxins	Fermented cereals and legume foods, condiments	
			Weaning cereal foods	Nigeria, Ghana, Mauritania
	Sh. Flexneri	Shiga toxin	Traditional weaning foods	W. Africa Countries
	Salmonella	Invasiveness	Traditional cassava and unfermented cowpea paste	Ghana, Cote d'Ivoire
	E. coli			
	C. sakazakii		Contaminated traditional foods	Nigeria, Ghana, Senegal
	V. cholera serogroup O1 or O139	Zona occuludens toxin		
Viral Food Borne	Hepatitis A and E	Immune suppression	Fecal contaminated traditional foods	W. Africa Countries
Parasites	*Cryptosporidium*	Transmission through oocyst	Traditional foods under poor hygiene production	W. Africa Countries
	Giadia lamblia	Ingestion of cyst	Traditional foods under poor hygiene production	W. Africa Countries

Conclusion

Subjecting food to any unfavorable condition places it at high risk of contamination predominantly from microbes and heavy metals found in the environment. In addition, because of some of the nutrients that these foods possess, they enable these microbes to thrive well. Furthermore, if these factors are not put into consideration from farm to fork, consumers will be at high risk of food poisoning. An environment that is polluted with heavy metals, carcinogens, and other harmful substance can facilitate food poisoning if ingested by disrupting normal metabolic processes in the body. Similar happenings can also be likened to environmental water bodies where some industrial wastes which contains lead and other toxic substances are passed into the river, if ingested by fishes in the river could lead to food poisoning upon consumption by man as the toxins would cause dysfunction by affecting vital organs in the body (Samuel *et al*., 2020). To sum up, consumer's negligence and ignorance in Nigeria to existing allergies also places them at high risk of food poisoning.

Authors' Contributions

All listed author contributed equally to the literature writing, review and editing of this article.

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The authors declare no competing interest.

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Recommendation

It is expedient to note that the body system differs and the body immune response to pathogens will also differ. Individuals should therefore note substances that trigger them as allergy and abstain from them by reading food labels and asking questions. Also, precautionary measures should be heightened in terms of food safety and consumers should make sure that they eat safe foods. This can be strengthened by self-awareness, thorough preparation of foods, practicing food hygiene and keeping food safe.

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References

Abdolshahi, A. and Yancheshmeh, B. (2020). Food Contamination. 10.5772/intechopen.89802.

Abebe, E., Gugsa, G. and Ahmed, M. (2020). Review on Major Food-Borne Zoonotic. Bacterial Pathogens. *Journal of Tropical Medicine* 1-19.

Ahmad, A., A., Broce, and Z., Ludek. (2006). Evaluation of significance of bacteria in larvaldevelopment of *Cochliomyia macellaria* (Diptera: Calliphoridae). *Journal of Medical Entomology* **43**: 1129 - 1133.

Akdis, C.A., Blaser, K., Akdis, M. (2004). Apoptosis in tissue inflammation and allergic disease. Curr Opin Immunol, **16**: 717-723.

Ameme, D.F., *et al*. (2016). Foodborne disease outbreak in a resource-limited setting: a tale of missed opportunities and implications for response. Pan African Medical Journal. 23:69. [doi: 10.11604/pamj.2016.23.69.7660

Astwood, J., Leach, J. & Fuchs, R. (1996). Stability of food allergens to digestion in vitro. Nat. Biotechnol **14**, 1269–1273. https://doi.org/10.1038/nbt1096-1269

Balali, G. I., Yar, D. D., Dela, V.G.A., and Adjei-Kusi, P. (2020). Microbial Contamination, an Increasing Threat to the Consumption of Fresh Fruits and Vegetables in Today's World. *International Journal of Microbiology*. *8*, 51–54. Article ID 3029295 –

Bankole, S. A., and Adebanjo, A. (2003). Mycotoxins in Food in West Africa: Current Situation and Possibilities of Controlling it. *Review Journal of Biotechnology*, **2**: 254-263.

Bankole, S., Mabekoje, O. (2004). Mycoflora and Occurrence of Aflatoxin B 1 in Dried Yam Chips from Markets in Ogun and Oyo States, Nigeria. Mycopathologia 157, 111–115 https://doi.org/10.1023/B:MYCO.0000012211.31618.18

Barrel, R. and Rowland, M. (1979). The relationship between rainfall and well water pollution in a West African (Gambian) village. *Journal of Hygiene* **83**;143-150.

Boyce, J.A., Assa'ad, A., Burks, A.W., *et al*. (2010). Guidelines for the Diagnosis and Management of Food Allergy in the United States: Summary of the NIAID-Sponsored Expert Panel. Report. *Journal of Allergy and Clinical Immunology*, **126** (6): 1105–1118.

Bulgarelli, M. A., Beuchat, L. R., McWatters, K. H. (1988). Microbiological quality of cowpea paste used to prepare Nigerian Akara. *Journal of Food Science*, **53** (2): 449

Byrd, J. H. (1998). Secondary Screwworm, Cochliomyia macellaria (Fabricius). University of Florida. IFAS Extension. EENY-022: 1 - 3. http://edis.ifas.ufl.edu/pdffiles/IN/IN14900.pdf.

Casas, E. L., P. K. Harein, and B. S. Pomeroy. (1972). Bacteria and fungi within the Lesser Mealworm collected from poultry brooder Houses. Environmental Entomology **1**: 27 - 30

Devi, S. J., and Murray, C. J. (1991). Cockroaches (Blatta and Periplaneta species) as reservoirs of drug-resistant salmonellas. Epidemiology and infection, **107**(2), 357–361. https://doi.org/10.1017/s0950268800048998

Efunshile, M. A., Onwakpu, K. O., Robertson, L. J. and Jokelainen, P. (2020). Opinions and knowledge on globally important foodborne parasites among healthcare professionals at a tertiary teaching hospital in Nigeria. Food and Waterborne Parasitology, **18**:1-6.

Emmanuel, A., Mangai, J. M., Kayong, E. A., Afoi, B. B., Goshit, J. D., Naman, K., and Innocent, O. (2015). Assessment of practice of food safety and hygiene among food vendors within Jos North Local Government Area of Plateau State, Nigeria. *International Journal of Medical and Health Research*, **1**(2) 83-86.

Fathpour, H., G. Emtiazi, and E. Ghasemi. (2003). Cockroaches as reservoirs and vectors of drug resistant *Salmonella spp*. *Iranian Biomedical Journal* **7**: 35 - 38.

Folarin, A., O. (2014). Safety Challenges Associated with Traditional Foods of West Africa, Food Reviews International, **30**:4, 338-358, DOI: 10.1080/87559129.2014.940086

Food and Agricultural Organization and World Health Organization (2009). Codex Alimentarius: food hygiene basic text (4th edition). Food Safety in the WHO African Region. *African Journal of Food, Agriculture, Nutrition and Development* **12**(4):6317-6335.

Forster, M., Sievert, K., Messler, S., Klimpel S., and Pfeffer, K. (2009). Comprehensive study on the occurrence and distribution of pathogenic microorganisms carried by synanthropic flies caught at different rural locations in Germany. *Journal of Medical Entomology* **46**: 1164 -1166

Forster, M., Klimpel, S., MehLhorn, H., Sievert, K., Messler, S., and Pfeffer, K. (2007). Pilot study on synanthropic flies (e.g. Musca, Sarcophaga, Calliphora, Fannia , Lucilia, Stomoxys) as vectors of pathogenic microorganisms. Parasitology Research **101**: 243-246.

Gbolabo, J. K., Adebola, A. A. and Abdul-Hakeem, O. A. (2020). Assessment of Knowledge, Attitude, and Practice of Meat Hygiene among Meat Handlers in Lagos State, Nigeria. *Nigerian Journal of General Practice* **18**:27-36.

Gil, R., A. Latorre, and A. Moya (2004). Bacterial endosymbionts of insects: Insights from comparative genomics. *Environmental Microbiology* **6**: 1109 -1122 .

Goddard, J. (2009). Infectious diseases and arthropods. Humana Press. A part of Springer Science + Business Media, LLC. 251 pp.

Gray, J. P., C.W. Maddox, P.C. Tobin, J.D. Gummo, and C.W. Pitts (1999). Reservoir competence of Carcinops pumilio for Salmonella enteritidis (Eubacteriales: Enterobacteriaceae). *Journal of Medical Entomology* **36**: 888 - 891.

Greenberg, B. (1973). Flies and Disease. Volume 2: Biology and Disease Transmission. Princeton University Press. 447 pp.

Grzimek, B. (2004). Grzimek's Animal life encyclopedia. (2nd edn). Volumes 12-16, Mammals I- V, edited by Michael Hutchins, Devra G. Kleiman, Valerius Geist, and Melissa C. McDade. Farmington Hills, MI: Gale Group. Volume 16.

Guerrant, R.L., Hughes, J.M., Lima, N.L., Crane, J., et al. (1990) Diarrhoea in Developed and Developing Countries: Magnitude, Special Settings and Etiologies. Reviews of Infectious Diseases, 12, 41-50. http://dx.doi.org/10.1093/clinids/12.Supplement_1.S41

Hamidi, K. (2015). First parasitological survey of Calomyscus elburzensis (Rodentia; Calomyscidae); two new records of tick from Iran. *Journal of Zoology* **2**(2): 42-46.

Hollis, J. H., F. W. Knapp, and K. A. Dawson. (1985). Influence of bacteria within bovine feces on the development of the Face Fly (Diptera: Muscidae). Environmental Entomology **14:** 568 - 571. https://doi.org/10.1155/2020/3029295, 1-13.

Høst, A., Halken, S., Jacobsen, H. P., Christensen, A. E., Herskind, A. M., and Plesner, K. (2002). Clinical course of cow's milk protein allergy/intolerance and atopic diseases in childhood. Pediatric allergy and immunology: official publication of the European Society of Pediatric Allergy and Immunology, 13(s15), 23–28. https://doi.org/10.1034/j.13993038.13.s.15.7.x

Hussain, M. A. (2016). Food Contamination: Major Challenges of the Future. Foods. doi:10.3390/foods5020021, **5**(21):1-2.

Ifeadike, C. O., Ironkwe, O. C., Adogu, P. O., and Nnebue, C. C (2014). Assessment of the food hygiene practices of food handlers in the Federal Capital Territory of Nigeria. *Tropical Journal of Medical Research*, **17**(1), 10 - 15.int/water_sanitation_health/diseases/hepatitis/en/ (accessed 2014).

Janisiewicz, W. J., W.S. Conway, M. W. Brown, G.M. Sapers , P. Fratamico , and R. L. Buchanan (1999). Fate of Escherichia coli O157:H7 on fresh cut apple tissue and its potential for transmission by fruit flies. Applied and Environmental Microbiology **65**: 1 - 5

Jones, F. T., R. C. Axtell, D.V. Rives, S.E. Scheideler, F.R. Tarver, R.L. Walker, and M. J. Wineland (1991). A survey of Salmonella contamination in modern broiler production. *Journal of Food Protection* **54**: 502 - 507.

Kamboj, S., Gupta, N., Bandral, J. D., Gandotra, G. and Anjum, N. (2020). Food safety and hygiene: A review. *International Journal of Chemical Studies* **8**(2): 358-368.

Klowden, M.J. and Greenberg B. (1976). Salmonella in the American Cockroach: Evaluation of vector potential through dosed feeding experiments. Journal of Hygiene, Cambridge **77**: 105 - 111

Kopanic, R. J., Jr, Sheldon, B. W., and Wright, C. G. (1994). Cockroaches As Vectors of Salmonella: Laboratory and Field Trials. Journal of food protection, **57**(2), 125–135. https://doi.org/10.4315/0362-028X-57.2.125

Krauss H, Weber A, Appel M, Enders B, Isenburg HD, *et al*. (2003) Zoonoses: infectious diseases transmissible from animals to humans. Washington DC, ASM Press, USA, pp. 214-215.

Lee, A.J., Thalayasingam, M., Lee, B.W. Food allergy in Asia: how does it compare? Asia Pac Allergy. 2013 Jan;**3**(1):3-14. https://doi.org/10.5415/apallergy.2013.3.1.3

Linnerberg, A. (2008) The allergic march in early childhood and beyond. Clin Exp allergy, **38**: 1419 – 1421.

Loven, J. (2010). Controlling rodents in commercial poultry facilities. Publ No. ADM-3-W. Purdue Cooperative Extension Service. West Lafayette, Indiana, USA.

Meerburg, B.G. Kijlstra, A. (2007). Role of rodents in transmission of Salmonella and Campylobacter. *Journal of Science Food Agriculture* **87**: 2774-2781.

Mensah, P., Mwamakamba, L., Mohamed, C., Nsue-Milang, D. (2012). Public health and food safety in the who African region. *Afr. J. Food Agric. Nutr. Dev*. **12**, 6317–6335. [Google Scholar]

Moravvej G, Hamidi K, Nourani L, Bannazade H (2015) Occurrence of ectoparasitic arthropods (Siphonaptera, Acarina, and Anoplura) on rodents of Khorasan Razavi Province, northeast of Iran. Asian Pacific *Journal of Tropical Diseases* **5**(9): 930-934..

Niggemann, B. (2008). Suggestions for a uniform terminology in allergology and pneumology. *Pediatr Allergy immunol* **19**:99-107.

Ntambwe M. (2016). Risk Factors and Outcomes of Food Poisoning in Africa, Significance, Prevention and Control of Food Related Diseases, Hussaini Anthony Makun, IntechOpen. Retrieved from https://www.intechopen.com/books/significance-prevention-and-control-of-food-related-diseases/risk-factors-and-outcomes-of-food-poisoning-in-africa. DOI: 10.5772/62274.

Nyatoti, V. N., Mtero, S. S., and Rukure, G. (1997). Pathogenic Escherichia coli in traditional African weaning foods. Food Control, **8**(1), 51-54.

Nyenje, M. E. and Ndip, R.N. (2013). The challenges of foodborne pathogens and antimicrobial chemotherapy: A global perspective. *African Journal of Microbiology Research* **7**(14):1158-1172.

Odeyemi, O. A. (2016). Public health implications of microbial food safety and foodborne diseases in developing countries. Food and Nutrition Research 60: 29819 – http://dx.doi.org/10.3402/fnr.v60.29819.

Odeyemi, O. A. and Bamidele, F. A. (2016). Harnessing the potentials of predictive microbiology in microbial food safety and quality research in Nigeria. Future Science OA **2**(1): FSO91- 93.

Odeyemi, O. A. and Sani, N. A. (2016). Antibiotic resistance and burden of foodborne diseases in developing countries. Future Science OA **2**(1): FSO139.

Ofuebe, J. I (2015). Food hygiene practices among food vendors in University of Nigeria, Nsukka Campus: Implication for consumer protection, *International Journal for Human Kinetics, Health and Education*, **1**(1), 92-98.

Oguntoyinbo, F. and Oni, O. (2004). Incidence and Characterization of Bacillus cereus Isolated from Traditional Fermented Meals in Nigeria. *Journal* of food protection. 67. 2805-8. 10.4315/0362-028X-67.12.2805.

Okeke, I.N., Adebayo, L., John, C., Filip, D., James, B., James, P.N. (2000). Heterogeneous Virulence of Enteroaggregative Escherichia coli Strains Isolated from Children in Southwest Nigeria, *The Journal of Infectious Diseases*, Volume 181, Issue 1, January, Pages 252–260, https://doi.org/10.1086/315204.

Oladoyinbo, C. A., Akinbule, O. O. and Awosika, I. A. (2015). Knowledge of food borne infection and food safety practices among local food handlers in Ijebu-Ode Local Government Area of Ogun State. *Journal of Public Health and Epidemiology* **7**(9):268-273.

Olsen, A. R. and Hammack, T. S. (2000). Isolation of *Salmonella spp.* from the Housefly, Musca domestica L., and the Dump fly, Hydrotaea aenescens (Wiedemann (Diptera: Muscidae), at caged-layer houses. *Journal of Food Protection* **63**: 958 - 960.

Onyeaka, Helen., Osmond, C.E, Ukpai, A.E, Queeneth, I.O., Job, A., Ogueri, N., and Joy, O.C., 2021. "Improving Food Safety Culture in Nigeria: A Review of Practical Issues" Foods 10, no. 8: 1878. https://doi.org/10.3390/foods10081878

Onyeneho, S. N. and Hedberg, C. W. (2013). An Assessment of Food Safety Needs of Restaurants in Owerri, Imo State, Nigeria. International Journal of Environmental Research and Public Health 10:3296-3309.

Pepple, N. (2017). Environment and Food Poisoning: Food Safety Knowledge and Practice among Food Vendors in Garki, Abuja – Nigeria. Journal of Health Education Research and Development **5**(1):1-4.

Peters, C.J. (2006). Emerging infections: lessons from the viral hemorrhagic fevers. Transaction of the American Clinical Climatology Association 117:189-197

Priest, F. G., and Goodfellow, M. (2000). Applied microbial systematics. Kluwer Academic Publishers. 479 pp.

Rajan, T.V. (2003). The gell-coombs classification of hypersensitivity reactions: a re-interpretation. Trends Immunol, **24**: 376-379.

Ryan K.J., Ray, C.G. (2004). Sherris medical microbiology: an introduction to infectious diseases, (4th edn). New york: McGraw-Hill, USA.S41–S50.

Sampson, H.A. (1999). Food Allergy. Part 1: Immunopathogenesis and Clinical disorders. *J allergy Clin Immunol*, **103**: 717-728.

Samuel, E. O, Chidiebere, F. U, and Ugochi, R.E. (2020). Foodborne Diseases and Intoxication in Nigeria: Prevalence of Escherichia coli 0157:H7, Salmonella, Shigella and Staphylococcus aureus. *Journal of Advances in Microbiology*, **20**(12), 84-94.

Savage, J.H., Matsui, E.C., Skripak, J.M. (2007). "The natural history of egg allergy". *J Allergy Clin Immunol*. 1**20** (6): 1413–1417.

Sharma, P., Garg, P., Kumar, P., Bhatia, S. K. and Kulshrestha, S. (2020). Microbial Fermentation and Its Role in Quality Improvement of Fermented Foods. Molecular Diversity Preservation International (MDPI) 6(106) doi:10.3390/fermentation6040106

Sicherer, M., Scott, H. (2006). Understanding and Managing Your Child's Food Allergy. Baltimore: Johns Hopkins University Press.

Sicherer, S. H., & Sampson, H. A. (2018). Food allergy: A review and update on epidemiology, pathogenesis, diagnosis, prevention, and management. *The Journal of allergy and clinical immunology*, **141**(1), 41–58. https://doi.org/10.1016/j.jaci.2017.11.003

Singh, S.P., M. S. Sethi, and V. D. Sharma (1980). The occurrence of Salmonellae in rodent, shrew, cockroach and ant. International Journal of Zoonoses **7**: 58 - 61.

Szyfres, B., Acha, P.N. (2003). Zoonoses and communicable diseases common to man and animals. Parasitic Zoonoses. Pan American Health Org, USA

Tabler, T., Farnell, M., Wells, J., Yakout, H., Liang, Y. (2014). Controlling rodents on the poultry farm. Mississippi State University, USA, pp. 7.

Tamang, J.P., Shin, D., Jung, S. and Chae, S. (2016). Functional Properties of Microorganisms in Fermented Foods. Frontiers in Microbiology 7(578) doi: 10.3389/fmicb.2016.00578.

Tetteh, G. L., Sefa-Dedeh, S. K., Phillips, R.D., Beuchat, L.R. (2004). Survival and growth of acid adapted and unadapted *Shigella flexneri* in a traditional fermented Ghanaian weaning food as traditional fermented meals in Nigeria. J. Food Protect. *67*, 2805–2808.

Urban, J.E., and Broce, A. (1998). Flies and their bacterial loads in greyhound dog kennels in Kansas. Current Microbiology **36**: 164 - 170 .

WHO, (2006). Five Keys to Safer Food. The WHO Department and Food Safety, Zoonoses and Foodborne Diseases.

World bank. (2018). The Safe Food Imperative: Accelerating Progress in Low and Middle-Income Countries. Retrieved from https://www.worldbank.org/en/topic/agriculture/publication/the-safe-food-imperative-accelerating-progress-in-low-and-middle-income-countries

World Health Organisation, 2015.

World Health Organization, 2001. Water Sanitation Health. Prepared for World Water Day. http://www.who.

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