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Foodborne Diseases and Intoxication in Nigeria: Prevalence of *Escherichia coli* 0157:H7, *Salmonella, Shigella* and *Staphylococcus aureus*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The prevalence of foodborne diseases in Nigeria is alarming despite efforts by Government and Non-governmental Organizations to prevent the spread of foodborne pathogens. Health and socio-economic implications of foodborne diseases are enormous, including loss of productivity and low quality of life. In Nigeria, most people eat food at least once outside their homes every day. Food is an indispensable basic need of all humans and animals to sustain a healthy, reproductive and productive life. Humans are very active and highly productive when they consume safe food and are in a state of good health; however, consuming food already contaminated with microbial pathogens or its products such as *Escherichia coli* 0157:H7, *Salmonella* spp., *Shigella* spp., *Clostridium spp., Campylobacter spp.,* and *Staphylococcus aureus*-toxin to a harmful level can cause severe illnesses and even progress to death. Therefore, it is essential for food handlers and vendors to maintain proper personal hygiene, undergo regular health checks, constantly improve environmental sanitation and adequately prepare food to prevent the spread of foodborne diseases. Consumers of ready-to-eat foods and food products should consider the overall safety of the food; environment where the food was prepared, where and how the food is distributed in order to mitigate likely foodborne infections and diseases. Water used in preparing food and watering animals should be clean and safe.

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1. INTRODUCTION

The quality of food available and ready for consumption directly impacts the quality of life obtainable in any given society. Improved health and higher productivity is achievable in the absence of disease including foodborne illnesses. Food is one of the most essential and indispensable basic needs of humans required for nourishment and sustainability of life. Safe food is important and foundational for a healthy, productive and reproductive life. Lack of access to safe food causes a destructive cycle of disease precisely affecting people with ill-health, children, and the elderly [1]. Since the existence of man, foodborne diseases have been a critical challenge for all nations and people of the world [2]. According to the World Health Organization (WHO) report, 550 million people become ill and 230 000 die yearly due to diarrhoeal diseases associated with the ingestion of foods already contaminated by microbial pathogens [1]. In another report by World Bank [3], the overall productivity loss linked to foodborne diseases in developing countries is estimated to cost $95.2 billion annually, and the amount spent in treating foodborne illnesses per year is estimated at $15 billion. According to the report, the highest occurrence of foodborne diseases is in Asia and sub-Saharan Africa when compared to the rest of the world.

Nigeria, being the most populated country in sub-Saharan Africa is currently faced with foodborne disease problem usually not reported except in cases of outbreaks. In January, 2018, the Nigerian Centre for Disease Control (NCDC), was alerted of a botulism outbreak linked to food consumption in Abuja [4]. Foodborne pathogens of public health importance such as *Escherichia coli* 0157:H7, *Salmonella, Shigella*, *Staphylococcus aureus* and *Clostridium* spp. have been isolated from fresh-cut ready to eat fruits, vegetables and ready-to-eat foods sold on the streets, markets, schools, major cities and fast-food restaurants in Nigeria [5,6,7,8,9]. Food handlers and or peddlers have been implicated as sources of pathogens' contamination of foods by [10]. Moreso, *Campylobacter* spp. has been detected in water used in poultry in Abia State and on the body of healthy goats reared in Sokoto State [11,12]. Due to poverty endemic in this region, scarcity and ignorance, many people ingest any available food that satisfy their hunger and or quench their thirst. Safer food is paramount for general well-being and socio-economic growth.

The aim of this current review was to evaluate what has been published in literature; the prevalence of foodborne pathogens, routes of transmission and contamination of foods. Articles downloaded and evaluated were sourced from Google Scholar and few from Research Gate using phrases like foodborne diseases and Nigeria, foodborne pathogens and Nigeria etc. High preference was given to more recent articles and articles without detailed research methods as well as clear result discussion were not considered for evaluation. The main objective remains to help prevent the contamination of foods by microbial pathogens and the subsequent diseases. Table 1, shows microorganisms isolated from ready-to-eat foods and other food products in Nigeria.

2. PREVALENCE OF SELECTED FOODBORNE PATHOGENS

2.1 *Escherichia coli* 0157:H7

E. coli 0157:H7 is a pathogenic strain of *Escherichia coli*. *E. coli* is a Gram-negative bacterium, non-spore-forming, facultatively anaerobic rods of family Enterobacteriaceae[28]. Most *E. coli* strains live in the gut of humans and other warm-blooded animals without causing any harm; however, some strains such as enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC), enteroinvasive *E. coli* (EIEC) and enterohaemorrhagic *E. coli* (EHEC) or verocytotoxin-producing *E. coli* (VTEC) may cause disease [2]. Ingesting contaminated foods and water are the major modes of transmission of the organism. Excretion of the pathogen can lead to person-to-person transmission. Symptoms of infection include vomiting, diarrhoea, abdominal pain, fever, haemorrhagic colitis, dehydration and shock [2]. *E. coli* infections, particularly enterohaemorrhagic *E. coli* (EHEC), of which the most commonly recognized is *E. coli* 0157, can result in life-threatening complications such as haemolytic uraemic syndrome characterized by acute renal failure, thrombocytopenia and haemolytic anaemia [28,2]. Several studies in Nigeria have isolated *E. coli* 0157:H7 and other *E. coli* strains from fresh foods, ready-to-eat foods, locally fermented drinks, and many food products. A study by [29] on the incidence and antibiotics susceptibility of *E. coli* 0157:H7 from beef in Ibadan municipal,

Table 1. Microorganisms isolated from Ready-To-Eat foods and other food products in Nigeria

S/N	Food	Microorganisms Isolated	References
1	Beef, fish, soup and chicken.	*Escherichia coli* 0157:H7, *Staphylococcus aureus*, *Salmonella* spp., *E. coli*.	[13,14,15]
2	Healthy goats	*Campylobacter* spp.	[12]
3	Edible land snail, seafood, eggs and vegetables.	*Salmonella* spp., *Vibrio* spp., *E. coli*, *Staphyloc- occus aureus*, *Streptococcus*, *Cryptosporidium* oocysts, *Shigella* spp., Corynebacteria.	[16,17,18,19]
4	Rice, beans, fufu, masa, agidi, fresh and frozen shrimps, moin moin, yam, meat, epiti, and shawarma.	*E. coli*, *Staphylococcus aureus*, *Bacillus cereus*, *Shigella* spp., *Mucor* spp., *Campylobacter*, *Klebsiella* spp., *Enterobacter aerogens*, *Proteus* spp., *Micrococcus* spp., *Clostridium perfringens*, *Aspergillus* spp., *Pseudomonas* spp.	[7,20,21,22,23,24]
5	Watermelon, kunun-zaki and zobo drinks, fermented milk, okpa, pealed orange, egg roll, apple, plantain chips, aki-na-ukwa, doughnut, meat pie, cashew nut.	*E. coli*, *Mucor* spp., *Staphylococcus aureus*, *Proteus mirabilis*, Yeast, *Salmonella* spp., *Enterobacter* spp., *Pseudomonas*, *Klebsiella pneumonia*, *Penicillium* spp., *Acinetobacter* spp., Streptococci.	[5,25,26,27]

isolated 116 non-sorbitol fermenting *E. coli*, 71 were confirmed as *E. coli* 0157:H7. The meat samples were cultured on sorbitol MacConkey agar and confirmation was done by serological agglutination kits. They reported that all the isolates were found to resist one or multiple antibiotics, giving rise to 8 distinct resistance patterns. In another study by [13] on the multidrug resistant *E. coli* 0157:H7 contamination of beef and chicken in abattoirs of Southwest Nigeria, out of the 800 meat samples obtained for experimental analyses, the overall prevalence of *E. coli* 0157:H7 was reported to be 17.1%(19.8% and 14.5% of beef and chicken). Comparing the levels of contamination of the samples obtained from different locations, the prevalence of *E. coli* 0157:H7 in beef from Ibadan-Lagos were 28.5% and 11.0%, that of chicken from Ibadan-Lagos markets were 13.0% and 14% while those from Ibadan and Lagos farms were 18.0% and 13.0% respectively. In their study, [26] reported the presence of *E. coli* 0157:H7 in Nigerian fermented milk samples collected in Nasarawa State, Nigeria. From the 420 locally made milk samples examined, 19 which represents 4.5% were unsafe due to the contamination with *Escherichia coli* 0157:H7; highest incidence rate(5.7%) was recorded in samples collected from Wamba, Akwanga, and Doma Local Government Areas while 2.9% was from Lafia and Keffi areas. The authors employed cultural techniques, biochemical and serological assays in carrying out the investigation. Oxoid diagnostic kit; latex(R30959601) was used in the confirmation of the presence of *E. coli* 0157:H7. Water used in preparing food, herding and irrigation may be contaminated with this organism. According to [30], *E. coli* 0157:H7 was isolated from River Kaduna, Nigeria, which was a main source of water used for drinking, irrigation and herd watering. Of the 204 water samples taken and analyzed, a total of 59 *E. coli* isolates were found, out of which 15 isolates representing 25.4% were of serotype 0157:H7. They stated that the occurrence of *E. coli* 0157:H7 in all the screened water samples was calculated to be 7.4%. In examining raw bovine meat in households across Cross River State, Nigeria, [31] recorded 76 *E. coli* 0157:H7 isolates from 360 tested samples; representing 21.11% prevalence rate. The authors used standard cultural and serological methods to identify and confirm the presence of the organisms. In an extensive research by [32] on the occurrence of *E. coli* 0157:H7 in selected food samples sold in local markets in Nigeria, it is of a huge concern that 36(60%) *E. coli* 0157:H7 were isolated from 60 different food samples examined; 3 each of meat pie, yoghurt, watermelon, groundnuts, cabbage, cucumber, garden egg, bread, chicken, apple, salad, unpasteurized milk and pawpaw. This result indicates that public health is not secure in consuming these contaminated foods.

In a separate study, [33] reported the prevalence and antibiotics resistance of *E. coli* 0157:H7 serotype from chicken droppings in Cross River State, Nigeria. Of the 360 cloacal swap samples (360 from free-ranged chicken and poultry birds), 24(6.6%) *E. coli* 0157:H7 were isolated from free ranged chicken while 7(1.94%) were isolated from poultry. All the isolates were found to be resistant to at least one antibiotic tested for antimicrobial susceptibility. In Lagos, Nigeria, [34] isolated microbial pathogens including *E. coli* from vended foods. 12 food samples were randomly collected from 10 locations within Lagos environments. The food samples aseptically obtained were Amala, Eba, Jollof rice, Fried rice, Beans, Dodo, Moi moi, Fried fish, Ewedu and Salad. In assessing the bacteriological content of the samples, the authors blended the food samples separately and 10 gram of each sample was introduced into 90ml of sterilized physiological saline, homogenized and serially diluted. It was then inoculated into MacConkey agar, Nutrient agar, and *Salmonella-Shigella* agar. The viable colonies were enumerated after 18-36 hours incubation at 37°C. Subcultures were made on Eosin methylene blue agar and MacConkey agar for the isolation of *E. coli* and *Enterobacter aerogenes*. Morphological and biochemical characteristics were employed for the identification of *E. coli* and other isolates. In Port Harcourt City, Nigeria, [24] examined the microbiological composition of ready-to-eat-food(Shawarma) purchased in the city. The 12 samples collected were serially diluted and plated out on Nutrient agar, MacConkey agar, *Salmonella-Shigella* agar, Sabouraud 4% Dextrose agar, Mannitol Salt agar, Buffered Peptone water, Triple Sugar Iron(TSI) agar and Kovac's Indole reagent using the spread plate method. The inoculated plates were incubated for 24 hours at 37°C in the incubator. The authors reported a predominant presence of bacterial pathogens(84.6%), out of which *E. coli* (13.6%) was the second most occuring genera of the pathogenic bacteria isolated after *Proteus* spp(22.7%). Another research work, [15] determined the bacteriological quality and safety of street vended foods in Delta State, Nigeria using scientific experimental procedures. A total of 106 street peddled food samples were screened for bacterial contamination. The food samples were fried meat, fried fish, bean porridge, banga soup, owho soup, egusi soup, fufu, starch, eba, stew, jollof rice and plain rice. The towns where the samples were collected were Agbor, Asaba, Obiaruku, Abraka, Sapele, Ugheli, Warri, Oleh and Patani; all in Delta State. The samples were bacteriologically screened using standard laboratory and microbiological methods. The researcher found that 69% of the food samples contain bacteria count beyond the recommended limits, while 67% of the sampled foods had total coliform count above the recommended safe level(<100 coliform/g). *E. coli* was among the 9 bacterial species found in the food samples. Retail fresh-cut ready-to-eat fruits in Southwestern Nigeria as well as fruits and vegetables sold in Kaduna metropolis have been found to be contaminated with *E. coli* [9,35]. Bacteriological and mycological quality of some ready-to-eat foods available for sale in Kaduna State University market, Kaduna, Nigeria, were assessed by [36]. The authors assembled a total of 160 ready-to-eat food samples which include yam, rice, beans, and waina(rice cake). The samples were collected from 12 food vending sites which served as the major food centres to the student community. Pour plate method was used for the isolation of bacteria on different media and the fungi on Potato Dextrose Agar. The authors characterized and identified the isolates using standard techniques. Although, some of the food samples were found to meet up the proposed microbiological limits in relation to the specifications by International Commission for Microbiological Specification for Foods(ICMSF), waina had microbial contamination (30%) of the isolates of which *E. coli* was predominant.

2.2 *Salmonella* spp.

This is a Gram-negative bacterium, mesophilic, facultatively anaerobic, non-spore-forming rod and motile. *Salmonella* can survive for long times in the environment [28]. The principal symptoms include fever, headache, nausea, vomiting, abdominal pain and diarrhoea. Transmission is often by ingestion of the organisms in food gotten from infected food animals [2]. Food can be contaminated by infected food handlers, cross-contamination can occur as a result of poor hygiene and person-to-person transmission may also occur during the course of the infection. Sequelae caused include reactive arthritis, septicaemia, colitis, meningitis, osteomyelitis, pancreatitis and rheumatoid syndrome [2]. Poultry, cattle, pigs, pets such as tortoise, dogs and cats are major reservoirs or sources. Humans are carriers as well. Salmonellosis is the disease condition caused by *Salmonella*. They often contaminate eggs and poultry. Research results have shown the isolation of *Salmonella*

spp from food samples in Nigeria; frozen seafoods, edible land snails, locally fermented drinks, and ready-to-eat foods such as eba, amala, moi moi, fried rice, beans, jollof rice, fried fish and salad purchased from food vendors across the country [16,25,15,22,34]. Mobile food vendors are common in Nigeria and they usually push their ready-to-eat foods along the streets, homes, schools, industrial sites and round the markets. People especially the young population highly patronize them without questioning the hygiene of the food peddlers and the overall safety of the food. Eateries or fast-food restaurants are prevalent and people go there to eat at will; many do not believe or know that served food can be a potential source of pathogen's infection and subsequent diseases. In their study on the occurrence of multi-drug resistant *Salmonella* in carcass and contact surfaces in Kwata slaughterhouse, Awka, Anambra State, Nigeria, [37] isolated 67 *Salmonella* spp from 200 swab samples examined. The prevalence of *Salmonella* was calculated to be 33.5% and out of the 67 isolates, 25.4% was resistant to Ciprofloxacin; 27% to ofloxacin; 35.8% to ceftriaxone; 88.1% to amoxicillin/claxulanic acid; 59.7% to chloramphenicol; 34.3% to gentamicin; 49.3% to streptomycin and nalidixic acid; 76% to trimethoprim/sulfamethoxazole; 89.6% to nitrofurantoim and 100% to ampicillin. The study performed by [10] on the microbiological safety of food peddlers in Wudil LGA of Kano State, isolated 200 non-duplicate bacteria from 200 hand-swab samples screened. Out of the 200 bacterial isolates, 60(30%) were *Salmonella typhi* and 52(26%) were *Salmonella choleraesuis*. The food handlers examined were 100(50%) male food handlers and 100(50%) female food vendors, most of which were children (33.3%) within the age range of 8-12 years. 96.5% of the food peddlers that were assessed exhibited poor levels of personal hygiene and lack the knowledge of safe food handling practices. The authors were of the opinion that the prevalence of these pathogens can be associated with the low literacy levels and lack of safe food handling culture among the peddlers. They further suggested that food handlers should be trained on how to hygienically handle food, practice adequate hand hygiene, and periodically undergo health checks. A detailed study by [11] examined the prevalence and antimicrobial susceptibility profile of bacterial pathogens isolated in selected poultry farms in Umuahia, Abia State Nigeria. The authors isolated a total of 92 bacterial pathogens, out of which were 26 *Salmonella* spp. The *Salmonella* isolates showed 100% resistance to cefuroxime, ceftazidime, cefixime, erythromycin, cotrimoxazole, streptomycin and tetracycline. 50% of the 26 isolates were susceptible to gentamycin, 76.9% to ofloxacin, 76.9% to ciprofloxacin and 73.1% to nitrofurantoin. Their result finding showed that poultry products can be potential vehicle for the transmission of antibiotic-resistant foodborne pathogens to humans and can possibly lead to diseases or outbreaks. Another recently published research paper by [38] investigated the prevalence of *Salmonella* in commercial poultry farms in Nigeria and further identified the serotypes based on whole genome sequence. The researchers examined 558 pooled socks and dust samples from 165 poultry farms in Northwest Nigeria established for commercial purposes. The required information on farm management practices to ascertain risk factors for *Salmonella* prevalence were gotten through questionnaires. Culture, biotyping, serology, and polymerase chain reaction (PCR) were employed to identify *Salmonella*. This study reported 47.9% farm prevalence for *Salmonella* and 15.9% sample level prevalence. A total of 23 different serotypes were identified; *Salmonella* Kentucky, and *Salmonella* Isangi been the most prevalent (32.9% and 11%). The occurrence of *Salmonella* in edible frogs (*Hoplobatrachus* spp) obtained from Hanwa frog market Zaria, Nigeria, was investigated by [39]. A large percentage of Nigerians in all the geopolitical zones consider frog a rich delicacy because it is rich in protein. [39] Examined the presence of *Salmonella* in the intestinal contents of the 202 frogs collected for testing. Of the 202 samples, 22(10.9%) *Salmonella* spp were isolated and the prevalence was high in frogs obtained from Tudun Wada (20%) and least in Katsina(8.5%). In an outbreak of Salmonellosis in Southwestern Nigeria, [40] isolated *Salmonella* serotypes from visceral organs of post-mortem chickens. The researchers examined the tissue samples of the heart, liver, lungs, kidneys, spleen, small intestine, proventriculus, caecum and bile of the chickens submitted for postmortem examination. The *Salmonella* spp isolated and confirmed using Polymerase Chain Reaction (PCR) were serotyped using the White-Kauffmann-Le Minor Scheme; disc diffusion method was used to assess susceptibility profiles of the isolates. Of the 324 samples examined(270 from 30 commercial poultry farms, and 54 from 6 backyard farms), the *Salmonella* serotypes identified were *Salmonella* Zega, *S*. Kentucky, *S*. Nima, *S*. Tshiongwe, *S*. Telelkebir, *S*. Herston,

and *S*. Colindale. They were 100% sensitive to ciprofloxacin, gentamycin, enrolfloxacin, ofloxacin, and pefloxacin. They showed 100% resistance to ampicillin, penicillin, erythromycin, and co-trimoxazol. Considering the findings of the researchers, the emerging bacterial pathogens are fast becoming resistant to multi-drugs and can become potential danger to public health. Analyses of the microbiological content of ready-to-eat(RTE) foods in Nigeria have revealed the presence of *Salmonella* spp in those foods. According to [41], *Salmonella* spp were found in ready-to-eat foods(meat pie, roasted groundnut, doughnut, fried fish) bought from food vendors in mobile outlet catering units in Nigeria. Similarly, [42] reported the contamination of fish with *Salmonella* spp in 64 samples of smoked fish sold in Ibadan which were screened by the authors. The authors asserted that fish species which were been sold in Ibadan markets are not fit for human use. Moreso, 200 food samples were examined by [43] for the presence of *Salmonella* spp. The food samples examined include 50 cooked meat, 50 raw meat, 50 meat products and 50 cooked spoilt meat. The authors used REVEAL serology kit, culture methods and PCR method for detection of *Salmonella* spp from the sampled foods. 74% of the food samples were positive for *Salmonella* spp using REVEAL serology kit, 19% for culture methods and 62% and 54% for PCR methods (primer set salm¾ and STII/ STI5).

2.3 *Staphylococcus aureus*

S. *aureus* is one of the important foodborne pathogens well-known to cause foodborne intoxication. *S*. *aureus* is a Gram-positive bacterium, non-spore-forming, non-motile, and facultatively anaerobic coccus. Heat-stable toxin is often produced by some *S*. *aureus* strains when they infect food and the ingestion of such toxin-contaminated food is a major cause of intoxication; often of abrupt and violent onset [2]. Severe nausea, cramps, vomiting and prostration follow. Diarrhoea may also occur. The major disease condition is toxin-mediated gastroenteritis. Humans are the major reservoirs and source of contamination of food [2]. In a well researched work by [44] to detect the presence of enteric viruses of gastroenteritis and bacterial species from *Eidolon helvum* bat species in Ondo State, Nigeria, two species of *Staphylococcus; S*. *aureus* and *S*. *epidermidis* were isolated from 25 samples of faecal droppings of the bats examined. Bats are hunted and eating by some communities in Nigeria. The authors isolated the bacterial species by pour plate method, and used standard microbiological methods and API kits to identify the isolates. In assessing food handlers in Kano State(Wudil LGA), Nigeria, [10] isolated 40(20%) *S*. *aureus* from 200 hand-swab samples collected from 200(100 male and 100 female) food peddlers in the sample location. The finding clearly indicates that some of the food vendors are carriers and potential agents of *S*. *aureus* transmission and contamination of foods. It further indicates that the food sold may have been contaminated with *S*. *aureus* or its toxin. In assessing the microbial composition of ready-to-eat food and food contact surfaces in restaurants in Okada, South-South Nigeria, [8] isolated species of *Enterobacter*, *Streptococcus*, *Micrococcus*, *Bacillus*, *Saccharomyces* and *S*. *aureus*. The composition of *S*. *aureus* was found to be unacceptable in the tested food samples consumed in the restaurants. The authors opined that the food served to consumers at the restaurants assessed were not of acceptable microbiological quality. Hence, food consumed in those restaurants can lead to intoxication and or foodborne disease. Estimating the bacterial load of fried rice prepared in some restaurants in Abraka, Delta State, [45] found the presence of *S*. *aureus* in the food samples screened which were obtained from 5 different restaurants in the study area. The author used the cultural and morphological characteristics and biochemical tests to identify the bacterial isolates. Study by [46] evaluated the bacteriological composition of smoked rabbit meat sold along Lagos-Benin Expressway and found that *S*. *aureus* had the highest percentage occurrence of 30.3%; however, the authors suggested that the rabbit meats were of satisfactory bacteriological quality. Branded retail ice cream products in Lagos metropolis, Southwest Nigeria, were assessed by [47] for its microbiological quality. The researchers examined 6 different ice cream brands purchased from vendors in Lagos metropolis; they isolated 5 prominent bacteria species which include *Klebsiella*, Bacillus, *Escherichia coli*, *Enterobacter* and *S*. *aureus*. Surprisingly, *S*. *aureus* had the highest percentage prevalence of 100% followed by *Klebsiella* spp., 66%, *Bacillus* spp., 66%, and *E*. *coli* 50%. The findings suggest that the ice cream products are already contaminated and consumption will lead to infection with foodborne pathogens or its products. The authors suggested proper education of the hawkers and adoption of standard hygiene cultures. Processed garri has been implicated as a source

of bacterial hazards to students by preliminary studies carried out by [48]. According to results from questionnaires administered to the students, 54% of the University students agreed that they had experienced symptoms of ill health after eating garri that was soaked in water; they reported stomach upset, malaise, fever, nausea, and vomiting. The researchers aseptically collected 50 samples of processed garri ready to be sold in Agbani; a suburb in Enugu State, for bacteriological analysis. The outcome of the analysis indicates that 60% of the samples obtained were contaminated with *S. aureus*. Further tests carried out by the authors confirmed that the isolates were positive for haemolysin and biofilm formation which points to its pathogenic abilities. Meat pie sold in a Nigerian North Central town (Markudi) had been screened for contamination with *E. coli* and *S. aureus* by [49]. The antibiotics susceptibility patterns of the isolates were determined; result showed that the occurrence of *S. aureus* was 38.9% from 180 samples. The isolates showed 87.1% resistance to cloxacillin and 88.6% susceptibility to ofloxacin. The scholars advocated a regulation of meat pie production in order to reduce contamination and prevent the transmission of antibiotic-resistant researchers were surprised to record 30.2% occurrence of *Staphylococcus* spp., from 3 live catfish collected for 6 months for assessment. The *Staphylococcus* spp., isolates were highly susceptible to antibiotics tested. Lack of proper environmental sanitation and unhygienic culture of food handling are possible channels of pathogen transmission [50]. Locally produced non-alcoholic beverage drinks particularly kunun-zaki and sobo have been identified for its microbiological safety by [25]. They reported a higher prevalence of *Staphylococci* spp., in 150 kunun-zaki samples and 100 sobo samples analyzed for for microbial contamination. Amazingly, these beverage drinks are highly consumed in Nigeria daily by all class of citizens. A scholarly research by [21], on the incidence of antibiotic resistant *S. aureus* in some street vended foods in Ogun State, reported a prevalence of 0-40% in the 140 street-vended food samples screened. The *S. aureus* isolates displayed 45.8% resistance to gentamycin and lowest to contrimoxazole(4.2%) and another 4.2% to erythromycin. Food handlers should always practice proper personal hygiene during bacterial pathogens to consumers. Catfish (*Clarias gariepinus*) harvested from river Lavun, Bida Niger State, had been examined by [51]. The preparation and distribution of foods to protect public health.

2.4 *Shigella* spp.

Shigella is a non-motile, non-spore-forming, Gram-negative bacterium and facultatively anaerobic rods. Shigellosis is a public health challenge of importance. The mode of transmission is usually faecal-contaminated food and water. An important route also includes person-to-person transmission through faecal-oral route [2]. Food handlers with poor personal hygiene have been proven to be essential vehicles of transmission and food contamination. *Shigella* infects animals especially poultry birds and chickens. Diseases of livestock leading to high morbidity and mortality have been associated with *Shigella* infection [28]. Major symptoms include abdominal pain, vomiting, fever, diarrhoea, mucus and pus. Disease conditions caused include haemolytic uraemic syndrome, erythema nodosum and splenic abscesses [2]. Some food poisoning and bloody diarrhoea in humans have been linked to *Shigella* infection [52]. Investigating the occurrence and antibiogram of *Shigella* spp in free range and intensivey reared chickens in Nsukka, Enugu State, Nigeria [53] screened 300 cloacal swabs obtained from 150 free range and 150 intensively reared chickens in the area. The authors using standard microbiological and biochemical methods isolated 10(3.3%) shigellae from the 300 samples experimentally analyzed. The prevalence in free range was 6.7% while that of intensively reared chicken was 0%. The *Shigella* spp were found to be sensitive to ciprofloxacin(100%), gentamicin(70%), ofloxacin(70%), tetracycline (70%) and 60% to nalidixic acid and cotrimoxazole. They were completely resistant to amoxicillin (100%) and augmentin (100%). Determining the bacteriological and mycological quality of some ready-to-eat foods in Kaduna State University market, [36] isolated *Shigella* spp., from the samples that were collected. Although, the occurrence was least compared to other microorganisms isolated, it is possible to constitute a health problem to individuals with compromised immunity. In a full length research paper, [11] found that some poultry farms in Umuahia metropolis, Abia State, were contaminated with *Shigella* spp. The scholars isolated 92 bacterial pathogens of which 13 were *Shigella* spp. Also, [54] isolated *Shigella* spp from fermented indigenous food condiments collected from middle-belt and Southwestern Nigeria. *Shigella* dysenteriae was found to be 168(4.7%), *Shigella flexneri* was 60(1.7%) and *Shigella sonnei* (39[1.1%]). Food and water consumed by humans and those served to

livestock should be properly handled to prevent *Shigella* contamination and prevent disease and possible outbreak.

3. PREVENTION AND CONTROL

One of the proactive steps and valuable measures in mitigating the spread of foodborne illnesses is by starting to addressing the major contributing factors to the wide occurrence of foodborne pathogens in food. The factors actively promoting the prevalence of foodborne pathogens in Nigeria include low literacy levels of some of the food handlers or vendors, lack of personal and general hygiene, poor environmental sanitation, use of contaminated water in food preparation and preservation, and ineffective surveillance and monitoring on the side of agencies and or policy makers saddled with the responsibility of ensuring food security and safety. Public health is threatened when what is consumed is not adequately screened and regulated. Food industries and handlers should implement Hazard Analysis Critical Control Point(HACCP) during food preparation, packaging and distribution [28]. This helps to identify the potential sources of food contaminants and how to prevent it. Everyone is actively involved in the fight against foodborne diseases. The contamination of food by foodborne pathogens and the subsequent metabolic activities should be prevented to preserve the quality of food and secure public health safety. Stringent preventive measures such as handwashing, proper personal and general hygiene [55] and environmental sanitation should be observed and regularly practiced to stop the transmission of foodborne pathogens and subsequent diseases. Sanitary measures and surveillance of food handlers and water supplies are control strategies to mitigate the spread of foodborne pathogens [28]. Food should be adequately prepared before consumption to ensure the presence of no pathogen. Water used for cooking food as well as wash utensils, knives, cutting boards, tables used in sampling food substances and watering animals should be clean and safe. Cooked food should not be exposed for long and fresh foods require washing well with clean and safe water before ingestion.

4. CONCLUSION

The consumption of food contaminated with pathogens is the major cause of foodborne diseases in Nigeria. The presence of two or more pathogenic organisms in one ready-to-eat food sample calls for urgent public health awareness on the health risks or hazards associated with the consumption of pathogen-contaminated food. The prevalence of foodborne pathogens in Nigerian ready-to-eat foods and fresh-cut ready to eat fruits indicate poor levels of personal hygiene and environmental sanitation on the side of the food handlers and fruit vendors. Hygiene practices should not be neglected during and after food preparation. Infected poultry products such as eggs, farm animals and contaminated water used in preparing food and watering farm animals can be potential sources of pathogens' transmission and contamination of food. It is essential to practice adequate hand-hygiene during and after contact with domestic or farm animals including its products. Undercooked food may still contain foodborne pathogens and consumption can cause illnesses or lead to outbreaks. Moreso, some of the research papers evaluated were not able to identify the specific serotypes or strains of pathogenic organisms isolated from the examined food samples; it is hoped that future research works would solve the problem.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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