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ASSESSMENT OF FOOD QUALITY AND SAFETY LEVELS OF SOME SELECTED READY-TO-EAT FOODS SOLD IN OPEN AND SUPER-MARKETS IN KANO, NIGERIA.

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ABSTRACT

Food safety remains a critical concern for human health and national development, particularly in postharvest handling practices, including processing and storage. This study evaluated the safety and quality of dried and ready-to-eat (RTE) foods—roasted groundnuts, smoked dried fish, and cassava grit (garri)—collected from two open markets and two supermarkets in Nigeria. The samples were analyzed for total aflatoxin, polycyclic aromatic hydrocarbons (PAHs), and hydrogen cyanide using High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), and spectrophotometric methods, respectively. Data were subjected to statistical analysis, with mean differences compared at a 5% probability level. foodborne pathogens of significant concern were isolated; however, Enterobacter aerogenes was the predominant microorganism in samples from open markets. Total aflatoxin levels in groundnuts varied significantly ($p < 0.05$) between markets, ranging from 39.53 to 104.92 µg/kg in open markets and 11.93 to 53.02 µg/kg in supermarkets. Aflatoxin B1 (AFB1) accounted for 91% of the total aflatoxin levels. While the mean aflatoxin concentrations in open market samples exceeded both the European Union (4 µg/kg) and Codex Alimentarius (15 µg/kg) standards, 75% of supermarket samples fell within the permissible limits. Among the 24 PAHs recommended for monitoring by the European Union and the US Environmental Protection Agency, benzo[a]pyrene was detected at the highest concentrations (26.28 µg/kg and 20.19 µg/kg) in BT-1 and SH-1 samples, respectively. Despite fewer PAHs being detected in BT-1, it recorded the highest total PAH concentration (204.42 µg/kg). Significant differences ($p < 0.05$) in PAH levels were observed between markets, except for BT-1 and BT-2. The hydrogen cyanide content in garri ranged from 0.0428 to 0.0811 mg HCN/10g (4.28 to 8.11 ppm), well below the WHO lethal concentration (LC50) threshold of ≥10 ppm. No insect activity or presence was observed in any of the samples. These findings underscore the need for improved processing, packaging, and storage practices to enhance the safety and quality of RTE foods. This study highlights critical research gaps and emphasizes the importance of policy interventions to address food safety challenges in Nigeria.

INTRODUCTION

Ready-to-eat (RTE) foods are a category of food products designed for direct human consumption without the need for further cooking or processing to eliminate or reduce microbial hazards to acceptable levels (Regulation (EC) No. 2073/2005). These foods are typically pre-cleaned, precooked, and packaged, offering convenience to consumers while maintaining nutritional value (Huang, 2012). RTE foods can be either traditionally or industrially processed, packaged or unpackaged, and are often integral to communities' cultural heritage and cuisine, passed down through generations (Kraig & Taylor, 2013). In Nigeria, for instance, popular RTE delicacies such as *kulikuli*, smoked fish, roasted groundnuts, *suya*, and *kilishi* are deeply embedded in the local food culture.

Despite their cultural significance and convenience, RTE foods are particularly vulnerable to contamination due to improper handling, packaging, and processing practices. In low- and middle-income countries (LMICs), including Nigeria, many RTE vendors operating in open markets or supermarkets—often lack adequate knowledge of good hygiene practices, increasing the risk of microbial contamination (Al Mamun et al., 2013; WHO, 2010). The situation is exacerbated by the common practice of vending RTEs in open environments, where they are exposed to air, aerosols, insects, rodents, and other sources of contamination. Additionally, improper packaging and storage can lead to the oxidation of inherent nutrients such as lipids and proteins, compromising the quality and shelf life of these products (Makinde et al., 2020).

Microbial contaminants commonly associated with RTEs include bacteria (*Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*), fungi (*Aspergillus*, *Alternaria*, *Fusarium*, *Penicillium*), parasites (*Ascaris lumbricoides*, *Toxoplasma gondii*), and viruses (e.g., hepatitis A virus). These microorganisms not only pose direct health risks but can also produce toxic metabolites such as cereulide (Ceuppens et al., 2011) and mycotoxins (IARC, 2015), which are linked to severe health outcomes, including cancer and neural tube defects. Non-microbial contaminants, such as heavy metals, pesticide residues, and polycyclic aromatic hydrocarbons (PAHs), further compound the risks associated with RTE consumption. Chronic exposure to these contaminants through contaminated RTEs can lead to a range of adverse health effects, from mild gastrointestinal symptoms to life-threatening conditions (Gibb et al., 2015).

Globally, food safety remains a critical public health concern. According to the Food and Agriculture Organization (FAO, 2019), over 420,000 people die annually, and nearly 600 million fall ill due to foodborne diseases. Despite the widespread belief that supermarket-vended foods are safer and of higher quality than those sold in open markets, emerging evidence challenges this assumption, highlighting the need for rigorous assessment of food safety practices across all vending platforms. In Nigeria, where regulatory oversight and compliance monitoring are often inadequate, the risks associated with improperly prepared and handled RTEs are particularly pronounced.

To address these challenges, the Nigerian Stored Products Research Institute (NSPRI), in line with its mandate to ensure food safety, has initiated an assessment of the quality and safety of dried and RTE foods commonly consumed in Nigeria. This study focuses on three widely consumed RTEs—roasted groundnuts, smoked dried fish, and cassava grit (*garri*)—sampled from both open markets and supermarkets in Kano City, Nigeria. By evaluating the levels of key contaminants and assessing handling practices, this research aims to provide critical

insights into the safety and quality of these products, contributing to the development of evidence-based interventions to mitigate foodborne risks in Nigeria.

MATERIALS AND METHODS

Materials:

Groundnut, garri, smoke-dried fish, glass wares, zip-locks bags, 'Bag-Co' bags, blender, weighing balance. All chemical and reagents consumable used were of analytical grades from Aldrich and BDH chemicals.

Methods:

Sample Collection and Handling

1000g sample each of garri, groundnut and smoke-dried fish samples were purchased in triplicates from two open markets and two super markets in Kano State and brought to the food laboratory. 100g each representative sample was measured, pulverized and packaged in zip-lock bags and ready for individual chemical analysis of total aflatoxin, polycyclic aromatic hydrocarbons and hydrogen cyanide contamination levels.

Determination of Total Aflatoxin Contamination

Total aflatoxin was determined according to Official Methods of Analysis (2000) of the AOAC Method 991.31 with slight modification. 5.0 g of homogenized sample was weighed and 30ml of methanol (80%) HPLC Grade was added and shaken for 30 minutes at 120 rpm and then filtered. 20ml of filtered solution was diluted 2:1 with phosphate buffer solution (PBS) and then centrifuged at 3500 rpm for 20 minutes and subsequently filtered with Whatman Pore size of 0.45Mm. 15ml of the filtrate was injected into immune-affinity columns with flow rate of 1.0ml per minute followed by 30ml of distilled water. Thereafter, fractions containing aflatoxins was slowly eluted drop by drop with methanol and evaporated at 45°C under nitrogen. Then, 2ml of mobile phase of water: methanol: acetonitrile (60:30:15 v/v/v) were used to dilute the eluent and then injected into HPLC with fluorescent detection at 254nm wavelength.

Determination of Polycyclic Aromatic Hydrocarbon

5.0g of each blended fish sample was spiked with d-PAHs and extracted with mixed solvents of 150ml hexane: dichloromethane (1:1) using soxhlet extraction apparatus for 10hours. The solvent was reduced to 1ml using rotary evaporator and nitrogen gas while the extract was passed through a clean-up column filled with 100-150 mesh silica gel followed by 1g of aluminium oxide and anhydrous sodium sulfate. The column was washed with 10ml of hexane and the PAHs were collected by eluting with 8ml of hexane and 5ml of dichloromethane. Thereafter, the extracts were concentrated to 1ml under nitrogen gas flow at ambient temperature. The solution was injected to GC/MS for PAHs analysis. Quantification of individual PAHs was done based on known concentrations of 24 PAHs standard calibrations.

GC-MS Analysis Conditions: GC-MS analysis was carried out on GCMS-QP2010 PLUS SHIMADZU. The column used was Perkin Elmer Elite - 5 capillary column measuring 30m × 0.25mm with a film thickness of 0.25mm composed of 95% Dimethyl polysiloxane. The carrier gas used was Helium at a flow rate of 0.5ml/min. 1µl sample injection volume was utilized. The inlet temperature was maintained as 250°C. The oven temperature was programmed initially at 80°C for 4 min, then raised to 280°C at a rate of 20°C/ minute and

maintained at this for 8min. Total run time was 35 min. The MS transfer line was maintained at a temperature of 200°C. The source temperature was maintained at 280°c. Mass spectra were collected by electron impact ionization at 70eV and data was evaluated using total ion count (TIC) for compound identification and quantification. The spectra of the components were compared with the database of spectrum of known components stored in the GC-MS library.

Determination of Hydrogen Cyanide Content

The cyanide content of 'garri samples were determined according to alkaline picrate method with modifications according to Williams and Edwards (1980). Firstly, alkaline picrate reagent was prepared by dispensing into test tube a 2ml of 2% KOH and 1ml of picric acid: sodium carbonate: water already prepared in the ratio of 1:5:200 (w/w/v). Picrate impregnated papers were made by dipping Whatman filter paper cut to 8cm x 1cm into the alkaline picrate solution.

For each standard cyanide solutions containing 50-250mgKCN/ml made and acidified with 20ml of 20% hydrochloric acid, three picrate impregnated papers were dipped into and left at room temperature (28±2°C) for 20-24 hours. The reddish-brown colour complex formed on the picrate papers were washed down using 20ml of 50% ethanol and was read at 510nm wavelength using PG T80+ UV/Vis Spectrophotometer after 30 minutes.

From 100g each of blended garri samples, 5.0g each was weighed and acidified with 20ml of concentrated 20% HCL solution and three picrate impregnated papers were sealed in each jar containing mix and left for 2hours at room temperature as done in the case of standard potassium cyanide above. The reddish-brown colouration formed on the picrate papers were washed down using 20ml of 50% ethanol and after 30 minutes was read using PG T80+ UV/Vis Spectrophotometer. The cyanide content of each sample were extrapolated from the standard curve of potassium cyanide as shown in figure 1.

B. Physical and entomological observation

Level of impurity of samples was determined by taking 200 grams from respective sample and carefully sorting out impurities i.e. matters that are unwanted in the produce such as plant mater, sand particles, dead insect, insect damaged seeds, chaff etc. and percentage level determined using the formula below:

$\frac{\text{weight of foreign mater}}{200\text{g}} \text{X} \frac{100}{1}$ was the percentage level of impurity for respective sample (FAO, 2021/2018; AHDB, 2016).

Insect infestation level was determined by first shaking respectively massed samples vigorously to miss-up properly before taking out 200 g from the lot, taken to represent a market sample, each weighed sample were carefully inspected for live adult insects, number of seeds with emergence holes/seeds with damages caused by insects and commodities with insect egg, all counted and recorded (FAO, 2021/2018; AHDB, 2016).

Insect damage levels were examined by picking two hundred seeds randomly from each groundnut lot and the seeds were carefully inspected using the microscope for holes caused by insect emergence or feeding activities; same was done for garri powder and dried fish.

$\frac{\text{number of insect infected commodity}}{\text{volume of commodit inspected}} X \frac{100}{1}$ was the percentage of insect damage for respective markets (FAO, 2021/2018; AHDB, 2016).

Egg counts was determined by picking two hundred seeds (200) randomly from respective groundnut, each grain lot (200 seeds) was carefully inspected using the microscope for presence of insect egg; same was done to garri and dried fish samples.

$\frac{\text{number of seeds with eggs}}{\text{total number of seeds inspected (200)}} X \frac{100}{1}$ was the percentage number of eggs present in samples.

C. Detection of *E. coli*, Salmonella and Shigella in Food Samples Collected in Kano Metropolis

Sample Preparation

Samples of groundnut, garri and smoked fish were bought from open markets and supermarkets within Kano Metropolis and transported to Microbiology laboratory of Nigerian Stored Products Research Institute Kano for detection of food borne pathogen of public health significance (*E. coli*, Salmonella and Shigella). The samples were homogenised using laboratory mortar and pestle. The stock solutions were prepared by transferring 25g of each samples into conical flask containing 100ml of sterile distilled water. Aliquot of 1ml from the stock solution was serially diluted up to 10^{-5} in 9ml of sterile distilled water. Aliquot of 1ml from 10^{-3} test tube were plated onto MacConkey agar and Salmonella Shigella agar, incubated at 37^{o}C for 18-24hours.

Plate Reading, Microscopy and Biochemical Identification

After incubation for 18-24 hours, colony growth were observed based on size, shape, consistency, lactose fermentation on MacConkey agar, hydrogen sulphide production on Salmonella shigella agar. Distinct colony were sub-cultured onto a new plate of MacConkey agar and incubated at 37^{o}C for 18-24hours for biochemical identification and microscopy.

Gram staining (Microscopy): A smear was made from the visible and distinct colonies, which was Gram stained to determine the morphology of the organism (cocci or bacilli) and classify them as either Gram positive or negative using Gram`s technique according to Forbes et al. 2007 and Cheeesbrough, 2006. A prepared smear from the culture was allowed to air-dry, passed through a Bunsen flame 3-4 times to heat fix, and covered with crystal violet stain for 1 minute. It was rapidly washed off with clean water and excess water was tipped off. The smear was then covered with Lugol's iodine for 1 minute, the iodine was washed off with clean water and was then decolorized rapidly (few seconds) with acetone–alcohol. The slide was washed immediately with clean water and covered with Safranine for 2 minutes. The stain was washed off with clean water; the back of the slide was wiped clean, and placed on a draining rack to air-dry. The slide was examined microscopically, first with the 40X objective to check the staining and to see the distribution of material, and then with the oil immersion objective to report the bacteria (Forbes et al., 2007; Cheeesbrough, 2006).

Biochemical Identification

The bacterial growths were subjected to Oxidase test, Indole production, Citrate utilization tests, triple sugar Iron Agar (TSI) to determine the identity of the bacteria.

Data Analysis

Data obtained from each analysis were analyzed using the t-test of SPSS 16.0 version 2007 at 95% confidence level (p <0.05) to compare means.

RESULTS AND DISCUSSION

Table 1: Total aflatoxin contamination of Ready-to-eat groundnut from two open and two super-markets in Kano

Aflatoxin	Sample Codes							
(µg/kg)	OM1 GR1	OM1 GR2	OM2 GR1	OM2 GR2	SM1 GR1	SM1 GR2	SM2 GR1	SM2 GR2
B1	36.46	35.97	63.24	95.48	10.86	13.11	9.61	48.25
B2	0.80	0.79	1.39	2.10	0.24	0.29	0.21	1.06
G1	1.60	1.58	2.78	4.20	0.48	0.58	0.42	2.12
G2	1.21	1.19	2.08	3.15	0.36	0.43	0.32	1.59
Total	40.07	39.53	69.50	104.92	11.934	14.411	10.558	53.020

OM1 and OM2 represent open markets 1 and 2; SM1 and SM2 represent Super-markets 1 and 2; GR1 and GR2 represent groundnut replicate samples

The total aflatoxin contamination levels in the ready-to-eat groundnut sampled from open and super-markets of Kano state is presented in Table 1. Total aflatoxin contaminations were observed to be profound in samples from open markets as it ranged from 39.53 to 69.50 µg/kg. This could be due to the non-selective measures on roasted or ready-to- eat groundnut samples which are usually brought for sale without cleaning up the outer seed cover. However, levels of aflatoxin contaminations in groundnut samples from the super-markets ranges from 10.56 to 53.02 µg/kg. Afolabi *et al.*, 2015 reported the presence of AFB1 at 1.3-59.1 µg/kg in roasted groundnut sold along road side while Bankole et al., (2005) reported concentration ranging from 5 to 165 ppb of Aflatoxin B1 in all aflatoxin-positive samples which he sampled and concluded that they might present potential health hazards to consumers. This might be associated to the fact that ready-to-eat-groundnut supplied to super-markets are usually cleaned up of their outer seed coats and carefully sorted based on the physical observations of any defect. RTE foods are a broad and diverse food category, prepared and stored in different ways and under different conditions, some of which support growth of some selected mycotoxins at specific storage and shelf-life conditions. The level of aflatoxins food contaminations cannot really be compared due to non- homogeneity of climatic differences and agricultural practices among others factors (**Williams, *et al*., 2004)**. To protect humans and animals from the harmful effects of mycotoxins, especially aflatoxin, the European Commission (EC) and international communities have proposed maximum allowable limits for aflatoxins in foods and feeds. It usually between 4-30ppb, depending on the country, for example, it 20ppb (20 µg/kg) in the USA (**Luc, *et al*., 2019).** Contamination by these fungi could have occurred during the removal of the skin of the seeds after roasting or when the snack is being distributed into nylons or by cross infection from other products displayed for sale in the markets.

Table 2 below presents the level of polycyclic aromatic hydrocarbons in smoke-dried fishes from open and super-markets of Kano state. All PAHs were detected in all samples except for BT-1, JF-2 and SH-1where fifteen, fourteen and twenty-two PAHs were only detected. Polycyclic aromatic hydrocarbons which are formed during incomplete combustion of organic matters are ubiquitous in the surrounding atmosphere and play important role in cancer risk assessments (Rengarajan, *et al*., 2015). Fish smoking is one of the many ways PAHs are formed. These compounds differ in their toxicity and carcinogenicity depending on their respective hydrophobicity.

Table 2: Polycyclic Aromatic Hydrocarbons (PAH) levels of Ready-to-eat smoke-dried fish from two open and two super-markets in Kano

Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs (µg/kg) in Smoke-Dried Fish samples							
	BT-1	BT-2	JF-1	JF-2	SH-1	SH-2	YM-1	YM-2
Naphthalene	12.78	4.23	2.71	1.95	8.64	8.78	1.91	2.07
Anthracene	9.70	9.04	2.07	2.10	8.91	7.28	2.03	2.10
Acenaphthene	5.74	11.27	2.87	2.67	5.23	6.52	2.65	2.76
Acenaphthylene	9.49	14.15	2.71	3.17	9.09	5.16	2.74	2.62
Fluorene	9.26	7.48	2.71	2.98	6.10	3.32	3.28	3.20
Phenanthrene	9.55	8.16	3.42	2.70	23.98	3.08	2.90	3.00
S-methyl chrysene	10.73	5.80	2.97	2.88	7.36	4.12	2.86	2.79
Benzo[a] anthracene	14.34	10.09	2.94	2.92	7.73	5.62	3.05	3.82
Benzo[b] fluoranthene	19.30	6.85	3.22	2.35	10.53	2.80	3.28	2.74
Pyrene	19.12	4.13	3.39	2.28	10.90	2.40	3. 40	3.30
Chrysene	18.30	6.79	2.45	2.54	13.69	5.69	2. 49	2.37
Benzo[a]pyrene	**26.28**	3.19	2.39	2.20	**20.19**	4.52	2.28	2.18
Benzo[j] fluoranthene	14.07	3.60	2.86	2.29	13.31	3.55	2.60	2.70
Dibenzo[a,h] pyrene	14.01	4.36	2.32	2.15	9.37	4.34	2. 42	2.39
Dibenzo[a,i] pyrene	11.34	17.52	2.42	2.39	ND	4.38	2.05	2.30
Dibenzo[a,l] pyrene	ND	4.41	2.16	2.09	ND	12.35	2.20	2.16
Indole[1,2,3, cd] pyrene	ND	4.16	2.22	2.32	ND	4.09	2.38	2.38
Cyclopenta [cd] pyrene	ND	5.29	2.50	2.78	ND	5.85	2.13	2.15
Benzo[ghi] perylene	ND	24.45	2.68	2.85	ND	18.89	2.38	2.54
Benzo[k] fluoranthene	ND	8.55	3.12	2.38	ND	9.29	2.75	2.72
Benzo[c] fluorine	ND	12.19	2.51	2.24	ND	5.05	2.94	2.94

Dibenz[a,h] anthracene	ND	11.77	2.37	2.15	ND	6.05	2. 44	2. 42
Dibenzo[a,e] pyrene	ND	10.62	2.07	ND	ND	4.62	2.25	2.19
Fluoranthene	ND	6.32	2.08	ND	ND	3.00	2.14	2.08
Σ *PAHs*	*204.01*	*204.42*	*63.16*	*54.38*	*155.03*	*140.75*	*50.8*	*59.5*

BT-1 = open market BT sample 1; BT-2= open market BT sample 2; SH-1= supermarket SH sample 1; SH-2= super market SH sample 2; JF-1= supermarket JF sample 1; JF-2= supermarket JF sample 2; YM-1=, open market YM sample 1; YM-2= open market YM sample 2. Σ *PAHs represent summation of sample PAHs. The levels of PAHs contamination are statistically (P<0.05) different between all market fish samples.*

The highest of any single PAHs of record in this study was the Benzo[a] pyrene with 26.28 µg/kg and 201.9 µg/kg in BT-1 and SH-1 respectively. The EU maximum limit for Benzo[a] pyrene for fish and fish products range between 2 to 10 µg/kg (EFSA, 2008). The high levels of total PAHs in each sample might not only be due to smoking of fishes alone, but also, due to PAHs contaminated fish feeds during aquaculture (Nnaji and Ekwe, 2018). Benzo[a] pyrene is generally used as exposure markers for cancer risk assessments and thus considered one of the most carcinogenic PAHs (Lee and Vu, 2010). Benzo[a] pyrene, benzo[a] anthracene and naphthalene have been reported with embryo toxicity in animals, thus making these PAHs of frontline concerns (Rengarajan, *et al*., 2015). In this study, samples from JF-1, JF-2, YM-1 and YM-2 perhaps had values for PAHs above 2 µg/kg but were all below 10 µg/kg maximum limit. This could affirm the report of Nnaji and Ekwe, 2018 that not only smoking of fishes but also could be from feeds used during aquaculture. In this study, PAHs values of ≥10 µg/kg were naphthalene in BT-1, Acenaphthene and Acenaphthylene in BT-2, S-methyl chrysene in BT-1, Benzo[a]pyrene in BT-1 and BT-2, chrysene, pyrene, benzo[a]pyrene, benzo[j]fluoranthene in BT-1 and SH-1samples, Dibenzo [a, h] pyrene in BT-1, Dibenzo [a, i] pyrene in BT-1 and BT-2, benzo[jhi] perylene in BT-2 and SH-2 samples. Samples from BT-2 and BT-1 followed by SH-1 and SH-2 recorded the highest sum of PAHs than other samples.

Table 3 presented the levels of hydrogen cyanide in 'garri' samples obtained from both open and super-markets in Kano state. Each value was as extrapolated from figure 1 standard curve equation of y = 0.0019x+0.019 where **y** represented the value of absorbance and **x** represented the concentration. Samples from super-markets had cyanide contents ranging between 0.0696± 0.15 to 0.0723± 0.50 mg HCN/10g while samples from open markets had HCN range between 0.0428± 0.01 to 0.0811± 0.10 mg HCN/10g. 'Garri are made from sweet cassava cultivars which are grouped of varieties with less than 50mg HCN /Kg (Ginting, 2011).

Table 3: Hydrogen cyanide Contents of 'Garri' samples from Open and Super-markets in Kano State.

Garri Sample	Cyanide content (mgHCN/10g)	Equivalence (ppm)	Relative % to LC_{50} (10ppm WHO limit)
SM_1G_1	0.0723± 0.50	7.23	27.7
SM_1G_2	0.0718± 0.10	7.18	28.2
SM_2G_1	0.0701± 0.50	7.01	29.9
SM_2G_2	0.0696± 0.15	6.96	30.4
OM_1G_1	0.0681± 0.15	6.81	31.9
OM_1G_2	0.0428± 0.01	4.28	57.2

OM_2G_1	0.0529± 0.15	5.29	47.1
OM_2G_2	0.0811± 0.10	8.11	18.9

Values are presented as means ±SD of three replicate experiment. **SM_1G_1** = supermarket 1 garri 1; **SM_1G_2** =supermarket 1 garri 2; SM_2G_1 supermarket 2 garri 1; **SM_2G_2** super-market 2 garri 2; **OM_1G_1** = open market 1 garri 1; **OM_1G_2** == open market 1 garri 2; **OM_2G_1** = = open market 2 garri 1 ; **OM_2G_2** = = open market 2 garri 2

These results inferred that the cassava varieties used in the making of these 'garri' sample had undergone serious processing which must have precipitated more than 95% of the potential hydrogen cyanide that would be produce by hydrolysis of cyanogenic glycoside (Onabolu, 2002; Bradbury, 2006). The content of hydrogen cyanide in root crops especially cassava is dependent of the variety and the extent of processing into products (Ginting and Widodo, 2012). Hydrogen cyanide formed due to hydrolysis of cyanogenic glycoside become more volatile at temperature ≥25°C when cassava tissues are undergoing processing into products (Cardoso, *et al*., 2005).

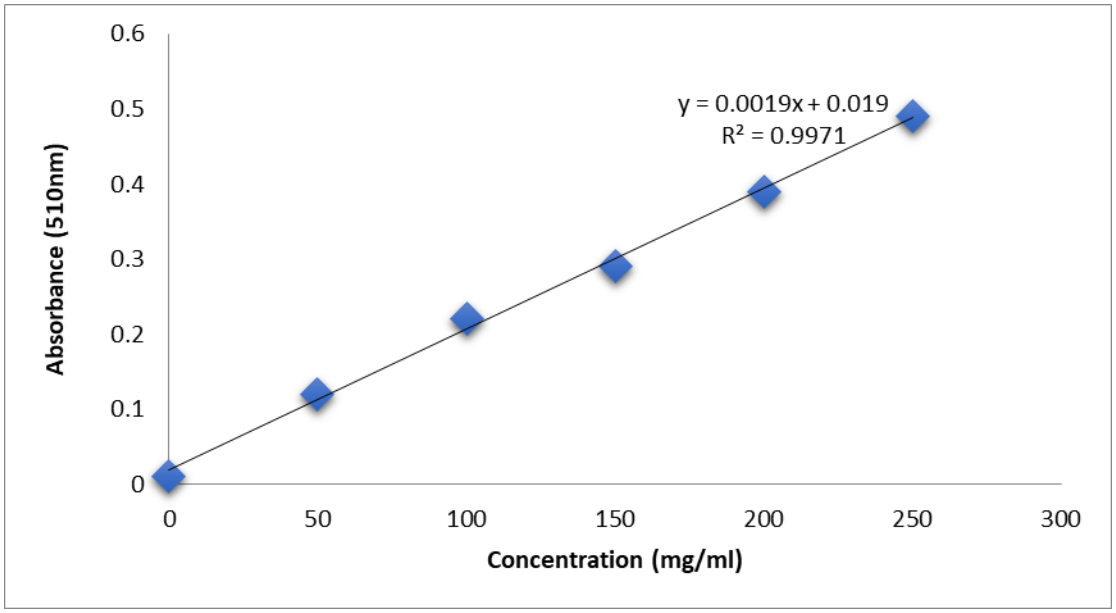

Figure 1. Standard curve of Hydrogen Cyanide

Extremely high dose of HCN beyond which the body can detoxify would result in stomach pains, headaches, dizziness, nausea and many a times diarrhea **(Burns, 2012**). Many cassava products either roasted or dried having less thickness have been reported to have less cyanide contents (Burns, 2012). With reference to Burns' assertion (2012), it can be deduced, that the more surface area of cassava products, the lesser the cyanide contents. Therefore, none of the garri sampled for this study have hydrogen cyanide contents of heath importance.

Table 4 above indicated some physical and entomological attributes of the RTE groundnut, garri and smoke-dried fishes that were sampled in two open and two supermarkets of Kano state. Neither insect egg nor insect damage was observed in all samples from both markets. The level of impurities of garri samples were percentage weight of light weigh garri fibers per 100g of sample.

Table 4: Preliminary physical and entomological observations of Ready-to eat Food stuffs sold in opens and supermarkets in Kano City.

Ready-to-eat Food	Physical Observation				
	Impurity (%)	Color	Egg (%)	Larvae (%)	Insect damage (%)
Groundnut					
A	0.00	Light-brown	0.00	0.00	0.00
B	0.00	Light-brown	0.00	0.00	0.00
C	0.00	Light-brown	0.00	0.00	0.00
D	0.00	Light-brown	0.00	0.00	0.00
E	3.5	Dark-brown	0.00	0.00	1.20
F	2.5	Dark-brown	0.00	0.00	0.50
G	2.0	Dark-brown	0.00	0.00	0.00
H	1.5	Light-brown	0.00	0.00	0.00
Smoke-dried fish					
BTI	1.5	Dark-amber	0.00	0.00	0.00
BT2	2.5	Dark-amber	0.00	0.00	0.00
YM1	1.5	Dark-amber	0.00	0.00	0.00
YM2	0.5	Dark-amber	0.00	1.30	2.5
JF1	0.00	Amber	0.00	0.00	0.00
JF2	0.00	Amber	0.00	0.00	0.00
SH1	0.00	Amber	0.00	0.00	0.00
SH2	0.00	Amber	0.00	0.00	0.00
Garri					
SM1G1	0.8	Creamy-white	0.00	0.00	0.00
SM1G2	0.5	Creamy-white	0.00	0.00	0.00
SM2G1	0.5	Creamy-white	0.00	0.00	0.00
SM2G2	0.5	Creamy-white	0.00	0.00	0.00
OM1G1	2.0	Whitish-grey	0.00	0.00	0.00
OM1G2	1.5	Whitish-grey	0.00	0.00	0.00
OM2G1	1.5	Creamy-white	0.00	0.00	0.00
OM2G2	2.0	Creamy-white	0.00	0.00	0.00

A to D represented groundnuts samples from Supermarkets while E to H represented groundnut samples from open markets. BT and YM are two different open markets; JF and SH are two different supermarkets; 1 and 2 represented replications.

More impurities were observed with garri samples from open markets (1.5 to 2.0%). Smoke-dried fishes from supermarkets were all de-gutted as no internal organ was observed in their dried form, however, those from open markets were all found with internal organs smoke-dried in them thus, impurities levels ranged from 0.5-2.5%. Groundnuts samples form supermarkets were carefully sorted as there were no physical impurity levels recorded for all of them; while groundnuts samples from open markets were much of impurities ranging from 1.5 to 3.5%. No insect damage was observed except in groundnut samples from open markets E and F and in smoke-fried fish tagged YM2. The damage observed in smoke fish YM2 was prompted by 1.30 % larvae.

Table 5: Pattern of Bacteria Isolated from Survey Samples

Sample	Gram	Oxidase	Citrate	Indole	TSI	Identified

	Reaction				**Slant**	**Butt**	**Gas**	**H_2S**	**Bacteria**
A	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-	-
D	-Ve	-Ve	+Ve	-Ve	Y	Y	+	-	Enterobacter aerogenes
E	-Ve	-Ve	+Ve	-Ve	Y	Y	+	-	Enterobacter aerogenes
F	-	-	-	-	-	-	-	-	-
G	-	-	-	-	-	-	-	-	-
H	-	-	-	-	-	-	-	-	-
Om1G1	-	-	-	-	-	-	-	-	-
Om1G2	-	-	-	-	-	-	-	-	-
Om2G1	-Ve	-Ve	+Ve	-Ve	Y	Y	+	-	Enterobacter aerogenes
Om2G2	-Ve	-Ve	+Ve	-Ve	Y	Y	+	-	Enterobacter aerogenes
Sm1G1	-	-	-	-	-	-	-	-	-
Sm1G2	-	-	-	-	-	-	-	-	-
SM2G1	-	-	-	-	-	-	-	-	-
SM2G2	-	-	-	-	-	-	-	-	-
JF1	-Ve	-Ve	+Ve	-Ve	Y	Y	+	-	Enterobacter aerogenes
JF2	-	-	-	-	-	-	-	-	-
SH1	-	-	-	-	-	-	-	-	-
SH2	-	-	-	-	-	-	-	-	-
YM1	-	-	-	-	-	-	-	-	-
YM2	-	-	-	-	-	-	-	-	-
BT1	-	-	-	-	-	-	-	-	-
BT2	-	-	-	-	-	-	-	-	-

A to D represented groundnuts samples from Supermarkets while E to H represented groundnut samples from open markets. BT and YM are two different open markets; JF and SH are two different supermarkets; 1 and 2 represented replications.

Consumption of unsafe food poses global health threat to human, food can be contaminated during production, packaging and transportation. Ready to eat food like garri (cassava flakes), groundnut and dry fish for instance may become contaminated with food borne pathogens such as salmonella and shigella which may be as a result of handling practices. Of all the 24 samples collected, no E. coli, Salmonella or shigella were isolated. This may be due to the fact that all the three samples (Groundnut, garri and smoked fish) collected had heating process at their last stage of processing (HPA, 2009). *E. coli*, Salmonella and shigella have been considered to be a relatively heat sensitive organisms which are killed by heating process of production, however, some species of *E. coli* such as O157: H7, *E. coli* A W 1.7 are heat resistant (Li & Ganzle 2016).

Enterobacter aerogenes was the only bacteria identified in all the samples with evidence of bacterial growth, mainly isolated from samples from open markets, which maybe as a result of cross contamination during market display. Poor post production handling practices in ready to eat food is a cause for concern, probably the vendors of such food are not conscious of the fact that ready to eat food might be a potential carriers of food borne pathogens of public health significance.

CONCLUSION AND RECOMMENDATIONS

This study has assessed roasted groundnut, smoke-dried fishes and 'garri' samples from two open markets and two super-markets of Kano state for the purpose of food safety in terms of presence of food pathogens, physical and entomological observation, likewise total aflatoxins, polycyclic aromatic hydrocarbons and hydrogen cyanide contents respectively. Total aflatoxin contaminations were highest among the roasted groundnut samples than from the super-markets samples. Polycyclic aromatic hydrocarbons were detected from among all samples of smoke-dried fishes and the total sum of PAHs detected were in BT-1 samples while the highest for a single PAH was Benzo[a] pyrene in two out of the eight samples. Hydrogen cyanide contents of all samples of 'garri' showed that they remain safe within the lower boundary of WHO permissible limit. No bacteria of food safety concern were isolated, *Enterobacter aerogenes* was the predominant isolates from samples from open market. No form of insect activity or presence was observed in all the samples. From this study, therefore, it is recommended that safety protocols from proper sorting, through safe processing methods should be advocated and routinely assessed by relevant agencies for the making of all ready-to-eat foods that would sold both in the open markets and at the super-markets.

REFERENCES

AOAC International (2000). *Official methods of analysis* of AOAC International. 18th edition. Gaithersburg, MD, USA, Association of Analytical Communities. *Research International*, *2015*, 789508.

Bankole S.A , B.M. Ogunsanwo , D.A. Eseigbe (2005). Aflatoxins in Nigerian dry-roasted groundnuts. Food Chemistry 89 (2005) 503–506

Bradbury, J.H (2006). Simple Wetting Method to Reduce Cyanogen Content of Cassava Flour. *Journal of Food Composition Analysis.*Vol.19: 388-393.

Burns, A.E., Bradbury, J.H., Cavagnaro, T.R., Gleadow, R.M (2012). Total Cyanide Content of Cassava Food Products in Australia. In *Journal of Food Composition and Analysis.* Vol.25: 79-82.

Cardoso, A.P., Mirion, E., Ernesto, F., Massaza, J., Cliff, M.R., Hague, Bradbury, J.H (2005). Processing of Cassava roots to Remove Cyanogen. *Journal of Food Composition Analysis.* Vol. 18: 451-460.

Cerna-Cortes, J. F., Leon-Montes, N., Cortes-Cueto, A. L., Salas-Rangel, L. P., Helguera Repetto, A. C., Lopez-Hernandez, D., Gonzalezy-Merchand, J. A. (2015). Microbiological quality of ready-toeat vegetables collected in Mexico city: Occurrence of aerobic mesophilic Bacteria, fecal coliforms, and potentially pathogenic non tuberculous *Mycobacteria*. *BioMed*

Ceuppens, S., Rajkovic, A., Heyndrickx, M., Tsilia, V., Van De Wiele, T., Boon, N., & Uyttendaele, M. (2011). Regulation of toxin production by *Bacillus cereus* and its food safety implications. *Critical Reviews in Microbiology*, *37*(3), 188–213.

Cheesbrough, C. (2006). District Laboratory Practice in Tropical Countries Part 2. Cambridge, UK: Cambridge University Press. Pages 74-75, 64-70

European Commission. Guidance document on official controls, under Commission Regulation (EC) No 2073/2005of 15 November 2005 on microbiological criteria for foodstuffs 15 November, 2005.

European Food Safety Authority (2008). Polyclic Aromatic Hydrocarbons in Food: Scientific Opinion of the Panel on Contaminations in the Food Chain. *The EFSA J.* 724:1- 114.

FAO. 2019. The Future Of Food Safety. There is no food security without food safety, Rome.

Forbes, B.A., Sahm, D.F., Weissfeld, A.S. (2007). Bailey and Scott's Diagnostic Microbiology. China: Mosby Elsevier, 12th Edition. 78-91, 221-232.

Gibb, H., Devleesschauwer, B., Bolger, P. M., Wu, F., Ezendam, J., Cliff, J.,Bellinger, D. (2015). World Health Organization estimates of the global and regional disease burden of four foodborne chemical toxins, 2010: A data synthesis. *F1000Research*, *4*, 1393

Ginting and Widodo (2013). Cyanide Reduction in Cassava Root Products. In: Bulletin Palawija. Number 25. Indonesian Legumes and Tuber Crops Research Institute.https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:02005R207320140601&from=DA

Health Protection Agency. Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods. London: Health Protection Agency, November 2009.

Huang, L. (2012). Advances in Meat, Poultry and Seafood Packaging || In-package pasteurization of ready-to-eat meat and poultry products. , 437 450. doi:10.1533/9780857095718.3.437

International Agency for Research on Cancer (IARC). (2015). *Mycotoxin control in low- and middle-income countries* (IARC Working Group Report No. 9). Lyon, France: Author

Kraig, B., & Taylor, C. (2013). *Street food around the world: An encyclopaedia of food and culture*. Santa Barbara, CA: ABC-CLIO.

Lee, B., Vu, V.T. (2010) 'Source, Distribution and Toxicity of Polycyclic Aromatic Hydrocarbons in Particulate matter' In Air Pollution (London: InTech-Open) 99-122.

Li H and Gänzle M (2016) Some Like It Hot: Heat Resistance of *Escherichia coli* in Food. *Front. Microbiol*. 7:1763. doi: 10.3389/fmicb.2016.01763

Luc, I., Micheal, S., Abimbola, A., Setondji, E.H. (2019). Regional Sub-Saharan African Diet

Makinde OM, Ayeni KI, Sulyok M, Krska R, Adeleke RA, Ezekiel CN.(2020). Microbiological safety of ready-to-eat foods in lowand middle-income countries: A comprehensive 10- year (2009 to 2018) review. *Compr Rev Food Sci Food Saf*. 2020;19:703–732. https://doi.org/10.1111/ 1541-4337.12533

Nnaji, J.C Ekwe, N,P (2018). Effect of Smoking on Polyclic Aromatic Hydrocarbons (PAHs) in Catfish and Tilapia Muscles. *Journal of Applied Sciences and Environmental Management.* Vol. 22(2): 293-297.

Onabolu, A.O., Oluwale, O.S., Bokanga, M.(2002). Loss of Residual Cyanogen in Cassava Foods During Short term storage. *Internation al Journal of Food Science and Nutritions.* Vol. 53: 343-349.

Rengarajan, T, Rajendran, P., Nandarkumar, N., Lokeshumar, B., Nishigaki, I. (2015). Exposure to Polycyclic Aromatic Hydrocarbons with Special Focus on Cancer. *Asian Pac. Journal of Bio medicals.* Vol.5: 182-189.

Study in Benin, Cameroon, Mali and Nigeria Reveals the Presence of 164 Mycotoxins and Other Secondary Metabolites in Foods. Journal of Toxins; 11; 54; doi 10.3390/toxins 11010054. www.mdpi.com/journal/toxins

Williams, J.H., Philips, T.D., Jolly, P.E., Stile, J.K, Jolly, C.M., Aggarwal, D. (2004). Human Aflatoxicosis in Developing Countries: A Review of Toxicology, Exposure, Potential Health Consequences and Interventions. American Journal of Clinical Nutrition.80: 1106-1122.

World Health Organization (WHO). (2010). Basic steps to improve safety of street-vended food. International Food Safety Authorities Network (INFOSAN) Information Note No. 3/2010-Safety of street vended food.