ISSN No:-2456-2165

Heavy Metal Analysis of Some Common Foodstuffs Sold at Motor Parks in Ogun State, Southwestern Nigeria

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Abstract:- **Food consumption is one of the sources of human exposure to heavy metals. In growing medium sized cities in developed countries, heavy metal in food is caused by industry and vehicular emissions. Most foods sold in Nigerian outdoor markets are not properly packaged thus making them more susceptible to environmental pollution. Food contaminated with heavy metals is unsafe and long term exposure to heavy metals poses health risks such as cancer. This study investigated the concentration of manganese, copper, iron, zinc and lead in Garri, Beans and Noodles obtained from motor parks situated in selected towns of Ogun State, Southwestern Nigeria. They were analyzed after digestion by AAS. Results showed that Iron had the highest concentration ranging from 88.413 – 281.180 mg/kg in all the samples analyzed and was significantly higher than WHO permissible limit, 40.7 mg/kg. Manganese, Zinc and Copper had concentrations ranging from 6.426 – 29.990 mg/kg, 10.742 – 56.737 mg/kg and 0.0479 – 20.701 mg/kg respectively and were within acceptable limits. Lead was not detected in all the samples analyzed. Continuous consumption of poorly packaged food in Nigerian outdoor markets could lead to heavy metal toxicity especially iron toxicity.**

Keywords:-
Contamination; Heavy metals; Environmental Pollution; Food; AAS.

I. INTRODUCTION

Food is a vital substance required by all organisms for the sustenance of life, and its associated functions, such as growth, development, and maintenance of the body [1] [2] [3]. Most food materials are mainly derived from plants (fruits, vegetables, cereals, tuber, grains, etc.) and animals [3]. Food provides the body with essential resources, such as vitamins, proteins, carbohydrates, fats & oils, water and minerals. However, food borne diseases constitute a widespread and ever-increasing public health problem in both developing and developed countries [4] [5].

They can occur because of consumers ingesting food items contaminated with microorganisms and harmful chemicals [6]. The Food and Agriculture Organisation of the United Nations (FAO) estimated that up to 2 million people per year, mostly children, die as a result of diseases caused by contaminated food and water [7]. According to the World Health Organisation (WHO), food borne diseases have devastating health implications, such as kidney and liver failure, brain and neural disorders, reactive arthritis and cancer, with fatal results.

Heavy metal pollution can originate from natural and anthropogenic sources. Activities such as mining, smelting operation and agriculture have contaminated extensive areas of the world [8]. Heavy metal contamination of the environment is a major problem especially for the growing medium sized cities in developing countries primarily due to uncontrolled pollution levels driven by causative factors like industrial growth and heavy increase in traffic using petroleum fuels.

Typically, humans absorb heavy metals through drinking water, food, and air. Long-term exposure could slowly lead to progressing physical, muscular, and neurologically-degenerating disease conditions [9] [10].

Overpopulation for a country of low gross domestic product spells poverty for the majority of the citizens and poverty prevents proper maintenance of internal combustion, resulting in the use of rickety, old, smoke – belching cars, two-stroke engine motorcycles (“Okada”) as means of public transport in the cities. Road traffic is identified to be a major source of air pollution in most Nigerian cities [11]. Air pollution in turn could be a correlate of food contamination. Most food items sold in the Nigerian outdoor markets are not adequately packaged. A great majority of foods such as local snacks, staple foods (cassava foods, rice, beans, grains, oil, fish, vegetable and meat) are displayed close to roadsides. These foodstuffs are packed in containers such as basin, bowls, without any covering and displayed by the roadside. Alternatively, food vendors hawk them at motor parks as fast snack food, for commuters.

Food safety is an important aspect of a nation’s economic stability and due to previous reports on the degree of pollution of some other food items [12]. Food safety is a scientific discipline describing handling, preparation and

storage of food in ways that prevent food borne illness. Safety of food chain can be broken by both contamination and adulteration of food in different steps of the cycle. Unsafe food causes many acute and life-long diseases, ranging from diarrheal diseases to various forms of cancer.

The increasing demand of food safety has accelerated research regarding the risk associated with consuming food contaminated by heavy metals [13]. This study was aimed at determination of level of some heavy metals such as Pb, Cu, Mn, Zn and Fe in some foodstuffs such as garri, beans and noodles sold in motor parks in three different locations in Ogun State, Nigeria. The motorparks are situated in Ago-Iwoye, Oru and Ijebu-Igbo, respectively.

II. EXPERIMENTAL SECTION

A. Sample Site and Sample Collection

The study area is located within latitude 6°N and 8°N and longitude 2.5°E and 5°E. Food samples such as noodles, beans and garri were obtained from motor parks situated in the towns of Ago-Iwoye, Oru and Ijebu Igbo respectively (see Fig. 1). Controls were taken from locations within the town distant from sources of major pollution. The collected portions were subsequently combined to give a composite of each individual sample.

Fig. 1. Collection of Food Samples at Oru Motor Park

The food samples were pulverized and labelled accordingly and stored in a polythene bag. Table I shows the sampling details.

Table I: Sampling Details

Sample Code	Sample/Location
BA	Beans/Ago-Iwoye
BI	Beans/Ijebu Igbo
BO	Beans/Oru
GA	Garri/Ago-Iwoye
GI	Garri/Ijebu Igbo
GO	Garri/Oru
NA	Noodles/Ago-Iwoye
NI	Noodles/Ijebu Igbo
NO	Noodles/Oru

B. Sample Preparation

The samples were oven dried at 105°C for two hours and left to cool at room temperature before crushing using mortar and pestle, then sieved with a 0.02 mm sieve mesh, and stored in polythene bag. About 5g of each sample was weighed and put into pre-washed and oven dried standard flask, digested and labeled appropriately [10].

C. Sample Digestion

Each food sample was transferred into 250 ml standard flask, and diluted with 50 ml of 2M nitric acid (HNO_3), and then heated in the water bath for about 3 hours at a temperature of 95°C to 100°C. The digested solution was evaporated to near dryness, and allowed to cool at room temperature. It was then filtered into standard flask, and diluted to 100 mL with distilled water, and shaken vigorously. Subsequently, it was poured into 100 ml plastic bottle prior to aspiration into the Atomic Absorption Spectrophotometer (Buck Scientific Model 210) to determine the metals (see Fig. 2).

Fig. 2. Atomic Absorption Spectrophotometer (AAS) in Use

D. Quality Control

Triplicate samples were analyzed to validate the instrument and method used. The standard calibration curves for all parameters were gotten using a series of varying concentrations. All calibration curves were linear with correlation coefficients close to 1.

III. RESULTS AND DISCUSSION

Analysis was carried out for each of the sample collected. The arithmetic mean was found for each analyzed sample. The standard deviation was used as measure of accuracy for the analysis.

ISSN No:-2456-2165

Results of analysis carried out on all the powdered samples analyzed showed that they contained Manganese, Iron, Copper and Zinc. The presence of heavy metals is due to the source and locations of the samples used for study i.e. locations of the motor parks. As observed in this study there are significant differences in the concentrations of heavy metals in the food samples from the various motor parks.

Manganese: The concentration of Manganese (Mn) in Garri ranges from 6.42 to 10.12 mg/kg; Mn in Beans ranges from 26.91 to 29.99 mg/kg mg/kg while Mn in Noodles ranges from 5.78 to 7.15 mg/kg mg/kg, as shown in Table II and Fig. 3.

Table II: Mean Concentration (in mg/kg) of Manganese in Food Samples

Sample	Mean ± S. D (Mn)	Control (Mn)	WHO Permissible Limit
NA	7.158 ± 1.031	8.750	66.1
NO	5.786 ± 0.509	21.087	66.1
NI	6.122 ± 0.565	3.229	66.1
GA	7.152 ± 0.825	8.431	66.1
GO	10.123 ± 3.829	18.679	66.1
GI	6.426 ± 0.567	6.029	66.1
BA	27.802 ± 6.952	7.501	66.1
BO	29.990 ± 4.784	19.150	66.1
BI	26.912 ± 4.133	8.113	66.1

S. D = Standard Deviation

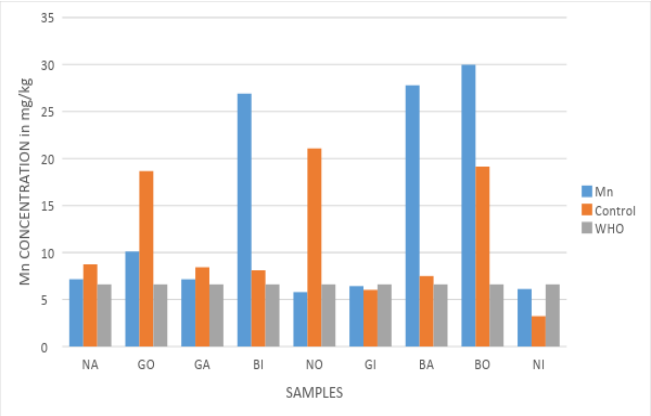

Fig. 3. Mean Concentration of Sample, Control and WHO Permissible Level of Mn in Selected Foodstuff

The highest mean concentration of Mn in Garri is 10.123 mg/kg in Oru while Ijebu Igbo has the least concentration of 6.42 ± 0.56 mg/kg. The highest mean concentration of Mn in Beans is 29.99 ± 4.78 mg/kg in Ijebu Igbo which also has the least concentration value of 26.91 ± 4.13 mg/kg. The highest mean concentration of Mn in Noodles was 7.15 ± 0.82 mg/kg in Ago-Iwoye while Oru has the least concentration of Mn which is 5.78 ± 0.5 mg/kg.

The mean concentration of Mn in all three locations is below the WHO permissible limit (66.1 mg/kg) in food samples but above the control value. Mean concentration of Mn in Beans in Ago-Iwoye, Ijebu Igbo, and Oru are 27.80 ± 6.95 mg/kg, 26.91 ± 4.13 mg/kg, and 29.99 ± 4.78 mg/kg respectively. The mean concentration of Mn in tested food samples in all the locations are below the WHO permissible limit in food samples. Since the overall concentration of Mn is below the WHO permissible limit, the food is safe for consumption, the differences depicted when the mean concentration is higher than the control value might be due to contamination during storage.

Copper: The concentration of Copper (Cu) in Garri ranges from 1.31 to 20.70 mg/kg; Beans ranges from 6.03 to 8.82 mg/kg; Noodles ranges from 0.47 to 1.21 mg/kg, as shown in Table III and Fig. 4.

Table III: Mean Concentration (in mg/kg) of Copper in Food Samples

Sample	Mean ± S. D (Cu)	Control (Cu)	WHO Permissible Limit
NA	1.211 ± 1.549	1.971	30.000
NO	1.475 ± 0.462	7.609	30.000
NI	0.479 ± 0.450	0.521	30.000
GA	1.345 ± 2.054	0.784	30.000
GO	1.312 ± 1.360	5.519	30.000
GI	20.701 ± 34.899	1.912	30.000
BA	8.828 ± 4.994	2.002	30.000
BO	6.158 ± 0.786	8.500	30.000
BI	6.0356 ± 1.874	2.123	30.000

S. D = Standard Deviation

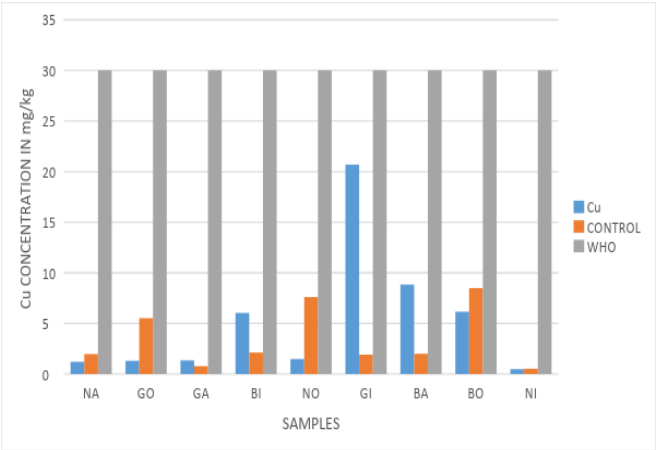

Fig. 4. Mean Concentration of Sample, Control and WHO Permissible Level of Cu in Selected Foodstuff

It is observed that the highest Cu Concentration in Garri is 20.70 ± 34.89 mg/kg in Ijebu Igbo while Oru has the least concentration of 1.312 ± 1.36 mg/kg. The highest mean concentration of Cu in Beans is 8.82 ± 4.99 mg/kg in Ago-Iwoye while Ijebu Igbo has the least concentration of 6.03 ± 1.87 mg/kg. The highest mean concentration of Cu in Noodles is 1.47 ± 0.46 mg/kg which is in Oru and Ijebu Igbo has the least Cu concentration which is 0.479 ± 0.45 mg/kg.

ISSN No:-2456-2165

Mean concentration of Cu in Garri in Ago-Iwoye, Ijebu Igbo and Oru are 1.34 ± 2.05 mg/kg, 2.27 ± 0.62 mg/kg, and 1.31 ± 1.36 mg/kg respectively. The mean concentrations of Cu in Garri all the locations are below the WHO permissible limit of Cu (30.00 mg/kg). Mean concentration of Cu in Beans in Ago-Iwoye, Ijebu Igbo and Oru are 8.82 ± 4.99 mg/kg, 6.03 ± 1.87 mg/kg, and 6.15 ± 0.78 respectively. The mean concentration of Cu in Beans in all the locations is below the WHO permissible limit and above the control value in food samples. Mean concentration of Noodles in Ago-Iwoye, Ijebu Igbo and Oru are 1.211 ± 1.549 mg/kg, 0.4792 ± 0.45 mg/kg, and 0.46 ± 0.50 respectively. The mean concentration of Cu in Noodles in all the locations is below the WHO permissible limits but above the control value in food samples.

Iron: As shown in as shown in Table IV and Fig. 5, the concentration of Iron (Fe) in Garri ranges from 149.32 to 160.41mg/kg; Beans ranges from 88.41 to 250.86 mg/kg; Noodles in Ago – Iwoye ranges from 144.99 to 281.18 mg/kg.

Table IV: Mean Concentration (in mg/kg) of Iron in Food Samples

Sample	Mean ± S. D (Fe)	Control (Fe)	WHO Permissible Limit
NA	149. 211 ± 78.139	168.846	40.7
NO	281.180 ± 182.023	321.739	40.7
NI	144.994 ± 65.840	50.729	40.7
GA	149.326 ± 136.646	181.863	40.7
GO	160.415 ± 139.699	184.434	40.7
GI	150.525 ± 126.040	213.578	40.7
BA	250.864 ± 254.659	200.422	40.7
BO	88.413 ± 25.606	232.550	40.7
BI	98.420 ± 29.662	50.047	40.7

S. D = Standard Deviation

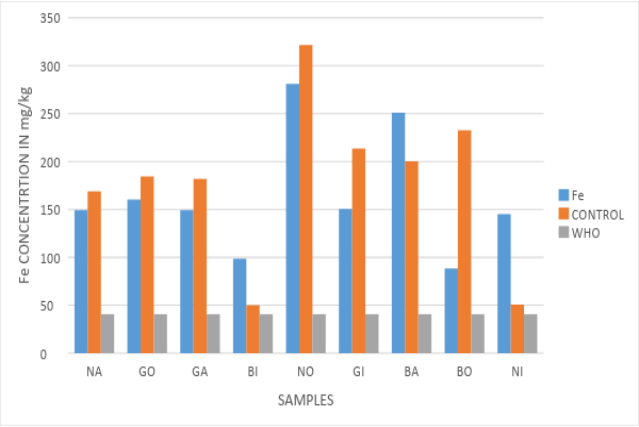

Fig. 5. Mean Concentration of Sample, Control and WHO Permissible Level of Fe in Selected Foodstuff

The highest Fe Concentration in Garri is 160.41 ± 139.69 mg/kg in Oru while Ago-Iwoye has the least Fe concentration of 149.32 ± 136.64 mg/kg. The highest mean concentration of Fe in Beans is 250.86 ± 254.6mg/kg in Ago-Iwoye while Oru has the least Fe concentration of 88.41 mg/kg. The highest mean Concentration of Fe in Noodles is 149.21 ± 78.13 mg/kg which is in Ago-Iwoye while Oru has the least Fe concentration (88.41mg/kg).

Mean concentration of Fe in Garri in Ago-Iwoye, Ijebu Igbo, and Oru are 149.32 ± 136.64 mg/kg, 150.52 ± 126.04 mg/kg, and 160.41 ± 139.69 mg/kg respectively. The mean concentration of Fe in Garri in all the locations are above the WHO permissible limits, but are below the control value in food samples. Mean concentration of Fe in Beans in Ago-Iwoye, Ijebu Igbo, and Oru are 250.86 ± 254.65 mg/kg, 98.42 ± 29.66 mg/kg, and 88.413 ± 25.60 mg/kg respectively. The mean concentration of Fe in Beans in all three locations is above the WHO permissible limit and above the control value in food samples.

Mean concentration of Fe in Noodles in Ago-Iwoye, Ijebu- Igbo, and Oru were 149.21 ± 78.13 mg/kg, 144.94 ± 65.84mg/kg, and 281.18 ± 182.02 respectively. The mean concentration of Mn in all the locations are below the WHO permissible limit but that of Ago-Iwoye and Oru are below the control value, Ijebu Igbo is above the control value in food samples. The disparity in the differences may be due to environmental factors such as car exhaust, or during storage.

Zinc: As shown in Table V and Fig. 6, the concentration of Zinc (Zn) in Garri ranges from 10.74 to 13.85 mg/kg; Beans in Ago – Iwoye ranges from 30.89 to 48.98 mg/kg; Noodles in Ago-Iwoye ranges from 39.75 to 57.26 mg/kg.

Table V: Mean Concentration (in mg/kg) of Zinc in Food Samples

Sample	Mean ± S. D (Zn)	Control (Zn)	WHO Permissible Limits
NA	57.262 ± 0.726	18.990	100. 000
NO	39.750 ± 22.314	52.283	100. 000
NI	56.737 ± 3.712544	11.042	100. 000
GA	10.742 ± 1.788	60.735	100. 000
GO	12.810 ± 0.570	34.387	100. 000
GI	13.859 ± 12.069	51.569	100. 000
BA	48.981 ± 18.345	50.053	100. 000

BO	30.899 ± 12.027	46.750	100. 000
BI	36.198 ± 1.611	51.085	100. 000

S. D = Standard Deviation

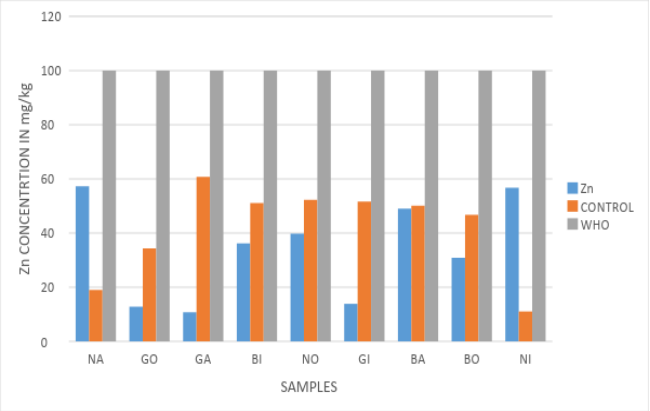

Fig. 6. Mean Concentration of Sample, Control and WHO Permissible Level of Zn in Selected Foodstuff

The highest Zn Concentration in Garri is 13.85 ± 12.06 mg/kg in Ijebu Igbo while Ago-Iwoye has the least concentration of 10.74 ± 1.78 mg/kg. The highest mean concentration of Zn in Beans is 48.98 ± 18.34 mg/kg in Ago-Iwoye while Oru has the least concentration; 30.89 ± 12.02 mg/kg. The highest mean concentration of Zn in Noodles is 57.26 ± 0.72 mg/kg in Ago-Iwoye while Oru has the least mean concentration of Zn which is 39.75 ± 22.31 mg/kg.

Mean concentration of Zn in Garri in Ago-Iwoye, Ijebu Igbo and Oru are 10.74 ± 1.78 mg/kg, 13.85 ± 12.06 mg/kg, and 12.81 ± 0.57 mg/kg respectively. The mean concentration of Zn in all the locations is below the WHO permissible limit and the control value in food samples. Mean concentration of Zn in Beans in Ago-Iwoye, Ijebu Igbo and Oru are 48.98 ± 18.34 mg/kg, 36.19 ± 1.61 mg/kg, and 30.89 ± 12.02 respectively. The mean concentration of Zn in all the locations is below the WHO permissible limits and the control value in food samples. Mean concentration of Zn in Noodles in Ago-Iwoye, Ijebu Igbo and Oru are 57.26 ± 0.72 mg/kg, 56.73 ± 3.71 mg/kg, and 30.89 ± 12.02 respectively. The mean concentration of Zn in all the locations are below the WHO permissible limit and Oru control values but those of Ago-Iwoye and Ijebu Igbo are higher than the control value in food samples as shown in Table V**.** The differences in the concentration indicate contamination of the foodstuff which may be due to ecological factors or during storage.

Lead: The concentration of Lead (Pb) in the tested food samples was not detected.

IV. CONCLUSION AND RECOMMENDATION

The main goal of this research work was to assess five (5) metals (Mn, Fe, Pb, Cu, and Zn) in food samples collected in motor parks from selected locations in Ago-Iwoye, Oru and Ijebu igbo areas of Ogun state, southwestern Nigeria. The assessment was carried out in comparison with WHO environmental guidelines. Lead (Pb) was not found in samples collected from Oru, Ago iwoye and Ijebu igbo because these areas are not industrialized and most heavy metals found in the soils are either naturally occurring or from agricultural activities. High Iron (Fe) occurrence may be attributed to the activities of local blacksmiths in the region.

The authors recommend that food substances are kept safe at all times from the cultivation stage to the processing, and storage. Traders should cultivate the habit of covering food items sold in Nigerian outdoor markets giving the food items a befitting packaging while ensuring a clean market environment.

Furthermore, environmental health workers should sensitize the market women on the dangers of exposing food items in the market, particularly by the road side, and regular assessment should be carried out to ascertain the level of heavy metals contamination in the soil, extensively water and crops.

ACKNOWLEDGMENT

The authors acknowledge the astute guidance of Prof. Babatunde Ogunsanwo of Olabisi Onabanjo University in the execution of this research.

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