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Research Paper

Determination of Heavy Metals in Roasted and Unroasted Plantain Purchased from Selected Areas in Lagos State

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Abstract
There has been an increasing ecological and global public health concern associated with environmental contamination due to heavy metals. Plantain is one of the foods widely consumed which is suspected to be contaminated with heavy metals. The aim of this study is to determine heavy metals present in raw and roasted plantain purchased along Iyana Iba, Igando and Iyana Ipaja roadside. Digestion method was used to extract the heavy metals present in the plantain samples. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) analytical technique was used for heavy metal quantification. The data generated were subjected to descriptive and statistical analysis including Principal Component Analysis (PCA), Correlation Coefficient and Cluster Analysis. The results showed that the mean concentrations of heavy metals for roasted plantain samples are (1.84 ± 1.211) mg/kg for Cu, (0.013 ± 0.023) mg/kg for Ni, (3.233 ± 4.696) mg/kg for Zn, (0.033 ± 0.058) mg/kg for Pb while the mean concentrations of heavy metals for unroasted plantain are (5.59 ± 1.321) mg/kg for Cu, (0.819 ± 0.067) mg/kg for Ni, (3.177 ± 0.747) mg/kg for Zn, (0.041 ± 0.021) mg/kg for Cd. The results show that the concentrations of some heavy metals are within the permissible level as recommended by Food and Agriculture Organization (FAO)/World Health Organization (WHO) such as 0.05 mg/kg for As, 2.30 mg/kg for Cr, 0.30 mg/kg for Pb, etc are permissible level recommended by FAO/WHO. The presence of detected heavy metals in the roasted plantain might be due to vehicular emission, tyre wear, metal corrosion, wire gauze and the contents like stones, plastics, etc added to charcoal to roast the plantain. There is need for proper design of contamination control and further monitoring of heavy metal accumulation in roadside roasted plantain for the safety of man by the National Environmental Standards and Regulations Enforcement Agency (NESREA). In conclusion, toxic metals such as Pb and Ni are present in the roasted plantain.
Keywords: *Heavy metals, Plantain, digestion, ICP-OES, Principal Component Analysis*

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I. Introduction

Heavy metals are naturally occurring elements with a density at least five times that of water [1]. They have a wide distribution in the environment due to their numerous applications in domestic, agricultural, medicine, pharmacy, and technology. In recent years, there has been an increase in ecological and worldwide public health concern over these metals' environmental contamination. [2]. Geogenic, industrial, agricultural, pharmaceutical, home effluents, and atmospheric sources have all been identified as sources of heavy metals in the environment [3]. Mining, foundries and smelters, and other metal-based industrial operations all contribute significantly to environmental pollution [1, 2, 3]. Although heavy metals are naturally occurring elements found throughout the earth's crust, the majority of environmental contamination and human exposure are caused by anthropogenic activities such as mining and smelting, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds [3-6]. Metal corrosion, air deposition, soil erosion of metal ions and heavy metal leaching, sediment re-suspension, and metal evaporation from water supplies to soil and ground water can all cause environmental pollution [7]. Weathering and volcanic eruptions have also been documented to contribute significantly to heavy metal contamination [1, 2, 3, 6, 7]. Metal processing in refineries, coal combustion in power plants, petroleum combustion, nuclear power stations and high tension lines, plastics, textiles, microelectronics, wood preservation, and paper processing plants are all industrial sources [8-10]. Natural elements known as heavy metals frequently have densities of at least 5 g/cm^3. They are present in little amounts throughout the crust of the world. They are located in rows 4 or above and columns 3 to 16 of the periodic table. They are lanthanides, post-transition metals, and transition metals. [11]. Heavy metals in food contamination are of great concern to human health due to issues such as a loss in immunological protection, intrauterine growth that affects psychosocial behaviour, limits caused by malnutrition, and an increase in the prevalence of upper intestine cancer [12]. Mining, tailings, industrial waste, agricultural waste, and vehicle emissions are likely sources of heavy metals. Heavy metals like iron (Fe), cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni), chromium (Cr), manganese (Mn), and zinc (Zn), along with other pollutants, are discharged into the environment through many parts of cars, including the fuel, engine oil, tyre wear, brake wear, and exhaust catalyst. Most of the time, vehicular emission particulates settle down in the environment, exposing both living and non-living creatures there to heavy metal pollutants. Food is an essential component of the human diet because it provides energy, strength, and growth. According to the World Health Organization, roadside foods are foods and beverages prepared and sold by vendors on streets and other public places for immediate or later consumption without further processing or preparation. Plantains are one of the most popular dishes in the West African sub region. In Nigeria, its consumption cuts across multiethnic group and various socio- economic classes because of the ease of preparation and consumption. In the roasted form, plantain is often eaten with palm oil or groundnuts. It is consumed with vegetable soup or stew when boiled. Plantain can also be fried into chips [13]. Food consumption is the primary method by which heavy metals enter human beings' systems. Consuming food contaminated with heavy metals depletes the body of some vital nutrients, creating a variety of health problems for people, including weakened immune systems, impaired psychosocial development in foetus, malnutrition-related disabilities and an increased incidence of upper intestinal cancer [14]. Because heavy metals are non-biodegradable and have long biological half-lives when absorbed by humans, their presence in and around cities has been a major source of concern. Plantain is one of the foods widely consumed in the West Africa sub-region and it is suspected to be contaminated with heavy metals. The aim of this study is to determine heavy metals present in raw and roasted plantain purchased along the roadside.

II. Materials and Methods

2.1 Study Area

The study was carried out in three different locations which are Iyana Iba, Igando and Iyana Ipaja in Lagos state. The locations were chosen based on high population of the area and high vehicular movements

Table 1: Characteristics of study area

SITE	LOCATION	CHARACTERISTIC
1	IGANDO	Commercial and Vehicular Activities
2	IYANA IPAJA	High Traffic Environmental Activities
3	IYANA IBA	High Traffic Environmental Activities

Figure 1: A typical roadside roasted plantain

Samples of the roadside roasted and unroasted plantain were randomly purchased from vendors by the roadside at three different locations, kept in a well labeled sterile polyethylene bag and taken to the laboratory. The vendors claimed to prepare the roasted plantain by firstly peeling the plantain and arranged the raw pulps on wire gauze placed over an open charcoal fire to roast until they are slightly brown. Laboratory size samples of the bulk were transferred separately into labelled 250 ml pyrex beakers (which were prewashed and oven dried), weighed and dried in an oven at 150 ^{0}C until constant weight was got to determine the moisture content.

The oven dried samples were pulverized and homogenized to aid digestion using agate mortar. 5.0 g each of the ground roasted and unroasted plantain samples per location was weighed into separate cleaned 250 ml pyrex beakers and added 50 ml solution of aqua regia. The mixtures were placed on a lowered temperature hot plate in fumed cupboard until yellow fume turned white indicating the completion of digestion. The digested samples were allowed to cool before filtrating into a 100 ml standard flask using a Whatman filter paper No. 42. The filtrate was made to the mark with distilled water and analysed for heavy metals with Agillent 750 ^{0}C Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). All the reagents used were analar grade and the water used to dilute was distilled water.

3.0 Results and Discussion

3.1 Results

The results showed that the mean concentrations of heavy metals for roasted plantain samples are (1.84 ± 1.211) mg/kg for Cu, (0.013 ± 0.023) mg/kg for Ni, (3.233 ± 4.696) mg/kg for Zn, (0.033 ± 0.058) mg/kg for Pb while the mean concentrations of heavy metals for unroasted plantain are (5.59 ± 1.321) mg/kg for Cu, (0.819 ± 0.067) mg/kg for Ni, (3.177 ± 0.747) mg/kg for Zn, (0.041 ± 0.021) mg/kg for Cd. The mean concentrations of heavy metals in roasted plantain and unroasted plantain are subjected to descriptive statistics as shown in Tables 2 and 3 respectively.

Table 2: Descriptive statistics for heavy metals in roasted plantain

Descriptive Statistics						
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**FAO (mg/kg)**
Al (mg/kg)	3	0	199.26	66.42	115.0428	
As (mg/kg)	3	0	1.36	0.7867	0.70465	0.05
Cr (mg/kg)	3	0.84	1.46	1.06	0.34699	2.30
Cu (mg/kg)	3	0.88	3.2	1.84	1.21062	73.3
Fe (mg/kg)	3	0.84	11.82	7.9533	6.16812	425.50
Mo (mg/kg)	3	0.16	2.14	0.8267	1.13742	
Mn (mg/kg)	3	0	0.42	0.14	0.24249	0.05
Ni (mg/kg)	3	0	0.04	0.0133	0.02309	67.90
Pb (mg/kg)	3	0	0.1	0.0333	0.05774	0.30
Zn (mg/kg)	3	0	8.62	3.2333	4.69614	99.40

Table 3: Descriptive statistics for heavy metals in unroasted plantain

Descriptive Statistics						
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**FAO (mg/kg)**
Al(mg/kg)	3	7.244	9.56	8.304	1.170374	
As(mg/kg)	3	0.000	0.742	0.304667	0.388383	0.05
Cd(mg/kg)	3	0.022	0.064	0.041333	0.021197	0.20
Co(mg/kg)	3	0.000	0.284	0.150667	0.142791	
Cr(mg/kg)	3	0.000	0.264	0.166	0.144541	2.30
Cu(mg/kg)	3	4.088	6.572	5.59	1.321122	73.30
Mn(mg/kg)	3	0.480	1.436	0.997333	0.482831	0.05
Ni(mg/kg)	3	0.766	0.894	0.819333	0.066613	67.90
Pb(mg/kg)	3	0.000	0.412	0.137333	0.237868	0.30
Zn(mg/kg)	3	2.542	4.000	3.177333	0.746834	99.40

The correlation efficiency was performed in a pair wise fashion employing Pearson correlation procedure for both roasted and unroasted plantain as shown in Tables 3 and 4 respectively. It shows the correlation coefficient of inter-elemental relationship between paired metals. The heavy metals have low, moderate and strong correlation with each other. Correlation coefficient values below 0.4 indicates low correlation, the one below 0.7 is moderate while 0.7 and above indicates strong. In roasted plantain samples, Zn strongly correlates with Pb (r^2 = 0.993). In unroasted plantain samples, Ni moderately correlates with Cu (r^2 = 0.557).

Table 4: Correlation coefficients of heavy metals in roasted plantain

	Al	As	Cr	Cu	Fe	Mo	Mn	Ni	Pb	Zn
Al										
As	0.262									
Cr	-0.549	0.663								
Cu	-0.286	0.850	**0.958**							
Fe	0.543	**0.953**	0.404	0.649						
Mo	-0.508	-0.965	-0.441	-0.680	-0.999					
Mn	1.000	0.262	-0.549	-0.286	0.543	-0.508				
Ni	1.000	0.262	-0.549	-0.286	0.543	-0.508	1.000			
Pb	1.000	0.262	-0.549	-0.286	0.543	-0.508	1.000	1.000		
Zn	0.993	0.149	-0.642	-0.394	0.443	-0.405	0.993	0.993	**0.993**	

Table 5: Correlation coefficients of heavy metals in unroasted plantain

	Al	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
Al										
As	-0.361									
Cd	-0.508	**0.987**								
Co	-0.699	0.919	**0.971**							
Cr	-0.886	0.752	0.849	**0.951**						
Cu	0.881	0.124	-0.039	-0.277	-0.561					
Mn	0.497	0.631	0.496	0.273	-0.038	**0.848**				
Ni	0.097	0.893	0.808	0.644	0.376	0.557	**0.912**			
Pb	-0.145	0.975	0.926	0.809	0.587	0.341	0.787	**0.971**		
Zn	0.997	-0.428	-0.570	-0.750	-0.918	0.844	0.432	0.024	-0.217	

The percentage moisture content of heavy metals for roasted plantain compared to the unroasted plantain, found to be high with 61.42 % in sample B (Iyana iba), 60.55 % sample G (Igando) and 59.52 % and sample Y (Iyana Ipaja) as presented in the Tables 4 and 5.

Table 6: Percentage moisture content of unroasted and (roasted) plantain

SAMPLE B (%)	**SAMPLE G (%)**	**SAMPLE Y (%)**
59.51(51.02)	59.74(47.52)	61.07(47.58)
60.32(49.62)	59.83(50.41)	59.62(51.65)
61.42(50.34)	60.55(49.71)	59.52(50.27)

Factor analysis (FA) and principal component analysis (PCA) were carried out using the statistical packaged for Social Sciences Software (SPSS) statistic 20 to determine association as well as the differences in the concentration among different locations as shown in Tables 6 and 7 respectively [15].

Table 7: Principal component of heavy metals in roasted plantain

VARIABLES	**Components**	
	PC-1	**PC-2**
Al	0.989	-0.146
As	0.400	0.916
Cr	-0.421	0.907
Cu	-0.143	0.990
Fe	0.660	0.752
Mo	-0.628	-0.778
Mn	0.989	-0.146
Ni	0.989	-0.146
Pb	0.989	-0.146
Zn	0.966	-0.259

Table 8: Principal component of heavy metals in unroasted plantain

VARIABLES	Components	
	PC-1	PC-2
Al	-0.595	0.803
As	0.964	0.266
Cd	0.994	0.105
Co	0.991	-0.136
Cr	0.900	-0.436
Cu	-0.144	0.990
Mn	0.402	0.916
Ni	0.742	0.670
Pb	0.881	0.473
Zn	-0.653	0.758

III. Discussion

From the results, it was shown that the mean concentrations of heavy metals detected are within the FAO / WHO recommended limits as shown in table 2 and 3 which might be suggesting very little to no heavy metal contamination due to anthropogenic sources. Factor analysis was used to explore association that provides information on the distribution and sources of the heavy metals in the both samples [16]. Two principal components were extracted in both roasted and unroasted plantain samples. In roasted plantain samples, the first principal component (PC-1) accounting for 60.35% of variance showed high positive loadings of Al, Mn, Ni, Pb, and Zn. The Pb loading might suggest contributions from vehicular emission; Zn loading might suggest possibilities of anthropogenic or natural sources; Ni loading might suggest contributions from tyre wear, metal corrosions and brake linings. Al and Mn suggested that they had similar source. The second principal component (PC-2) accounting for 39.65% of variance showed high positive loadings of As, Cr, Cu and Fe. The Cu and As loading might suggest possibilities of anthropogenic or natural sources; Fe and Cr might suggest that they had similar source. In unroasted plantain samples, the first principal component (PC-1) accounting for 60.00 % of variance showed high positive loadings of As, Cd, Co, Cr, Ni and Pb. The Pb loading might suggest contributions from vehicular emission; Ni loading might suggest contributions from tyre wear, metal corrosions and brake linings. As loading might suggest possibilities of anthropogenic or natural sources; Cr, Cd and Co might suggest that they had similar source. The second principal component (PC-2) accounting for 40.00 % of variance showed high positive loadings of Al, Cu, Mn and Zn. Zn and Cu loading might suggest possibilities of anthropogenic or natural sources; Al and Mn might suggest that they had similar source.

The correlation efficiency was performed in a pair wise fashion employing Pearson correlation procedure. It shows the correlation coefficient of inter-elemental relationship between paired metals. The heavy metals have low, moderate and strong correlation with each other. Correlation coefficient values below 0.4 indicates low correlation, the one below 0.7 is moderate while 0.7 and above indicates strong. In roasted plantain samples, Zn strongly correlates with Pb ($r^2 = 0.993$). In unroasted plantain samples, Ni moderately correlates with Cu ($r^2 = 0.557$).

IV. Conclusion

From this study ~~ies~~, the level of heavy metal concentrations in roadside roasted and unroasted plantain investigated using Inductively Coupled Plasma Optical Emission Spectrometry (ICP- OES) for heavy metal quantification shows that the concentrations of heavy metals in unroasted and roasted plantain are within the permissible levels as shown in the Tables 2 and 3 respectively as recommended by Food and Agriculture Organization (FAO)/World health Organization (WHO). The presence of detected heavy metals in the roasted plantain might be contribution from vehicular emission, tyre wear, metal corrosion, wire gauze and the contents like stones, plastics, etc added to charcoal to roast the plantain. There is need for proper design of contamination control and further monitoring of heavy metal accumulation in roadside roasted plantain for the safety of man by the National Environmental Standards and Regulations Enforcement Agency (NESREA). In conclusion, toxic metals such as Pb and Ni are present in the roasted plantain.

V. Recommendation

It is recommended that the study should be repeated in other part of the state to enabling proper design of contamination control and further monitoring of heavy metal accumulation in roadside roasted plantain for the safety of man by the National Environmental Standards and Regulations Enforcement Agency (NESREA).

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