

Road-side roasted plantain and maize in Zaria and environs: nutritional composition and heavy metal evaluation

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Abstract

This study aimed to assess the nutritional quality and heavy metal contamination of roasted and raw corn and plantain marketed in Zaria and its vicinity. Raw and roasted plantain and maize were obtained from three distinct areas of Zaria. The samples were air-dried and ground into powdered flour for analysis. Moisture content was lowest in roasted plantain ($4.67 \pm 0.54\%$) and highest in raw maize ($9.58 \pm 0.60\%$). Crude protein and crude fibre were most elevated in roasted maize samples (10.56 ± 0.26 , $3.22 \pm 0.13\%$, respectively) and lowest in raw plantain samples (8.62 ± 0.37 , $1.70 \pm 0.20\%$, respectively). Ash content was highest in raw plantain ($3.28 \pm 0.16\%$) and lowest in roasted maize samples ($2.00 \pm 0.26\%$). Nitrogen-free extract (NFE) was significantly higher ($P < 0.05$) in both raw ($78.42 \pm 0.64\%$) and roasted plantain ($78.63 \pm 1.14\%$). The mineral composition of roasted road-side plantain (Ca, 0.22 ± 0.04 ; Ph, 0.11 ± 0.03) and maize (Ca, 0.23 ± 0.02 ; Ph, 0.22 ± 0.00) reveal that calcium and phosphorus were found within the moderate limit adequate for human consumption. Based on the current study, raw and roasted plantain and maize across all the study locations were highly contaminated with Pb, Cr, and Cd, which may pose a public health concern.

Keywords: Road-side food, Proximate composition, Heavy metal contamination, Health risks,

INTRODUCTION

Food is an essential aspect of the human diet since it gives us energy, keeps us alive and helps us grow. By mending and growing tissues in the body, it maintains, strengthens, and provides remedies and resistance to diseases. Contaminants in the environment, food safety, and human health are all intertwined (Rai, 2019). "Roadside/street foods," according to the World Health Organization, are foods and beverages made and sold by vendors in streets and other public places for immediate consumption or later consumption without further processing or preparation (FAO/WHO 2005).

Heavy metal concentrations in the environment have risen dramatically in recent years, and the sources of heavy metals in food crops differ across developing and developed countries

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(Nielen, 2008; Rai, 2019). In developed countries, industrial effluents and sewage sludge deposition as fertilizers are the principal sources of contamination in soil-crop systems. In addition, irrigation with untreated sewage or sludge in developing nations is the primary source of contamination for food crops (Tania, 2020). The safety of the food ingested requires immediate attention, especially with the global rate of industrialization and globalization (FAO/WHO 2005).

The people of Zaria, Nigeria, eat a variety of road-side foods, the most popular of which are roasted maize and plantain. However, no research has been done to determine their nutritional content or the likelihood of heavy metal exposure from dust particles from vehicle exhaust along road-side. Heavy metals persist in the environment for a long time since they are non-degradable, and they are translocated to other components, damaging the biota (Obodai, 2011; Rajaganapathy, 2011). Furthermore, several metals, such as Fe, Zn, Cu, Mn, Cr, Mo, and Se, are considered necessary in humans because their principal purpose is to serve as a catalyst, and only trace amounts are required for cellular operations. While metals like Pb, As Cd, and Hg, are thought to have no recognized biological function, they can enter the body by inhalation, uptake from the soil, water, and waste (Ekpo, 2008) and constitute a significant health risk to people. The safety of the food ingested, particularly given the velocity of globalization and industrialization, necessitates close environmental monitoring of food safety and quality. As a result, this study aimed to determine the nutritional quality and heavy metal contamination of road-side roasted and raw plantain and maize marketed in Zaria and the surrounding areas.

MATERIALS AND METHODS

Study area

The samples were randomly collected across three locations (Kofan Doka, Kwangila, and Samaru) in Zaria, based on the high levels of people activity and vehicular transportation.

Collection of food samples

Between April and June 2021, 48 samples of roasted and raw plantain and maize were randomly purchased from sellers along road-side in three (3) places in Zaria and environs.



Plate I: a) roasted plantain, b) roasted maize (corn) sold along road-side in Nigeria (Image Source: <https://www.google.com/>; <https://www.dreamstime.com/photos-images/roasted-plantain.html>)

Processing of samples

Tissue was used to wipe the samples clean. The maize seeds were manually extracted from the cob. Plantains were peeled and divided into four equal portions after peeling. The pieces were then sun-dried for 72 hours, ground into flour and stored in an airtight container before being sent to the food science laboratory of Ahmadu Bello University's Department of Animal Science for nutritional analysis and heavy metal analysis to the Soil Science Laboratory of Ahmadu Bello University in Zaria. Duplicates of each sample were taken.

Determination of nutritional composition

Determination of moisture content

Moisture content was determined according to standard method and technique as described in AOAC (2000). After the crucible was heated and weighed, ten grams (10g) of each sample were weighed. Oven drying at 100°C was used to evaluate moisture content. The sample was taken out and weighed after cooling in a desiccator. The formula calculated the moisture content:

$$\text{moisture content} = \frac{\text{wt of the sample before drying} - \text{wt of the sample after drying}}{\text{wt of the sample before drying}} \times 100$$

Determination of crude fibre

Five grams (5g) of each sample were digested into trichloroacetic acid and filtered after refluxing for 40 minutes. The residue was cleaned in boiling distilled water before being soaked in acetone. The dried residue was scraped into a porcelain crucible, weighed, and then placed in a muffle furnace for ashing at 550°C for 2 hours, after which it was removed and cooled in desiccators and weighed (AOAC, 2000).

$$\text{Fibre content} = \frac{\text{wt of crucible+residue} - \text{wt of crucible+ash}}{\text{initial wt of sample}} \times 100$$

Determination of crude protein (Kjeldahl Method)

Each sample was digested by mixing 2 grams of flour with 10 grams of anhydrous sodium, 0.9 grams of hydrated copper sulphate, and 50 millilitres of sulphuric acid. The digest solution was cooled and put into a 100 mL volumetric flask brought up to mark with distilled water when the light green colour was seen. Distilling 25 mL of the produced digest with 10mls 40% sodium hydroxide was done using Micro Kjeldahl distillation equipment. As the distillation progressed, the blue colour turned to a dark brown. The ammonia was condensed and collected in a receiver containing 10 mL of boric acid and an indicator solution. The condensed ammonia was then back-titrated to a pink endpoint with 0.01M HCl (AOAC, 2000).

$$\text{Percent Nitrogen (N)} = \frac{\text{titre value (A)} \times 1.4 \times 10^{-4} \times \text{volume made}}{\text{Aliquot taken} \times \text{wt of sample digest \% crude protein}} \times 100 = \text{N} \times 6.25$$

Determination of ash content

For correct ashing, two grams (2g) of each sample were weighed into a porcelain crucible and heated in a temperature-controlled furnace at 600°C for approximately 6 hours. The crucible was weighed immediately after cooling in a desiccator (AOAC, 2000).

Carbohydrate and caloric value

The difference approach was used to calculate the samples' total carbohydrate content. The caloric value was determined by multiplying the percentages of proteins and carbs by a factor of four (kcal/g) and total lipids by a factor of nine (kcal/g) (AOAC, 2000).

Determination of mineral contents

Atomic Absorption Spectrometry was used to determine potassium and sodium. Perchloric acid and nitric acid were used to digest the samples, and then examined using a digital flame photometer (Spectronic 20). The Vanado-molybdate colourimetric method was used to determine phosphorus. Atomic Absorption Spectrometry was used to determine the calcium concentrations (Buck Scientific, Norwalk).

Determination of heavy metal contents

0.5 g of each sample was weighed into a beaker, followed by 15 mL of HNO₃, 5 mL of HCl, and 5 mL of H₂SO₄. Filtered digested samples were prepared up to 50 mL with distilled water and filtered through 0.45 micropore size filter paper. An atomic absorption spectrometer (AAS) from Perkin Elmer (Model110B) was used to determine the heavy metal content.

Data analysis

All the tests were done twice. To see a significant difference in proximate composition, mineral, and heavy metal concentration between treatments, researchers employed a one-way analysis of variance (ANOVA). The heavy metal concentration in dietary samples was compared using bar charts across the different sites. Statistical significance was defined as a value of $P \leq 0.05$. MS-Excel and SPSS statistical tools were used for data analysis.

RESULTS

The nutritional composition of road-side raw and roasted plantain and maize sold in Zaria and environs is presented in table 1. The percentage of dry matter across the different feed samples was highly significant ($P < 0.05$). Roasted plantain had the highest percentage of dry matter (95.33 ± 0.54), followed by raw plantain (93.75 ± 0.57), roasted maize (92.83 ± 0.40), while raw maize had the lowest value (90.42 ± 0.60). (Table 1). Moisture, crude protein, crude fibre, oil, ash, and nitrogen-free extract (NFE) were significantly different between raw and roasted plantain and maize samples. Moisture content was lowest in roasted plantain (4.67 ± 0.54) and highest in raw maize (9.58 ± 0.60). Additionally, the crude protein and crude fibre were most elevated in roasted maize (10.56 ± 0.26 , 3.22 ± 0.13 respectively) and lowest in raw plantain samples (8.62 ± 0.37 , 1.70 ± 0.20 respectively). Furthermore, the oil content was highest in raw maize (3.05 ± 0.21), followed by roasted maize (2.57 ± 0.09), and no significant difference was an object with those with the lowest values, roasted plantain (1.39 ± 0.15) and raw plantain sample (1.57 ± 0.24). Ash content was highest in raw plantain (3.28 ± 0.16), and the lowest value was recorded for roasted maize (2.00 ± 0.26). The nitrogen-free extract (NFE) or energy content was significantly higher ($P < 0.05$) in both raw plantain (78.42 ± 0.64) and roasted plantain (78.63 ± 1.14). The lowest NFE value was found in raw maize (72.09 ± 0.85) (Table 1).

Table 1 also includes the mineral composition of raw and roasted road-side plantain and maize. The calcium concentration of all examined samples is not significantly different ($P > 0.05$). However, the phosphorus concentration of the samples showed a highly significant difference ($P < 0.05$). Raw and roasted maize had the highest phosphorus concentration, followed by roasted plantain, with raw plantain (0.10 ± 0.01) having the lowest (Table 1).

Table 1: Nutritional composition (%) of road-side raw and roasted plantain and maize sold in Zaria and environs, Kaduna State

	Raw plantain	Roasted plantain	Raw maize	Roasted maize	P-value
Dry matter	93.75±0.57 ^b	95.33±0.54 ^a	90.42±0.60 ^d	92.83±0.40 ^c	0.001**
Proximate composition					
Moisture	6.42±0.47 ^c	4.67±0.54 ^d	9.58±0.60 ^a	7.17±0.40 ^b	0.001**
Crude protein	8.62±0.37 ^c	9.68±0.58 ^b	9.80±0.32 ^b	10.56±0.26 ^a	0.023*
Crude fibre	1.70±0.20 ^c	2.71±0.24 ^b	2.98±0.22 ^b	3.22±0.13 ^a	0.001**
Oil	1.57±0.24 ^c	1.39±0.15 ^c	3.05±0.21 ^a	2.57±0.09 ^b	0.001**
Ash content	3.28±0.16 ^a	2.92±0.32 ^b	2.50±0.13 ^c	2.00±0.26 ^d	0.006**
NFE	78.42±0.64 ^a	78.63±1.14 ^a	72.09±0.85 ^c	74.49±0.32 ^b	0.001**
Mineral content					
Calcium	0.23±0.02 ^a	0.22±0.04 ^a	0.20±0.01 ^a	0.23±0.02 ^a	0.769 ^{ns}
Phosphorus	0.10±0.01 ^c	0.11±0.03 ^b	0.24±0.00 ^a	0.22±0.00 ^a	0.001**

Mean values with different alphabets across rows are significantly different ($P < 0.05$) *= significant, **= high significant, ns= non-significant

Heavy metal contamination of road-side raw and roasted plantain and maize sold in Zaria and its environs is presented in Table 2. Pb, Cr, and Cd levels were statistically higher ($P < 0.05$) in all examined samples analyzed (Table 2).

Table 2: Level of heavy metal (mg/Kg) contamination of road-side raw and roasted plantain and maize sold in Zaria and environs, Kaduna State

Heavy metals	Raw plantain	Roasted plantain	Raw Maize	Roasted maize	P-value
Lead (Pb)	94.73±22.31 ^a	92.75±14.80 ^a	62.20±13.73 ^b	44.64±21.08 ^c	0.002
Chromium (Cr)	62.77±7.37 ^c	64.47±19.09 ^c	90.00±19.62 ^a	76.70±17.85 ^b	0.005
Cadmium (Cd)	43.53±14.61 ^a	28.75±9.51 ^b	28.06±6.79 ^b	42.72±14.21 ^a	0.003

Mean values with different alphabets across rows are significantly different ($P < 0.05$)

The cadmium (Cd) contamination level of road-side roasted and raw plantain and corn samples sold in Zaria and surrounds is depicted in Figure 1. The highest degree of Cd contamination was found in raw plantain, corn, and roasted maize sold at Kofar Doka, followed by samples from Kwangila. In compared to Kofar Doka and Kwangila, those from Samaru were lower (Figure 1).

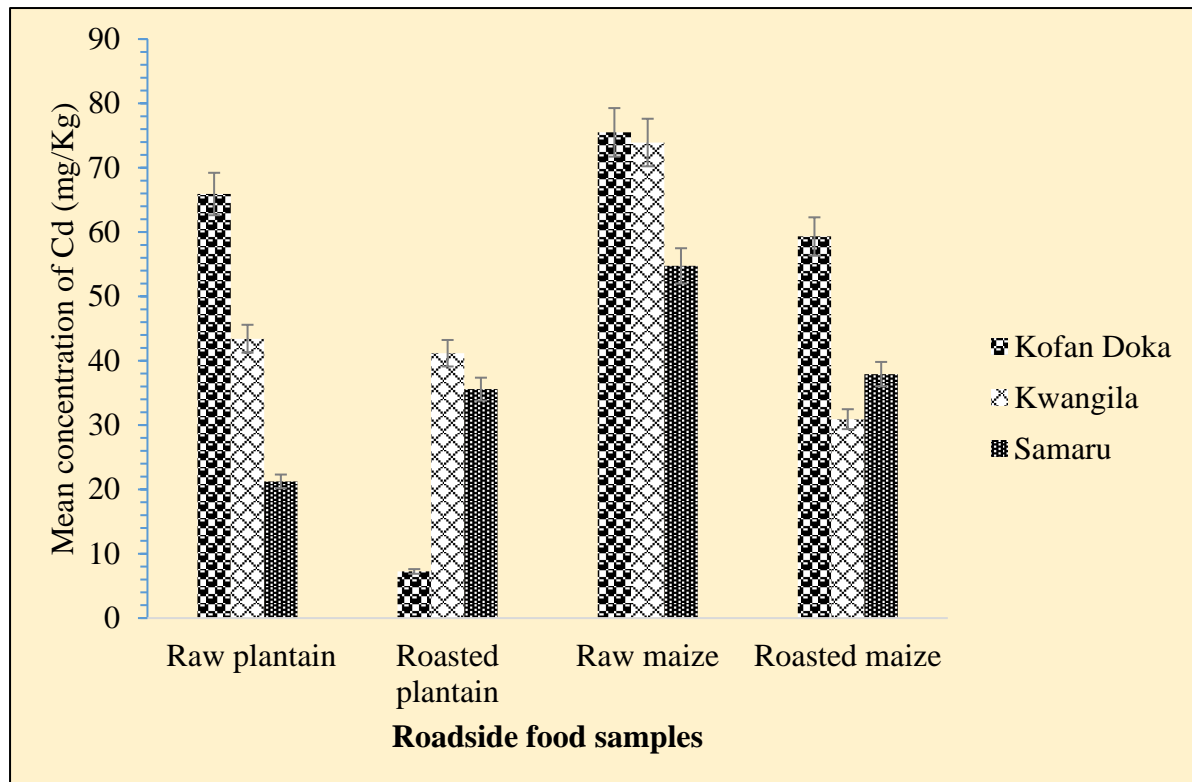


Figure 1: Level of Cadmium (Cd) contamination of road-side raw and roasted plantain and maize food sold in Zaria and environs, Kaduna State.

The level of chromium (Cr) in road-side raw and roasted plantain and corn is represented in Figure 2. At Kofar Doka and Samaru, the level of Cr pollution was higher. The three locations' samples are generally significant (Figure 2).

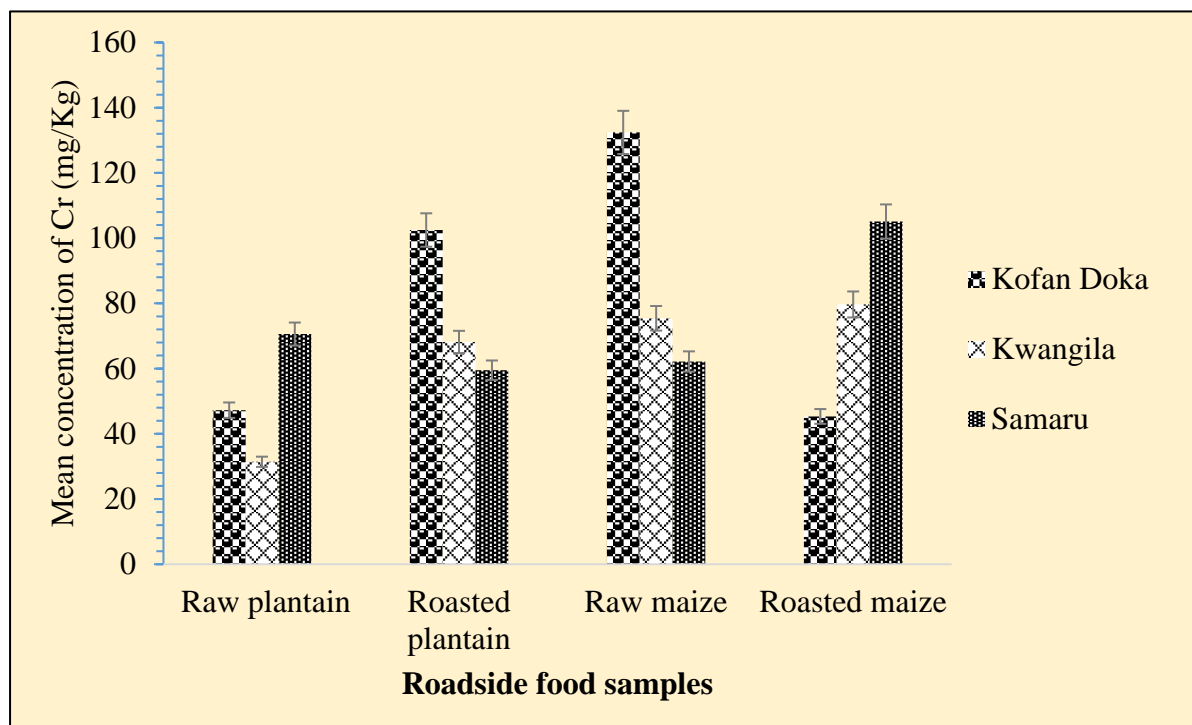


Figure 2: Level of Chromium (Cr) contamination of road-side raw and roasted plantain and maize food sold in Zaria and environs, Kaduna State.

Figure 3 shows the Lead (Pb) amounts in road-side roasted and raw plantain and maize. The raw and roasted plantains sold at Kofar Doka and Samaru had higher values (Figure 3).

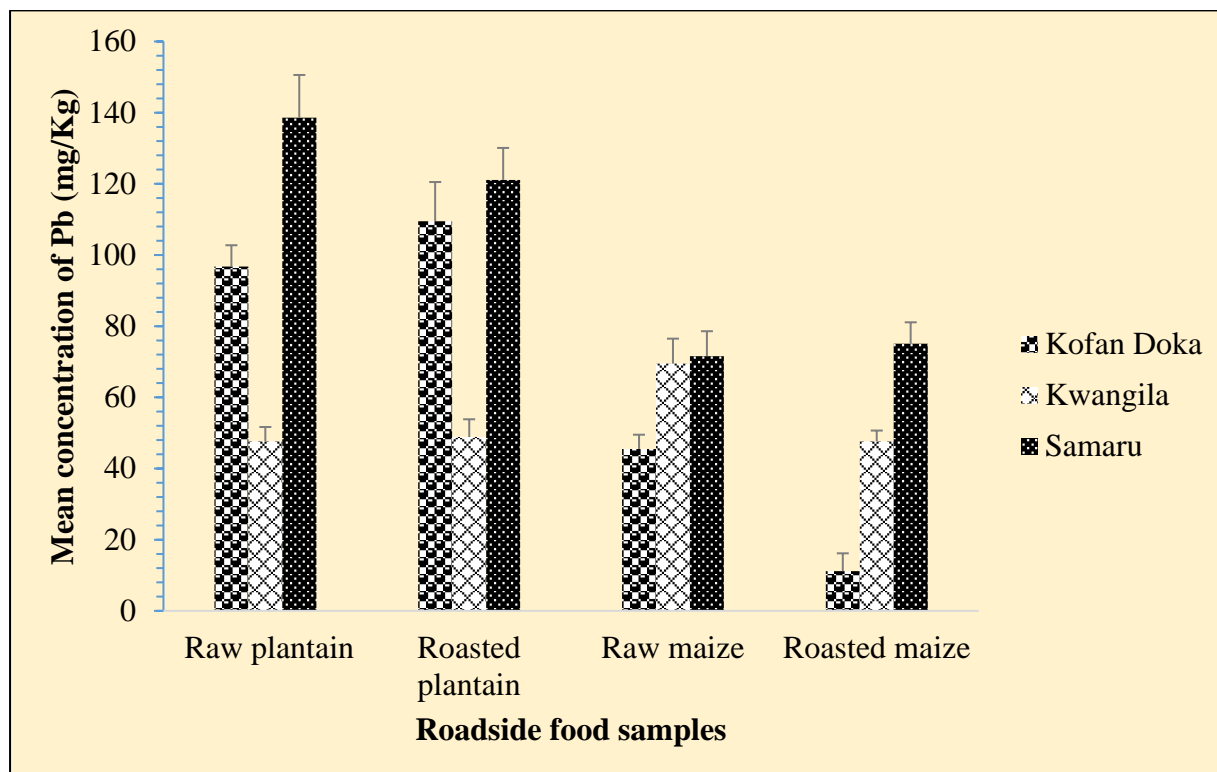


Figure 3: Level of Lead (Pb) contamination of road-side raw and roasted plantain and maize food sold in Zaria and environs, Kaduna State.

DISCUSSION

Roasting is a method of drying agricultural products in an oven or over an open fire (Makanjuola, 2013). The high dry matter content of roasted plantain and maize can be linked to the low moisture level found after roasting. These foods provide energy in foods (measured in kilocalories or kilojoules).

The amount of protein in a particular food is known as crude protein (Adepoju, 2015). Nitrogen-free extract (NFE) was considerably higher in raw and roasted maizes. The moisture, oil, and ash content of roasted plantain and maize, on the other hand, all decreased significantly. Food or processed product moisture and oil content indicate freshness and shelf life, and high moisture and oil content may favour microbial deterioration and shelf life, resulting in spoilage (Adepoju, 2015).

The amount of calcium in the raw and roasted plantain and maize samples examined was low. Calcium and phosphorus are required for muscle contractions such as heartbeat, blood clotting, and the formation of strong bones and teeth (Roth, 2003; Rolfes, 2009). The ash content of a sample indicates the amount of minerals present.

Within specific limiting amounts, heavy metals such as Lead, Cadmium, and Chromium are potentially hazardous due to direct potential toxicities to biota and indirect hazards to human health, such as contamination of groundwater and build-up in food crops (Cambra, 1999; Mohammed, 2016; Antoniadis, 2017). Heavy metals have atomic weights ranging from 63.545

to 200.5 grams. Some pollutants, such as Cd, lead (Pb), and mercury, may represent the most severe threat to our ecosystem (Maha, 2015).

Cadmium is a heavy metal poison with a specific gravity of 8.65 times water. A study conducted by Olajide et al. (2019) in Ibadan, Oyo state, found cadmium levels below the instrument's detection limit. The liver, placenta, kidneys, lungs, brain, and bones have all been recognized as organs that are susceptible to Cd poisoning (Sobha, 2007). Severe exposure can cause pulmonary oedema, which can lead to mortality. Subchronic inhalation exposure to Cadmium and its compounds can cause pulmonary and renal consequences (Duruibe, 2007). The level of Cadmium found in this study far exceeds the values reported by Oyelola et al. (2013), who found an average concentration range of 0– 0.06 mg/g for Cadmium in road-side roasted corn and plantain in Alimosho Local Government Area of Lagos State, Nigeria, and these heavy metal values were within the FAO and WHO permissible levels. Furthermore, Cadmium was not discovered in vended corn and plantain by Abolanle et al. (2018) in a comparative investigation.

All the food items tested had chromium levels that were much higher than the WHO/FAO permitted range for human consumption. Chromium (Cr) is the tenth most prevalent element in the earth's mantle. In living species, particularly humans, chromium is required for insulin function and deoxyribonucleic acid transcription. Intake of less than 0.02mg per day, on the other hand, may reduce cellular insulin responses (Kohlmeier 2003). Cr (VI) 's capacity to penetrate cell membranes and oxidize biological molecules gives it toxicity (Shaffer, 2001). The lead concentration in the three locations' examined samples is higher than the WHO/FAO allowed levels. Lead poisoning can cause problems with the kidneys, reproductive system, liver, and brain. Anaemia, tiredness, gastrointestinal issues, and anoxia are other long-term consequences (Odum, 2000). Oyelola et al. (2013) discovered an average concentration range of 0– 0.10 mg/g for Lead in road-side roasted maize and plantain in Alimosho Local Government Area of Lagos State, Nigeria. These heavy metal values were within the FAO and WHO acceptable thresholds. Furthermore, Abolanle et al. (2018) found no lead in vended corn and plantain in a similar experiment.

Generally, the high amount of heavy metals in raw plantain and maize could be attributed to soil contamination. The absorption of heavy metals by plant roots is one of the most common mechanisms for entering the food chain. Also, for the road-side roasted maize and plantain and contamination in farms, dust particles and pollution from car exhaust and movement may further lead to contamination of exposed food by road-sides. The intake of food contaminated by heavy metals causes severe human health issues such as gastrointestinal cancer, fragile Immunological mechanisms, mental growth retardation, and malnutrition (Prabhat, 2019). Heavy metals can also accumulate in human bones or fatty tissues through ingestion, depleting essential nutrients. Certain heavy metals, especially Pb and Cd, have carcinogenic effects and can lead to bone fractures, malformation, kidney dysfunction, hypertension, and other severe liver, lung, and nervous system (Khan, 2008, 2010; Rai, 2019).

CONCLUSION

Roasted plantain and maize have a nutritious, high level and a reduced quantity of dry matter. The mineral composition of roasted road-side plantain (Ca, 0.22 ± 0.04 ; Ph, 0.11 ± 0.03) and maize (Ca, 0.23 ± 0.02 ; Ph, 0.22 ± 0.00) reveal that calcium and phosphorus were found within the moderate limit adequate for human consumption. Based on the current study, raw and roasted plantain and maize across all the study locations were highly contaminated with Pb,

Cr, and Cd, which may pose a public health concern. To avoid contamination, thorough processing and enclosing within exhibit glass is recommended.

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